



## AGRARIAN SCIENCES

# Age and calving time affects production efficiency of beef cows and their calves

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**Abstract:** The aim of this study was to evaluate the influence of two sub-periods of the calving season and two cow maturity stages on the efficiency of beef cows and their calves. A total of 159 cow-calf pairs were divided by calving time (early or late) within the calving season and maturity stage (young or adult). Calves were weaned at 42 or 63 days after birth and evaluated until 210 days of age. Cows and calves had their development examined based on their weight and body condition score at calving, at weaning, and at 210 days. Reproductive performance was evaluated on the basis of time to become pregnant again. Milk yield was assessed by the direct method on three occasions spaced 21 days apart. Adult cows were heavier than young cows, at calving (398.5 vs 327.5 kg, respectively), weaning (397.3 vs 324.1 kg, respectively) at the end breeding season (424.1 vs 342.1 kg, respectively). Reproductive performance was influenced by calving time. Adult cows had higher pregnancy rates (83.75 and 69.17%, for early and for late calving, respectively) than young cows (57.03 and 35.01% for early and for late-calving, respectively). Calves from early-calving young cows weighed 158.8 kg at 210 days of age vs. 123.7 kg for those born from late-calving adult cows. However, late-calving cows produced 10.7% more milk than those that calved early in the season (227.0 vs 205.0 liters, respectively). Early calving associated with non-requirement of growth determine higher productivity efficiency in beef cows.

**Key words:** early weaning, pregnancy, milk yield, productivity.

## INTRODUCTION

The low calf birth and production rates in the south of Brazil indicate that this sector has space for improvement. In the state of Rio Grande do Sul, 56 calves are produced per 100 cows kept in the herd (Silva et al. 2014). This low reproductive rate compels producers to extend the breeding season and the calving interval (Rodrigues et al. 2014).

Many are the factors leading to low reproductive rates in beef herds. The low quality of natural pastures (Vaz et al. 2016) and the poor

management resulting from the high stocking rates used in these pastures culminate in lower calf weights at weaning and lower pregnancy rates (Pellegrini & Dias 2011).

Vieira et al. (2005) worked with a Nellore herd in the Central-West region of Brazil and observed that time to a new pregnancy had a quadratic relationship with the age of the cows in the herd, with cows aged five to seven years producing the most kilograms of calf and conceiving the most times. Adjusting the calving time for a greater pasture supply and the different cow categories for the right calving times increase

the herd's efficiency. The calving date proved to be a possible criterion for selection in herds (Simioni 2003), and this variable interferes with their real fertility, involving pregnancy and the calving interval (Viu et al. 2008).

Conceptions occurring early in the reproductive season consequently lead to births occurring early in the calving season, allowing the cows more time to recover before the subsequent breeding season (Viu et al. 2008, Cushman et al. 2007, Cushman et al. 2013). In natural pasture conditions, early-born calves benefit from the forage resources, being heavier at weaning. Heavier weaning weights mean improved efficiency of the cow-calf pair, since the amount of energy required to produce calf weight will be reduced due to dilution of the dam's maintenance expenditure (Di Marco et al. 2007). A higher calf weight at weaning is essential for success in the first breeding of a heifer (Vaz et al. 2012, Cushman et al. 2013).

The aim of the study was to investigate the combination, between calving time within the calving season and the maturity stage of beef cows on their biological and reproductive efficiency.

## MATERIAL AND METHODS

### Definition of experimental groups, production system and investigated characteristics

The experiment was developed in the Laboratório de Bovinocultura de Corte do Departamento de Zootecnia da Universidade Federal de Santa Maria, in the state of Rio Grande do Sul, Brazil. The study was approved by the Ethics Committee of Animal Use of Universidade Federal de Pelotas (Approval number CEEA n°. 8250-2015) and was developed considering the national guidelines for care and use of animals.

The study used 159 cow-calf pairs, which included young (3 and 4 years old – first and

second calving, respectively) or adult (5 to 12 years old – three calvings or more) Charolais (C) and Nellore (N) purebred cows and crossbreds with ¼ to ¾ Charolais proportions.

Cows were divided according to their genetic predominance so that they would be distributed evenly into two calving times within the calving season (early – calving from September 06 to October 15; and 'late' – calving from October 16 to November 30) and two maturity stages (young or adult), thus forming the following groups:

- Young cows calving in the first half of the calving season (early);
- Adult cows calving in the first half of the calving season (early);
- Young cows calving in the second half of the calving season (late); and
- Adult cows calving in the second half of the calving season (late).

From calving to the end of the reproductive season (December to February), calved cows were kept in natural pastures at a stocking rate of 0.9 AU ha<sup>-1</sup>. During the first 30 days, the reproductive method used was artificial insemination, followed by natural service for 60 days. Cows were separated by genetic group and exposed to the bulls in a continuous alternated crossbreeding system with the Charolais and Nellore breeds. Pregnancy diagnosis was performed 60 days after the end of the breeding season, by ultrasound.

Cows and calves were weighed at calving; at weaning (42 or 63 days after calf birth); at the start and end of the reproductive season; and at 210 days post-calving. Upon weighing, their body condition was assessed as described by (Fontoura Júnior et al. 2009).

Milk yield was estimated by the direct method, through manual milking, following the methodology described by Restle et al. (2003). Evaluations to estimate the cows' milk yield took place at 21, 42, and 63 days post-calving. Total

milk yield was calculated by multiplying the result of each evaluation by 21, corresponding the total produced in 21 days, and summing the three evaluation periods. A 450mL sample was taken from the extracted milk and immediately cooled for later analysis of lactose, fat, total solids, and crude protein contents.

Productivity was evaluated considering the total weight gains (kg) of the cow-calf pairs from calving to weaning. The production efficiencies of cows at calving and weaning were evaluated considering the kilograms of calf at weaning for every 100 kg of cow at calving and at weaning, respectively (Ribeiro et al. 2001).

Calf production index was calculated by associating the calf weight at weaning and the pregnancy rate of the cows, with the result expressed as kilograms of calf produced per cow kept in the herd in the subsequent year (Vaz et al. 2010). For the analysis of production efficiency as a function of the land area used for each cow-calf pair, we simulated the area required to allocate the cow-calf pair of each one of the groups, adopting a stocking rate of 0.9 AU ha<sup>-1</sup>, where 1 AU = 450 kg of body weight.

### Statistical analysis

A 2 × 2 factorial arrangement (two calving times within the calving season and two maturity stages) was adopted. Collected data were subjected to analysis of variance, including the effects of calving time and cow maturity stage as well as the interaction of these two factors in the model. Calf sex and cow genetic group were used as covariates. Analyses were carried out using the GLM procedure. Data were analyzed using the SAS statistical software version 6.08 (SAS 2001), adopting 5% as the maximum significance level by the *t*-test. Pregnancy rate was analyzed using the chi-square test (Gomez & Gomez 1984).

## RESULTS

The changes in weight at calving, at weaning, and at the end of the breeding season displayed had a similar trend (Table I). Young cows were lighter and had lower body condition scores compared to adult cows. Early-calving adult cows had higher weight gains from calving until the end of the breeding season as compared with young cows but did not differ from their late-calving counterparts.

Calves born from adult cows were heavier at weaning than those born from young cows in the late-calving group but did not differ from those born from young cows that calved early. At weaning, for the group weaned at 63 days of age, the calves from cows were lighter than those born from adult cows, independent of the calving time. At 210 days of age, early born calves were heavier than late-born calves.

Reproductive performance of cows was influenced by calving time and maturity stage (Table II). Adult cows had better results for this variable than their young counterparts: 46.8 and 97.6% for the early- and late-calving groups, respectively.

Production efficiencies at calving and at 210 days of age were higher in young cows that calved early in the season. Late-calving cows were less efficient, and no difference was observed between the maturity stages in this group.

When cow weights were adjusted for the subsequent reproductive performance of the cows, the early-calving adult cows were superior to the other groups. The worst result was observed in young cows that calved in the second half of the calving season. Early-calving young cows had similar performance to late-calving adult cows.

Total production of kilograms of the cow-calf pair decreased along with the calving time

**Table I. Means and standart erros for weight, a average daily gain, and body condition score of cows and calves born from cows calving at two distinct times within calving season and two maturity stages.**

Endpoints	Early-calving		Late-calving	
	Young	Adult	Young	Adult
<b>Cows -Weights, kg</b>				
At calving	322.6±10.2 <sup>b</sup>	397.4±7.6 <sup>a</sup>	331.5±10.4 <sup>b</sup>	399.6±5.2 <sup>a</sup>
At weaning	319.6±10.2 <sup>b</sup>	397.8±7.7 <sup>a</sup>	328.5±10.4 <sup>b</sup>	396.7±5.2 <sup>a</sup>
At end of breeding season	339.2±10.6 <sup>b</sup>	431.2±7.9 <sup>a</sup>	345.0±10.8 <sup>b</sup>	417.0±5.4 <sup>a</sup>
<b>Cows - Daily weight changes, kg day<sup>-1</sup></b>				
From birth to weaning	-0.050±0.07 <sup>a</sup>	0.005±0.05 <sup>a</sup>	-0.048±0.07 <sup>a</sup>	-0.046±0.03 <sup>a</sup>
From calving to end of breeding season	0.114±0.04 <sup>b</sup>	0.227±0.03 <sup>a</sup>	0.124±0.04 <sup>b</sup>	0.155±0.02 <sup>ab</sup>
<b>Cows - Body condition score, points</b>				
At calving	2.91±0.05 <sup>b</sup>	3.09±0.03 <sup>a</sup>	2.87±0.05 <sup>b</sup>	3.19±0.02 <sup>a</sup>
At weaning	2.89±0.05 <sup>b</sup>	3.13±0.04 <sup>a</sup>	2.84±0.05 <sup>b</sup>	3.22±0.02 <sup>a</sup>
At end of breeding season	3.06±0.06 <sup>b</sup>	3.38±0.04 <sup>a</sup>	2.99±0.06 <sup>b</sup>	3.22±0.03 <sup>a</sup>
<b>Calves - Weights, kg</b>				
At birth	31.6±1.14 <sup>ab</sup>	33.3±0.86 <sup>a</sup>	29.1±1.16 <sup>b</sup>	32.5±0.58 <sup>a</sup>
At weaning	56.4±2.77 <sup>b</sup>	70.7±1.97 <sup>a</sup>	57.3±2.74 <sup>b</sup>	68.2±1.39 <sup>a</sup>
At 210 d of age	158.8±4.21 <sup>a</sup>	164.4±3.91 <sup>a</sup>	107.2±5.31 <sup>c</sup>	123.7±2.6 <sup>b</sup>
<b>Calves - Daily weight changes, kg</b>				
From birth to weaning	0.390±0.04 <sup>a</sup>	0.590±0.02 <sup>a</sup>	0.450±0.04 <sup>a</sup>	0.560±0.02 <sup>a</sup>
From birth to 210 days of age	0.616±0.03 <sup>ab</sup>	0.639±0.02 <sup>a</sup>	0.467±0.03 <sup>c</sup>	0.577±0.01 <sup>b</sup>

<sup>a, b, c</sup> in the same row did not differ ( $P < 0.05$ ) according to the "t-test"

<sup>1</sup>Scale of 1 to 5, where 1 = very thin and 5 = very fat.

and young cows were superior than adult cows. Regardless of the age, early-calving cows were more productive.

As the cows grew older, their body weight increased. Thus, a larger area was required for the maintenance of the cow-calf pair when adopting a fixed stocking rate (0.9 AU ha<sup>-1</sup>). Early-calving adult cows required 1.32 ha for their maintenance, higher ( $P < 0.05$ ) than the area required for the maintenance of herds of early-calving young cows (1.08 ha), late-calving young cows (1.01 ha), and late-calving adult cows (1.22 ha). All areas required for maintenance of the cow-calf pair differed ( $P < 0.05$ ).

Production in kilograms of the cow-calf for early-calving cows was 168.2 and 158.0 kg for young and adult cows, respectively, values higher than the late-calving of 122.1 and 122.4 kg, respectively, for young and adults. Adjusting the area necessary for production revealed a superiority of young cows early-calving ( $P < 0.05$ ) which were higher in the other categories with 155.7 kg, no difference ( $P > 0.05$ ) between adult cows early-calving and young cows late-calving with 119.7 and 120.9 kg, respectively, higher than the 98.7 kg produced by the adult cows late-calving. The total yield and quality of the milk produced by the cows were affected by calving time and age ( $P < 0.05$ ; Table III). Late-calving cows

produced 12.5% more milk than early-calving cows. Milk yield decreased with the progression of lactation up to 63 days, regardless of cow age and calving time. The highest decrease was seen in young cows calving early in the season, which produced 2.7 times less milk at 63 days than at 21 days. The mean efficiency of transformation of milk into kilograms of calf was 14.62 L, corresponding to 6.85%.

Lactose and fat contents did not differ between the cow ages or calving times. Cows at full maturity were superior to young cows at both calving times; early- and late-calving adult groups produced 11.95 and 13.42% more protein, respectively.

Total solids was influenced by calving time, with lower values seen in early-calving cows compared with those that calved late, irrespective of their age.

## DISCUSSION

The lower weight of young cows in comparison with adult cows at calving, weaning and breeding season is a consequence of their stage of development, which has not yet finished. During pregnancy and lactation, female cattle have their metabolizable energy requirements increased on average by 30.7 and 61.5%, respectively (NRC

**Table II. Means and standart erros for reproductive performance and production efficiency of cows calving at two times within the calving season and two maturity stages.**

Endpoints	Early-calving		Late-calving	
	Young	Adult	Young	Adult
Pregnancy, %	57.03 <sup>C</sup>	83.75 <sup>A</sup>	35.01 <sup>D</sup>	69.17 <sup>B</sup>
Prod. efficiency at calving, kg <sup>1</sup>	49.9±1.6 <sup>a</sup>	42.3±1.2 <sup>b</sup>	32.7±1.6 <sup>c</sup>	31.1±0.8 <sup>c</sup>
Prod. efficiency at 210 days, kg <sup>2</sup>	42.4±1.3 <sup>a</sup>	35.0±0.9 <sup>b</sup>	29.0±1.3 <sup>c</sup>	27.2±0.6 <sup>c</sup>
Calf production index, kg <sup>3</sup>	90.6±3.8 <sup>b</sup>	137.6±2.7 <sup>a</sup>	37.4±3.7 <sup>c</sup>	85.5±1.9 <sup>b</sup>
Cow production, kg	50.5±4.5 <sup>a</sup>	58.1±3.3 <sup>a</sup>	44.4±4.6 <sup>b</sup>	45.8±2.3 <sup>b</sup>
Calf, kg	117.7±4.3 <sup>a</sup>	99.9±3.1 <sup>a</sup>	77.7±4.4 <sup>b</sup>	74.6±2.2 <sup>b</sup>
Cow-calf pair production, kg <sup>4</sup>	168.2±6.2 <sup>a</sup>	158.0±4.6 <sup>a</sup>	122.1±6.3 <sup>b</sup>	120.4±3.2 <sup>b</sup>
Area required for production, ha <sup>5</sup>	1.08±0.03 <sup>c</sup>	1.32±0.02 <sup>a</sup>	1.01±0.03 <sup>d</sup>	1.22±0.02 <sup>b</sup>
Cow-calf pair production, kg ha <sup>-1</sup>	155.7±6.3 <sup>a</sup>	119.7±5.1 <sup>b</sup>	120.9±6.5 <sup>b</sup>	98.7±4.1 <sup>c</sup>

<sup>a, b, c, d</sup> Means in the row differ at the 5% level according to the t-test; <sup>A, B, C, D</sup> differ (5%) according to the chi-square test.

<sup>1</sup>Calf weight at 210 days / Cow weight at calving \* 100 = kg calf /100 kg cow; <sup>2</sup>Calf weight at 210 days / Cow weight at 210 days \* 100 = kg calf /100 kg cow; <sup>3</sup> Calf weight at 210 days × pregnancy rate / 100 = kg of calf per cow kept in the herd; <sup>4</sup> (Cow weight + Calf weight) / (450 kg \* 0.9 AU/ha) = ha/for cow-calf; <sup>5</sup> (total cow + calf weight gain) / average real occupancy up to 210 days = kg/ha.

**Table III. Means and standart erros for daily and total yields, production efficiency, and milk components from cows calving at two times within the calving season and two maturity stages.**

Endpoints	Early-calving		Late-calving	
	Young	Adult	Young	Adult
<b>Milk yield, kg</b>				
21 days	4.18±0.36 <sup>ab</sup>	4.81±0.27 <sup>a</sup>	3.53±0.37 <sup>b</sup>	4.58±0.18 <sup>a</sup>
42 days	2.25±0.36 <sup>c</sup>	3.46±0.27 <sup>b</sup>	2.89±0.37 <sup>bc</sup>	4.48±0.18 <sup>a</sup>
63 days	1.53±0.44 <sup>c</sup>	3.37±0.32 <sup>ab</sup>	2.50±0.44 <sup>bc</sup>	3.71±0.24 <sup>a</sup>
Average milk yield	2.65±0.31 <sup>b</sup>	3.88±0.26 <sup>a</sup>	2.97±0.30 <sup>b</sup>	4.25±0.22 <sup>a</sup>
Total milk yield	167±7.3 <sup>b</sup>	244±6.8 <sup>a</sup>	187±6.5 <sup>b</sup>	268±6.9 <sup>a</sup>
<b>Lactation efficiency</b>				
Calf weight gain	24.8±2.4 <sup>b</sup>	37.4±2.7 <sup>a</sup>	28.2±2.4 <sup>b</sup>	35.7±2.8 <sup>a</sup>
kg milk per kg calf <sup>1</sup>	6.73±1.2 <sup>b</sup>	6.52±1.4 <sup>b</sup>	6.63±1.1 <sup>b</sup>	7.50±1.3 <sup>a</sup>
kg milk per kg calf <sup>2</sup>	14.9±0.33 <sup>a</sup>	15.3±0.32 <sup>a</sup>	15.0±0.33 <sup>a</sup>	13.3±0.31 <sup>a</sup>
<b>Milk components, %</b>				
Protein, %	2.76±0.15 <sup>b</sup>	3.09±0.11 <sup>a</sup>	2.83±0.15 <sup>b</sup>	3.21±0.08 <sup>a</sup>
Fat, %	3.71±0.17 <sup>a</sup>	3.50±0.13 <sup>a</sup>	3.46±0.30 <sup>a</sup>	3.38±0.10 <sup>a</sup>
Lactose, %	4.84±0.08 <sup>a</sup>	4.97±0.05 <sup>a</sup>	4.83±0.07 <sup>a</sup>	4.86±0.05 <sup>a</sup>
Total solids, %	11.29±0.47 <sup>b</sup>	11.76±0.17 <sup>b</sup>	12.46±0.25 <sup>a</sup>	12.12±0.16 <sup>a</sup>

<sup>1</sup>Total milk yield divided by calf weight gain = kg of milk to produce one kilogram of calf.

<sup>2</sup>Percentage efficiency of milk production.

<sup>3</sup>Within a row, means without a common superscript differ.

2000). These numbers are even higher in the case of young females, since, in addition to the requirements for maintenance and reproduction, they are also under development.

When the environment and nutrition conditions are not ideal, animal performance is compromised. In the present study, an elevated stocking rate was used (0.9 AU ha<sup>-1</sup>), which led to lower weight gains pre- and post-calving, in addition to negative effects on subsequent reproduction. Fagundes et al. (2003) evaluated primiparous cows kept at an average annual stocking rate of 0.8 AU ha<sup>-1</sup> and observed a pregnancy rate of 22.5%. However, when primiparous cows were kept at a stocking rate of 0.6 AU ha<sup>-1</sup>, they obtained a 67.0% pregnancy rate.

As previously mentioned, the larger body weight changes in adult cows compared with those still under development is in part due to the higher dietary requirements of the latter (Cerdótes et al. 2004, Bir et al. 2018). Early-calving cows, benefited by early weaning, have a longer period until the end of the breeding season and no longer have to lactate, which is exhausting to dams. In this way, they can convert the consumed feed into body weight (Vaz & Lobato 2010b, Arthington & Kalmbacher 2003).

The body weight gain of a cow after calving and during the subsequent reproductive period is fundamental to improve performance. Therefore, reproduction requirements are not the priority in the partitioning of nutrients from feeding, but the growth requirements. This fact

is proved by analyzing the young cows — even those that calved early in the season had inferior performance compared with late-calving adult cows.

Vieira et al. (2005) worked with primiparous cows or at their seventh calving in a Nelore herd in Central-West Brazil and found that weight gain during lactation is fundamental for pregnancy rate. With variations fluctuating from -120 to 30 kg, reproductive performance improved, accompanying higher weight gains and body conditions, with more marked impacts seen on the pregnancy rates of primiparous cows (Vieira et al. 2005).

At weaning performed at 63 days post-calving, the higher weight of calves born from cows at full maturity is a result of the higher milk yield of their mothers, whose growth was already completed and thus no nutrients were used for this process (Cerdótes et al. 2004). At 63 days post-calving, the milk yields of these two categories were 1.53 vs. 3.37 L day<sup>-1</sup>, respectively. However, at 210 days, the calf weights were similar. This fact can be partially explained by the compensatory gain of calves born from young cows, which were not supplying the amount of nutrients necessary for their development via milk.

Higher weights at 210 days after calving in calves born early in the calving season are attributed to their older age and longer feeding time. In these animals, an association effect occurs between the peak of diet quality of natural pastures and the higher milk production by their cows (Viu et al. 2006). Moreover, the older age of early-born calves allows for a greater development of their digestive system. As a consequence, these animals use better the natural pasture, which does not have the ideal quality for calves to achieve maximum performance (Viu et al. 2008). The lower weight of late-born calves is due lower milk production

(Carneiro et al. 2012), which is potentiated by the loss of quality of natural pastures during the period (Vaz & Lobato 2010b).

When the milk production of a cow is low, after the stress from weaning is over, compensatory gains might be seen in subsequent periods. In this regard, greater efficiency and higher weight gains are likely associated with larger metabolizable energy intakes, which are higher than the maintenance requirements (Poppi & McLennan 1995). Vaz & Lobato (2010a) worked with primiparous cows at three years of age under non-ideal environmental conditions and observed better performance in calves weaned at 67 days compared to those kept suckling until 148 days.

The higher reproductive performance of cows at full maturity compared with those still under development is likely a result of their lower nutritional requirements and adequacy to the natural pastures in terms of availability and quality (Leme et al. 1989, Carneiro et al. 2012). The growth of beef cows is a limiting factor for satisfactory reproduction performance, even when they wean their calves early. In this study, even when they calved early in the season, young cows were inferior in pregnancy recurrence compared with adult late-calving cows. For a successful pregnancy in primiparous cows, management strategies distinct from those used for the rest of the herd should be adopted, e.g., adjusting the stocking rate in the pasture (Fagundes et al. 2003), using cultivated pastures (Vaz et al. 2016), performing early weaning (Vaz & Lobato 2010a), and using hormonal protocols (Abel et al. 2017, Larson & White 2016).

Production in kilograms of calf for each kilogram of cow kept in the herd is an important trait to be evaluated. The higher production of young cows is partially explained by their smaller size. In addition to their lower weight at weaning, caused by depletion of their body

reserves, these cows produce more kilograms of calf. This fact is due in part to their early grazing, as influenced by the decline in the cows' milk production (Forster et al. 2010).

The higher calf production index of early-calving adult cows compared with the other categories is a consequence of their lower nutritional requirement in relation to young cows (Restle et al. 2003, Beffa et al. 2009) and the longer time of recovery from calving to the end of the reproductive season, which result in higher pregnancy rates associated with a longer calf suckling period (Larson & White 2016). For a higher production efficiency per cow kept in the herd, several adjustments must be made in production systems. Along with cow age, the early calving in the season is a fundamental factor for higher production (Viu et al. 2008, Larson & White 2016), and distinct management strategies are necessary according to the cow's requirements and calving time (Rangel et al. 2009). This was evident in the current study, where young cows, even with a longer nursing time, did not have a higher calf production index than late-calving cows.

Early-calving adult cows have superior reproductive performance, despite needing more land space for their maintenance and for the maintenance of their calves. This is due to the higher weights of the cow-calf pair, which may be detrimental to the production efficiency of the systems, in which case they should be analyzed considering the production obtained per used area. Heavier cows calving early in the season typically produce calves that are heavier at weaning, nevertheless their production per area may be lower (Farias et al. 2018), due to the lower numbers of animals allocated in the area when working with fixed stocking.

The lower production in kilograms of calf associated with the low pregnancy rate of late-calving young cows is worrisome. This because

this category includes cows in their first pregnancy, which should repeat their expected genetic, given their genetic superiority in relation to their mothers. It would thus be desirable that primiparous cows conceived again, considering the maintenance of desirable traits in the herds and the aim for genetic advancement (Alencar et al. 1999).

Higher production in kilograms of weight is usually expected for the adult cow-calf pair (Renquist et al. 2006). However, in the present study, with the adoption of early weaning, the likely higher total milk yield and greater persistence of lactation in adult cows were nullified by the interruption of lactation at 63 days post-calving. Weaning generates stress that may interfere with calf production, but under environmental adversities such as low milk production, high-quality supplementary feed improves calf performance (Vaz & Lobato 2010a).

The higher milk yield of cows late-calving in the calving season is likely a consequence of the pasture availability during their lactation. This is different in the case of early-calving cows, which are subjected to a low amount of natural pasture. At that time, in addition to decreased forage availability, dead and senescent material is present in the pasture due to the maturation of plants as the winter ends, with practically zero growth (Moreira et al. 2004). Our findings disagree with those of Rodrigues et al. (2014), who evaluated the milk yield of cows of different genetic groups up to 210 days compared with late-calving cows and observed 1082 and 860 kg per lactation, respectively. The divergence of results can be explained due to Rodrigues et al. (2014) evaluated a lactation of 210 days, different from the present study in which the lactation period was less than 63 days, and the early-calving cows were evaluated in a period of better fodder supply, which due to the short evaluation period can suffer from the climatic oscillations forages.



Between the maturity stages, the higher milk yield of adult cows is a consequence of their lower nutritional requirements. The NRC (2000) suggests that cows aged three to four years should produce 19% less milk, on average, than adult cows. The literature is contradictory when it comes to milk production and cow age. In prolonged lactations of 180 to 210 days, milk yield has a quadratic behavior, with adult cows being superior to young and old cows (Rodrigues et al. 2014). On the other hand, milk yield is not influenced by cow age in non-ideal feeding conditions (Restle et al. 2003). Greater body condition of the cows at calving, which metabolize their reserves may determine higher milk production (Mercadante et al. 2003).

Lactose is important, as it is the carbohydrate available for calves in this life stage. The average 4.88% participation of lactose in the composition of milk is within the range recommended by the NRC (2000). This shows that the proportion of lactose is not the determining factor for the performance of calves, but the total amount consumed by them, given the higher milk production of the cows (Cerdótes et al. 2004).

The higher percentage of protein in the composition of the milk from adult cows is associated with their higher milk yield, which provided a higher weight gain to calves until the end of lactation, at 63 days. Additionally, protein is an essential component for the development of calves in the pre-weaning stage (Restle et al. 2004). This assertion was proved in our study, where, from weaning to 210 days of age, other factors such as birth time started to influence calf performance.

Total solids are an important measure for evaluating the milk quality of beef cows, since it comprises all components except water. The higher concentration of components in the milk from cows calving late in the season is a consequence of their better body condition,

since they had more time under favorable feeding conditions pre-calving. For that matter, early-calving cows are impaired by the recent end of winter.

Higher total solids values are positively correlated with the other milk components (Rodrigues et al. 2014). The higher concentration of this fraction in the milk from late-calving cows did not promote a greater development of the calves because of their short suckling period of only 63 days. In longer lactations, the milk composition is essential for the development of calves. The total solids, the total solids content increases as lactation progresses, in a mechanism to offset the decline in milk production (Rodrigues et al. 2014).

In conclusion, young cows are lighter at calving, at weaning, and at the end of the subsequent breeding season. This animal group has a lower body condition score, weans lighter calves at 42-63 days post-calving, and is inferior in reproductive performance when compared with cows at full maturity.

Early-calving young cows have a higher production efficiency at calving and at weaning, requiring a smaller pasture area to maintain the cow-calf pair. On the other hand, when the calf weight at weaning is adjusted for the pregnancy of their dams, early-calving dams have a higher calf production index.

Late-calving adult cows are as productive as early-calving young cows and produce milk with a higher total solids content. Adult cows produce more milk and milk with higher protein contents than young cows.

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