

## Calving month and calf sex on the production and efficiency of herds

### Mês do parto e sexo do bezerro na produção e eficiência dos rebanhos

Ricardo Zambarda Vaz<sup>1\*</sup> , José Fernando Piva Lobato<sup>2</sup> , João Restle<sup>3</sup> , Pablo Tavares Costa<sup>4</sup> , Lidiane Raquel Eloy<sup>2</sup> , Otoniel Geter Lauz Ferreira<sup>4</sup> , João Luiz Benavides Costa<sup>2</sup> 

<sup>1</sup>Universidade Federal de Santa Maria – Campus Palmeira das Missões, Palmeira das Missões, RS, Brazil.

<sup>2</sup>Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil.

<sup>3</sup>Universidade Federal de Goiás, Goiânia, GO, Brazil.

<sup>4</sup>Universidade Federal de Pelotas, Pelotas, RS, Brazil.

\*Correspondent - [rvaz@terra.com.br](mailto:rvaz@terra.com.br)

#### Abstract

The calving period influences productivity and reproductive efficiency the herds. The objective of this study was to evaluate two calving months (October and November) and their effect on the efficiency of a breeding herd for three consecutive years. A total of 298 Braford cows were evaluated at three, four, and five years of age, with their calves early-weaned at 148 days of age. The performance characteristics of the cow/calf pairs were evaluated with the calving month and calf sex as the independent variables. The animals were kept as a single group for the three years of observation. Cows calving in November were heavier and had a higher body condition score at calving. Cows calving in October were heavier and produced heavier calves at weaning. Male calves were heavier at birth and weaning than females (30.8 vs 28.6 kg and 118.9 vs 114.7 kg, respectively). The pregnancy rate was 82.35 and 69.23% for cows calving in October and November, respectively. Calving intervals were shorter in cows calving in November. Cows calving in October were more efficient compared with those calving in November, with a higher actual fertility rate. The production of kilograms of the calf/cow pair was higher for cows calving in October.

**Key Words:** actual fertility; bovine; milk production; productivity; reproductive performance

#### Resumo

O período do parto influencia a produtividade e a eficiência reprodutiva dos rebanhos. O objetivo deste estudo foi avaliar dois meses de parto (outubro e novembro) e seus efeitos sobre a eficiência de um rebanho de cria por três anos consecutivos. Foram realizadas 298 avaliações de vacas Braford aos três, quatro e cinco anos de idade, com seus bezerros desmamados aos 148 dias de idade. As características de desempenho dos pares vaca / bezerro foram avaliadas com o mês e o sexo do bezerro como variáveis independentes. Os animais foram mantidos em um único grupo nos três anos de observação. As vacas que pariram em novembro foram mais pesadas e tiveram maior escore de condição corporal no parto. As vacas que pariram em outubro foram mais pesadas e produziram

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bezerros mais pesados no desmame. Os bezerros machos foram mais pesados ao nascer e ao desmame do que as fêmeas (30,8 vs 28,6 kg e 118,9 vs 114,7 kg, respectivamente). A taxa de prenhez foi de 82,35 e 69,23% para as vacas que pariram em outubro e novembro, respectivamente. Os intervalos de partos foram mais curtos nas vacas paridas em novembro. As vacas que pariram em outubro foram mais eficientes quando comparadas com as que pariram em novembro, com maior taxa de fertilidade real. A produção de quilogramas do par bezerro / vaca foi maior em vacas que pariram em outubro.

**Palavras-chave:** bovino; desempenho reprodutivo; fertilidade real; produção de leite; produtividade

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## Introduction

To be competitive with the other agribusiness sectors, livestock systems need greater efficiency, irrespective of the management strategy employed. The beef-cattle production stages are distinguished by the activities involved, management practices adopted, production time, and, mainly, economic return to the farmer<sup>(1)</sup>.

Calving is the period of livestock farming during which all the above-stated factors have a greater relevance when compared with other production stages such as post-weaning and finishing<sup>(2)</sup>. To increase the productive and reproductive efficiency of breeding herds, producers should first improve their nutrition<sup>(3)</sup> by adopting adequate stocking rates on natural pastures<sup>(4)</sup>. If necessary and deemed compatible, they should use cultivated pastures<sup>(5)</sup> and control and reduce the feeding period<sup>(6)</sup>, thereby improving the body condition of cows<sup>(7)</sup>. Additionally, the producer should also observe factors such as health, mineralization, and hormonal treatments, and prefer higher-yielding breeds or crossbreeds.

In addition to these aspects, the calving period<sup>(3)</sup> is a key factor to increasing herd productivity<sup>(1)</sup>, and just as important is the distribution of births across its months<sup>(8)</sup>. Maximal biological efficiency of beef cows consists of the production of one high-quality calf per year. With an average gestation length of 285 days, cows have approximately 80 days to return to their reproduction activity, which is a time that coincides with the lactation peak, implying higher nutritional requirements for the cow in the production cycle.

The annual cost of maintaining a cow is elevated<sup>(2)</sup>, regardless of whether or not a calf is weaned. In the sale of calves, or post-weaning stage of replacement heifers or steers for later finishing, weight and genetic composition are important factors<sup>(9)</sup>. For biological responses, however, the reproductive rates<sup>(10)</sup> and slaughter weight are characteristics to be taken into consideration. The importance of these variables increases proportionally to the intensity of the production system<sup>(11)</sup>.

This study proposes to investigate the effects of two months within the same calving season of a commercial herd, for three consecutive years, on the productive and reproductive efficiency of beef cows.

## Material and Methods

The experiment was carried out on Itú Farm (*Granja Itú*), located in Itaqui - RS, Brazil (29°12' S latitude and 55°36' W longitude). The climate in the area is subtropical, according to the Köppen classification. All procedures were approved by the Institutional Committee on Animal Use (CEEA nº. 8250-2015).

This study involved 141 primiparous Braford cows, at three years of age, whose criterion for permanence in the herd in the subsequent years was positive testing for pregnancy. Eighty-nine and 68 cows were evaluated in the second and third calving years, respectively. In the three years, the cows were divided according to the occurrence of their calvings into the months of October and November, which were the respective initial and final calving periods.

Regardless of the calving period, calves were managed as a single group at all times. From the first to second calving, as well as after the second weaning period, they were kept on a natural pasture at a stocking rate of 320 kg of live weight/ha. During the second and third lactations, cows and their calves were kept on *Brachiaria brizantha* cv. Marandu and *Brachiaria Humidicola* (Rendle) Schweick pastures, respectively.

The reproductive period was 62 days, starting on December 15 and ending on February 15 of each year. Cows were mated to bulls in natural service that tested positive in libido assessments and andrological examination, at a bull/cow ratio of 1:25. Ultrasound pregnancy testing was performed 30 to 45 days after the end of the reproductive periods.

Cows were weighed before 24 h post-calving, at weaning (148 days); at the beginning and end of reproductive periods; as well as between these dates, every 28 days, to adjust the stocking rates of the pastures. Weight changes were determined as the difference observed between weighing sessions divided by the number of days between them. Body condition score (BCS) was determined on the weighing events<sup>(12)</sup>, by assigning scores of 1 to 5, where 1 = too lean and 5 = too fat.

Calves were weaned on single dates, between March 03 and 06, at an average age of 148 days. Milk yield estimates were obtained at 35, 65 and 100 days and at weaning, by the indirect method through the difference in calf weight before and after suckling. Total milk yield was determined as the daily yield multiplied by the number of days in the period.

In the evaluation of herd productivity and efficiency of cows in reproduction, the weights and total body weight gains of cows and calves (kg) from calving to weaning were considered and analyzed individually or as a cow-calf pair. Calf production efficiency was determined based on the calf production index adjusted according to the pregnancy rate (PR), in kilograms of weaned calf per cow kept (Calf weight at conventional weaning × PR/100). For the other efficiency and productivity variables, calf production efficiency was adopted as the base value for the calculations, as it involves the weight of the calves associated with the reproductive performance of the cows.

For the productive efficiency of the cow at weaning, the ratios between calf production efficiency and body weight were calculated using the following formula: (Calf production efficiency/Cow body weight or Cow metabolic weight at weaning) × 100.

Milk production efficiency was determined as the amount of milk necessary to produce one kilogram of calf (Total milk yield/Total calf weight gain) and as the milk production used (%) by the calf ((Total calf weight gain/Total milk yield) × 100).

Actual fertility, which includes fertility and production of kilograms of calf weaned per effective year simultaneously, was also calculated, using the following equation: (Calf weight at weaning × 365)/Calving interval. In the present study, the equation was adapted by adjusting calf weight to the pregnancy of the cows [(Calf weight at weaning × Pregnancy /100) × 365]/Calving interval].

The variables year and cow age are confounded in the model, because the same animals were evaluated in different years and consequently, as they grew old. First, an analysis was run to check the behavior of the response variables within the years, and a similar behavior was found between the months of birth, within the years assessed. For this reason, and also because the production systems included cows of different ages within their herds, the variables were analyzed as a set, using the average of three years.

The experimental design was completely randomized, with a 2 × 2 factorial arrangement (two calving months × two calf sexes). Results were subjected to analysis of variance and F test. The mathematical model used for the analyses is described as follows:

$$Y_{ijk} = \mu + M_i + S_j + (M * S)_{ij} + Y_k + \Sigma_{ijk}$$

Where,  $Y_{ij}$  = dependent variables;  $\mu$  = average of all observations;  $M_i$  = effect of calving month  $i$ , in which  $i = 1$  (October) or  $2$  (November);  $S_j$  = effect of calf sex  $j$ , in which  $j = 1$  (male) or  $2$  (female);  $(M*S)_{ij}$  = effect of the calving month  $i$  × calf sex  $k$  interaction;  $Y_k$  = effect of year  $k$  and cow age set as a co-variable; and  $\Sigma_{ijk}$  = residual error.

Because the  $(M*S)_{ij}$  interaction was of low magnitude, it was removed from the final statistical model. Analyses were performed using the GLM procedure. Data were analyzed using SAS statistical software, adopting 5% as the maximum significance level. Means were compared by the t test. The variable 'percentage of pregnancy' in the two birth months was analyzed by the chi-squared test at the 5% significance level.

## Results

There was no interaction ( $P > 0.05$ ) between the calving months and calf sex. Thus, the data pertaining to these variables are presented and discussed separately.

Cows calving in October were lighter and had lower body condition scores at calving, compared with those calving in November (Table 1). At weaning, cows calving in October were heavier and had a higher daily weight change ( $P < 0.05$ ) as compared with those calving in November.

**Table 1.** Means ( $\pm$ SE) for development traits of cows and their calves calving in October and November in a production system over three consecutive years.

Trait	October	November
<b>Weights cows (kg)</b>		
At calving	362.1 $\pm$ 2.2 <sup>b</sup>	370.7 $\pm$ 2.4 <sup>a</sup>
At weaning	402.4 $\pm$ 2.7 <sup>a</sup>	394.7 $\pm$ 2.9 <sup>b</sup>
At the end of service	403.8 $\pm$ 2.4 <sup>a</sup>	398.3 $\pm$ 2.6 <sup>a</sup>
<b>Weights calves (kg)</b>		
At birth	30.0 $\pm$ 0.16 <sup>a</sup>	29.5 $\pm$ 0.18 <sup>a</sup>
At weaning	123.8 $\pm$ 1.5 <sup>a</sup>	109.8 $\pm$ 1.6 <sup>b</sup>
<b>Daily weight change of cows (kg)</b>		
From calving to weaning	0.275 $\pm$ 0.015 <sup>a</sup>	0.168 $\pm$ 0.016 <sup>b</sup>
<b>Body condition of cows (points)</b>		
At calving	2.94 $\pm$ 0.02 <sup>b</sup>	3.08 $\pm$ 0.02 <sup>a</sup>
At weaning	3.65 $\pm$ 0.03 <sup>a</sup>	3.56 $\pm$ 0.04 <sup>a</sup>
At end of service	3.58 $\pm$ 0.03 <sup>a</sup>	3.53 $\pm$ 0.03 <sup>a</sup>
<b>Estimated total milk production (L)</b>	635.0 $\pm$ 28.4 <sup>a</sup>	650.3 $\pm$ 33.0 <sup>a</sup>

<sup>a,b</sup> in the same row differ ( $P < 0.05$ ) by the F test.

The month of birth did not influence the birth weight of the calves. Between the months, higher calf weaning weights were observed in October, with a 12.75% difference.

Calf sex (Table 2) did not influence the weights, weight changes, or body condition scores of the cows from calving to weaning ( $P > 0.05$ ). Birth weight and development until weaning were higher

**Table 2.** Means ( $\pm$ SE) for development traits of cows nursing male or female calves evaluated in a production system over three consecutive years.

Trait	Males	Females
<b>Weights cows (kg)</b>		
At calving	367.7 $\pm$ 2.4 <sup>a</sup>	365.1 $\pm$ 2.2 <sup>a</sup>
At weaning	397.8 $\pm$ 2.9 <sup>a</sup>	399.2 $\pm$ 2.7 <sup>a</sup>
At the end of service	401.1 $\pm$ 2.6 <sup>a</sup>	401.0 $\pm$ 2.4 <sup>a</sup>
<b>Weights calves (kg)</b>		
At birth	30.8 $\pm$ 0.18 <sup>a</sup>	28.6 $\pm$ 0.16 <sup>b</sup>
At weaning	118.9 $\pm$ 1.6 <sup>a</sup>	114.7 $\pm$ 1.5 <sup>b</sup>
<b>Body weight change of cows (kg)</b>		
From calving to weaning	0.203 $\pm$ 0.016 <sup>a</sup>	0.230 $\pm$ 0.015 <sup>a</sup>
<b>Body condition of cows (points)</b>		
At calving	3.01 $\pm$ 0.02 <sup>a</sup>	3.02 $\pm$ 0.02 <sup>a</sup>
At weaning	3.61 $\pm$ 0.04 <sup>a</sup>	3.60 $\pm$ 0.03 <sup>a</sup>
At the end of service	3.56 $\pm$ 0.03 <sup>a</sup>	3.55 $\pm$ 0.03 <sup>a</sup>
<b>Estimated total milk production (L)</b>	661.8 $\pm$ 31.2 <sup>a</sup>	623.5 $\pm$ 29.1 <sup>a</sup>

<sup>a,b</sup> in the same row differ ( $P < 0.05$ ) by the F test.

Despite the additional 38 kg of milk produced by cows nursing male calves, the milk yield of cows nursing male and female calves was similar ( $P > 0.05$ ). The pregnancy rate of cows calving in October (82.35%) was higher than that of cows calving in November (69.23%) ( $P < 0.05$ , Table 3).

**Table 3.** Means ( $\pm$ SE) for productive and reproductive efficiencies of cows calving in different periods within the calving months evaluated in a production system over three consecutive years.

Trait	October	November
<b>Reproduction</b>		
Pregnancy rate (%)	82.35 <sup>A</sup>	69.23 <sup>B</sup>
Calving-conception interval (days)	106.0 $\pm$ 1.7 <sup>b</sup>	85.5 $\pm$ 1.9 <sup>a</sup>
Calving interval (days)	391.3 $\pm$ 2.6 <sup>b</sup>	368.0 $\pm$ 2.9 <sup>a</sup>
<b>Weight (kg)</b>		
Cow-calf pair, at calving	392.0 $\pm$ 2.2 <sup>b</sup>	400.2 $\pm$ 2.4 <sup>a</sup>
Cow-calf pair, at weaning	526.5 $\pm$ 3.0 <sup>a</sup>	504.4 $\pm$ 3.3 <sup>b</sup>
<b>Efficiency (kg)</b>		
Calf production efficiency <sup>1</sup>	102.0 $\pm$ 1.2 <sup>a</sup>	75.9 $\pm$ 1.3 <sup>b</sup>
Calf production efficiency/kg cow <sup>2</sup>	26.2 $\pm$ 0.36 <sup>a</sup>	19.5 $\pm$ 0.40 <sup>b</sup>
Calf production efficiency at service <sup>3</sup>	0.314 $\pm$ 0.01 <sup>a</sup>	0.280 $\pm$ 0.01 <sup>b</sup>
Actual fertility <sup>4</sup>	115.0 $\pm$ 2.4 <sup>a</sup>	109.0 $\pm$ 2.6 <sup>b</sup>
Actual cow-calf pair fertility <sup>5</sup>	132.1 $\pm$ 3.4 <sup>a</sup>	117.5 $\pm$ 3.6 <sup>b</sup>
<b>Total weight change (kg)</b>		
Calf, during suckling	93.8 $\pm$ 1.5 <sup>a</sup>	80.3 $\pm$ 1.6 <sup>b</sup>
Cow, during lactation	40.6 $\pm$ 2.2 <sup>a</sup>	24.9 $\pm$ 2.4 <sup>b</sup>
Cow-calf pair, during suckling	134.5 $\pm$ 2.6 <sup>a</sup>	104.2 $\pm$ 2.9 <sup>b</sup>
<b>Milk production efficiency</b>		
Efficiency in L/kg of calf	5.74 $\pm$ 0.28 <sup>a</sup>	6.37 $\pm$ 0.33 <sup>a</sup>
Efficiency of transformation (%)	20.7 $\pm$ 1.01 <sup>a</sup>	17.2 $\pm$ 1.18 <sup>b</sup>

<sup>A, B</sup> Differ by the chi-squared test ( $p < 0.05$ ); <sup>a, b</sup> in the same row differ ( $p < 0.05$ ) by the F test.

1 - (Calf weight at weaning  $\times$  Pregnancy rate)/100; 2 - [(Calf weight at weaning  $\times$  Pregnancy rate)/100]/Cow weight at weaning; 3 - Calf weight at weaning/Cow weight at the service of the previous year; 4 - (Calf weight  $\times$  365)/Calving interval; 5 - (Cow weight gain + Calf weight gain)  $\times$  365/Calving interval.

Despite having lower pregnancy rates, cows calving in November were earlier in the manifestation of the first heat post-calving and had shorter calving intervals.

The weights of the cow-calf pair differed at calving and at weaning ( $P < 0.05$ ). Higher values at calving were obtained for dams calving in November, and at weaning for those calving in October.

In the sum of the weight gains of cows and calves, the group of calvings concentrated in the month of October was superior by 29.07% in the production of kilograms of weight ( $134.5 \pm 2.6$  kg) compared with November ( $104.2 \pm 2.9$  kg).

Higher efficiency rates were observed in cows calving in October, irrespective of the evaluation method, considering calf weight at weaning, pregnancy rate, and calving interval. On average, considering the different evaluation parameters, cows calving in October were superior by 19.76% for this variable in relation to those calving in November.

Regardless of the type of evaluation, earlier-calving cows produced more kilograms of calves in the subsequent year per cow kept in the herd or per kilogram of cow at weaning. The  $102.0 \pm 1.2$  and  $75.9 \pm 1.3$  kg of calf obtained by cows calving in October and November, respectively, indicates the higher efficiency of early-calving cows in producing kilograms of calves in the months calving/weaning per cow exposed in the herd.

Despite the longer calving interval of cows giving birth in October ( $391.3 \pm 2.6$  days) compared with those calving in November ( $368.0 \pm 2.9$  days), the higher calf weight ( $123.8 \pm 1.5$  vs.  $109.8 \pm 1.6$  kg, respectively) was critical for the higher actual fertility value obtained by cows calving in October.

The efficiency of transformation of milk into kilograms of calf was superior ( $P < 0.05$ ) for cows calving in October, although the amount of milk necessary to produce one kilogram of calf was similar in both periods ( $P > 0.05$ ).

Calf sex did not influence the reproduction-related traits or the production efficiency of the herds ( $P > 0.05$ ); similar values were obtained for the efficiency of conversion of milk into calf body weight gain (Table 4). The higher weights of male calves (Table 2) were not sufficient to suggest higher efficiency, because when these weights were associated with the pregnancy weight of the cows, those nursing heifers had similar performance ( $P > 0.05$ ).

**Table 4.** Means ( $\pm$ SE) for reproductive and productive efficiencies of cows nursing male and female calves evaluated in a production system over three consecutive years.

Trait	Males	Females
<b>Reproduction</b>		
Pregnancy rate (%)	68.22 <sup>a</sup>	72.30 <sup>a</sup>
Calving-conception interval (days)	96.3 $\pm$ 2.0 <sup>a</sup>	95.3 $\pm$ 1.6 <sup>a</sup>
Calving interval (days)	381.5 $\pm$ 3.0 <sup>a</sup>	377.8 $\pm$ 2.5 <sup>a</sup>
<b>Weight (kg)</b>		
Cow-calf pair, at calving	398.5 $\pm$ 2.4 <sup>a</sup>	393.7 $\pm$ 2.2 <sup>a</sup>
Cow-calf pair, at weaning	516.9 $\pm$ 3.3 <sup>a</sup>	513.9 $\pm$ 3.0 <sup>a</sup>
<b>Efficiency (kg)</b>		
Calf production <sup>1</sup>	81.11 $\pm$ 1.1 <sup>a</sup>	82.93 $\pm$ 1.2 <sup>a</sup>
Calf production/kg cow	20.4 $\pm$ 0.32 <sup>a</sup>	20.8 $\pm$ 0.34 <sup>a</sup>
Calf production efficiency at service <sup>3</sup>	0.296 $\pm$ 0.01 <sup>a</sup>	0.286 $\pm$ 0.01 <sup>a</sup>
Actual efficiency <sup>4</sup>	113.1 $\pm$ 2.7 <sup>a</sup>	110.9 $\pm$ 2.2 <sup>a</sup>
Actual cow-calf pair efficiency <sup>5</sup>	123.8 $\pm$ 3.9 <sup>a</sup>	125.8 $\pm$ 3.2 <sup>a</sup>
<b>Total weight change (kg)</b>		
Calves, during suckling	88.1 $\pm$ 1.6 <sup>a</sup>	86.0 $\pm$ 1.5 <sup>a</sup>
Cows, during lactation	30.8 $\pm$ 2.4 <sup>a</sup>	34.6 $\pm$ 2.4 <sup>a</sup>
Cow-calf pair, during suckling	118.9 $\pm$ 2.9 <sup>a</sup>	120.6 $\pm$ 2.6 <sup>a</sup>
<b>Milk production efficiency</b>		
Efficiency in L/kg of calf	6.08 $\pm$ 0.31 <sup>a</sup>	6.03 $\pm$ 0.29 <sup>a</sup>
Milk-calf transformation efficiency (%)	18.2 $\pm$ 1.11 <sup>a</sup>	19.7 $\pm$ 1.04 <sup>a</sup>

<sup>a,b</sup> in the same row differ ( $p < 0.05$ ) by the F test.

1 - (Calf weight at weaning  $\times$  Pregnancy rate)/100; 2 - [(Calf weight at weaning  $\times$  Pregnancy rate)/100]/Cow weight at weaning; 3 - Calf weight at weaning/Cow weight at the service of the previous year; 4 - (Calf weight  $\times$  365)/Calving interval; 5 - (Cow weight gain + Calf weight gain)  $\times$  365/Calving interval.

## Discussion

The higher body weight and body condition score of cows calving in November are due to the later calving and consequent longer pre-calving period in the last third of gestation, which was during the spring, a period marked by a considerable improvement of pasture quality<sup>(13)</sup>. Cows calving in October, on the other hand, calved soon after the end of the winter, when pastures did not have sufficient quality and regrowth to provide cows with higher body weights. The changes observed in cow weight at calving between

the calving months are a result of fluctuations in the availability and quality of natural pastures<sup>(14)</sup> caused by the seasonal climatic conditions and the overall management of the herd throughout the years.

There is a positive correlation between the higher body weight gain coinciding with the month calving and the subsequent reproductive performance of cows<sup>(3)</sup>. However, this higher weight did not result in a higher body condition ( $P>0.05$ ), which might be due to the subjectivity of the evaluation.

The calving period influences the birth weight of the calves according to the nutritional quality imposed to the breeding herd<sup>(15)</sup>. However, these differences are manifested when calving periods are evaluated rather than months, and with reduced periods like that of the present study<sup>(16)</sup>.

In that study, higher calf weaning weights were observed in October. This is a result of the association between forage quality and the lactation period of the cows, coupled with the higher number of days of older age of the calves. Pereira and Muniz<sup>(17)</sup> evaluated the calvings of a Nellore herd occurring in eight months of the year and recommended the use of a better-defined breeding season associated with meeting the nutritional requirements of cows and calves, since these factors determine greater gains and weight at 205 days.

This better development of males in relation to female calves is because of testosterone production, which determines greater muscle deposition and consequently higher body weight and sexual dimorphism<sup>(16)</sup>.

Despite the additional 38 kg of milk produced by cows nursing male calves, the milk yield of cows nursing male and female calves was similar ( $P>0.05$ ). The literature is contradictory with respect to milk yield and calf sex, with cases of cows nursing male calves producing more milk than those nursing female calves<sup>(18)</sup>, or even a lack of effect on milk production, which was related to other factors<sup>(19)</sup>.

The 18.95% higher pregnancy rate of cows calving in October is likely a consequence of the shorter post-calving time of the cows calving in November, since the present study was conducted in a production system with fixed dates for the start and end of the reproductive period. In this way, cows with conceiving later and consequently calving enter into the subsequent reproductive period still in puerperium and consequently anestrus<sup>(20)</sup>.

A larger number of days from calving to mating is crucial to increasing pregnancy rates<sup>(3)</sup> and reducing the number of mounts, given the shorter period of recovery for the ovarian activity and reproductive system of cows<sup>(21)</sup>. Early calvings, though with a possible lower weight and body condition score of the cows, occurred when the natural pastures were improved, providing better nutritional values. Additionally, the cows were mated after the lactation peak, and so their energy requirement was reduced<sup>(13)</sup>.

The calving interval is an important characteristic in the evaluation of beef cattle production efficiency<sup>(22)</sup>, in addition to being a critical parameter in the production of one calf per year<sup>(6-9)</sup>. Though with lower pregnancy rates, cows calving in November

were earlier in the manifestation of the first heat post-calving and had shorter calving intervals. This fact may be crucial for higher milk production, leading to greater wear on the cows<sup>(23)</sup>, albeit not significant ( $P>0.05$ ) in this study. The better body condition of the cows at calving (Table 1) has a positive effect on reproduction when compared with the weight gain post-calving<sup>(24)</sup>. These traits are not greatly influenced by additive genetics; for this reason, changes in management such as adjustments in the calving month are more efficient in reducing the calving interval<sup>(25)</sup>. A longer interval between calvings does not preclude the subsequent pregnancy, which is actually benefited by the longer period of recovery of the cows. The latter, in turn, are then heavier and have better body condition scores and reproductive responses<sup>(26)</sup>.

Earlier-calving cows are lighter as compared with those calving later, which are benefited by the quality of feed in the early spring. Cows calving in October faced a longer period between calving and weaning, having already undergone the milk production peak and thus having their nutritional requirements decreased<sup>(19)</sup>. During the lactation stage, these cows gained 40.6 kg versus the 24.9 kg gained by cows calving in November. Furthermore, the calves born in October gained more weight (93.8 vs. 80.3 kg) as they aged and thus became less dependent on milk, transforming the pasture consumed into weight gain more efficiently. Calves born earlier start rumination in the month of higher pasture quality, especially in terms of protein, whereas those born later become ruminants at the time of greater pasture production, but with the downside of lower pasture quality<sup>(13)</sup>.

Productivity and efficiency are indicators that associate the calf weight at weaning, the pregnancy rate, and the cow weight at weaning<sup>(6)</sup>, or even the cow weight at the previous service. The 34.38% more kilograms of calf produced by cows calving in October denote that herds with late calvings require more animals to attain a production value similar to that of early-calving cows. This fact may allow for a reduction of the area to be managed with younger categories, which are more efficient and productive<sup>(14)</sup>, besides the lower sale of kilograms per hectare, decreasing the herd's off-take rate<sup>(27)</sup>.

The actual fertility index represents the relationship between the calving interval and the calf weaning weight; it is a more precise indicator of productivity because it does not involve one specific character separately in its calculation. The present results reveal that this indicator can be used as a selection criterion aiming at the selection of breeding herds with more fertile cows, capable of conceiving earlier<sup>(28)</sup>.

The transformation (milk into kilograms of calf) values of 20.7 and 17.2% for cows calving in October and November indicate how inefficient the conversion of pasture into milk and milk into kilograms of calf is, which culminates in a low profitability of the breeding herd<sup>(29)</sup>. Increased production efficiency is paramount to the profitability of the beef cattle industry; as such, production activities should be understood and managed through a systemic approach, aiming at profit maximization. Beef cattle production systems are complex and diversified, and there are no single formulae or recommendations that can be largely applied all over Brazil, but some categories are more efficient in the transformation of feed and are thus prioritized in production systems<sup>(30)</sup>.

The similarity between the sexes of calves regarding reproduction characteristics, the productive efficiency of herds and the efficiency of milk transformation in body weight gain of calves is due to these traits are more dependent upon nutrition, year<sup>(8)</sup>, and calving order of the cows<sup>(21)</sup> than on the sex of the calves<sup>(17)</sup>.

## Conclusions

Cows kept on natural pastures during gestation, calving in October, are lighter at calving but heavier at weaning due to the interaction between nutritional requirement and pasture availability at the end of gestation and during lactation. Coupled with the older age of the calves, these facts are decisive to obtaining higher calf weaning weights.

Male calves are heavier than females at birth and at weaning.

Cows conceiving later and consequently calving in November have a lower subsequent reproductive rate, but with shorter intervals between calving and conception and between calvings.

Cows calving in October are more efficient in calf production; further, their actual fertility is higher and they produce more kilograms of body weight from the cow/calf pair.

## Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

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