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Calving probability in the first and second reproductive years of beef heifers that reached the recommended body weight at first breeding season

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ABSTRACT - The objective was to evaluate factors that influence calving probability in the first and second reproductive years of beef heifers that reached the minimum recommended body weight (BW) in the first breeding season. Two hundred twenty-seven 24-month-old Charolais × Nellore heifers that mated between 2003 and 2012 were analyzed. The parameters evaluated were: year effect; individual and maternal heterozygosis; percentage of Charolais genotype; average daily gain (ADG) from weaning to the end of the first breeding season; BW at 18 and 24 months of age, end of breeding season, parturition, and weaning; Julian date of calving; and adjusted calf weight at weaning. These variables were subjected to logistic regression. Calving rates in the first and second reproductive years were 58.1 and 49.5%, respectively. Performance until the end of the first breeding season, BW before the first breeding season, and individual heterozygosis affected the calving probability in the first breeding season. In the second breeding season, BW variation from the first breeding season and calving, Julian date of calving, and BW at the end of the second breeding season influenced calving probability. Until the end of the first breeding season, ADG of beef heifers responded positively to the calving probability, even after reaching the usually recommended BW for the first breeding season. Primiparous cows calving at the beginning of the breeding season and gaining more BW between the first and second breeding season are more likely to give birth in the second breeding season.

Keywords: Charolais, cow, heifer, lactation, livestock, pregnancy

Introduction

One of the main challenges of beef cattle breeding is to understand how some parameters affect calving rates of bovine matrices in the first two reproductive years. In the first year, body weight (BW) at the beginning of the breeding season is one of the most studied parameters to guide management protocols and represents a good indicator of reproductive success chances in beef heifers (Pacheco et al., 2019). When such a condition is met, mean daily gains and body condition score become determinant factors (Cardoso et al., 2014). In the second year, the combined effect of growth and first lactation increase nutritional requirements and reduce chances of pregnancy. Bovine reproduction is still affected by other parameters such as year, especially in extensive production systems. Genetic parameters such as animal adaptability to environmental traits, and its interaction with heterosis and breed complementarity effects, are also widely reported as critical to heifer performance during the first and second breeding seasons (Koger et al., 1975).

Such cascading effects on reproduction are often approached in a piecemeal way in isolated experiments, disregarding interaction complexity. Therefore, productive resources may not be used in cases of real urgency of farms. In this sense, nonlinear statistical procedures can be interesting tools to identify productive parameters that most contribute to breeding. However, there are few studies modeling influencing factors such as effect of year, BW, ADG, Julian date of delivery, and others on genetic parameters and calving rate. Such information may be relevant for reproductive success estimates of bovine females in the first two breeding years, as well as for technological recommendations for different breeding systems.

We aimed to identify and evaluate, by logistic regression, the relationship among performance, BW, genetic parameters, Julian date of delivery, and progeny weight on breeding performance and calving probability in the first and second breeding seasons for beef heifers, with the recommended BW for the first breeding season.

Material and Methods

The study was developed in Santa Maria, RS, Brazil, located in the Central Depression physiographic region, altitude 153 m, latitude 30° S, which has a predominantly humid subtropical climate (Cfa), according to the Köppen classification (Alvares et al., 2013). Average annual temperature ranges from 14.3 to 25.2 °C, with a minimum of 9.7 °C in August and a maximum of 29.9 °C in January. Average annual relative air humidity is 73% and precipitation is 1650.9 mm.

This study considered performance data of 227 beef heifers from an experimental herd, mated between 2003 and 2012. These females came from a continuous rotational crossbreeding project between Charolais and Nellore cattle started in 1984. In this project, males are slaughtered, and females are mated for the first time at two years of age. The herd has an average of 280 beef females kept in natural pasture with a capacity of 350 kg BW/ha. Annual heifer replacement was approximately 50, and the mean pregnancy rate was approximately 65%.

Reproductive management consisted of keeping the animals in natural grazing areas from first mating to culling. Breeding season consisted in 45 days of artificial insemination (December 1 to January 15). Semen was obtained from commercial insemination centers, with a ratio of six bulls of each breed (Charolais or Nellore). Subsequently, an additional 45 days of natural field breeding season (one bull for 30 to 40 cows) (January 16 to March 1).

Calving season was between September 15 and December 15. Calves were identified with a tattoo on the ear, weighed, and dewormed. Cows were weighed and received a 5-point body condition score (BCS), in which 1 = very lean, 2 = lean, 3 = normal, 4 = fat, and 5 = very fat.

Nutritional management aimed at achieving BW of approximately 62% of adult BW at 24 months of age (NRC, 2000). After weaning (60 to 90 days of age), heifers were kept in warm-season cultivated pasture provided with free-choice access to high protein supplementation (above 16%), based on corn, soybean meal, wheat, or white oats, in the order of up to 1% of BW. Then, they were transferred to cold-season cultivated pasture receiving no supplementation. After 12 months of age, in the second summer, nutritional management varied according to costs of keeping animals in cultivated pasture and to BW and BCS. Most heifers grazed on summer-cultivated pasture or natural pasture with supplementation. From 18 months of age to the end of first breeding season, heifers were managed in deferred grazing pasture. Pregnant animals were kept with other cows in the natural pasture. Endo- and ectoparasite control and vaccinations were applied according to need and/or regional sanitary recommendations. Animals had free-choice access to mineral supplement containing sodium chloride and dicalcium phosphate.

During the entire study period, the grass species used after weaning during spring/summer were elephant grass (*Pennisetum purpureum*), millet (*Pennisetum americanum* (L.) Leeke), or Tifton 85 (*Cynodon* spp. Tifton 85), and in winter/spring, black oat (*Avena strigosa* Schreb.) and/or ryegrass (*Lolium multiflorum* Lam.). Natural pastures were highly infested with lovegrass (*Eragrostis plana* Ness).

Birth date and BW at birth, weaning, and 7, 18, and 24 months of age were recorded, as well as at the end of breeding season and at calving. Each BW was adjusted considering age and period between weighing days. Average daily gain (ADG) from 7 to 18 and 18 to 24 months of age, from 24 months of age to the end of the first breeding season, from calving to weaning, and from weaning to the end of the second breeding season were obtained by the ratio of the difference between BW values at each period and number of days between weighing dates. The BW difference between 24 months of age and first calving was also calculated. Calves were weighed at calving and weaning, which was adjusted according to age and number of days between birth and weaning wight. The mature BW was calculated using the mean BW at slaughter of 517 cows from the same herd and with the same genotype slaughtered between 2003 and 2013.

The study was divided according to female development as the first (model I) and second (model II) reproductive year. The inclusion criteria were: heifers that reached at least 50% of mature BW at 24 months of age (Funston et al., 2012); crossbred genotypes of the 2nd, 3rd, 4th, or 5th generation; and heifers mated for the first time between 23 and 26 months of age between 2003 and 2012. The second part of the study (model II) included heifers that calved in the first reproductive year and early weaned their calves (between 60 and 90 days of age).

To consider the genetic effects, heterozygous values were calculated for each genotype based on the model by Koger et al. (1975), who considers linearity between heterosis and heterozygosis. This information was used as covariates represented by individual and maternal heterozygosis (heterotic genetic effect). The percentage of Charolais blood in the studied genotypes (additive genetic effect) was also calculated (Table 1).

The next step was the statistical evaluation of model I (n = 227) and model II (n = 95) data. Model elaboration and statistical analysis were obtained by using the SAS (Statistical Analysis System, version 9.2) software. Calving rate response in the first and second reproductive years was represented by 1 for pregnant and 0 for non-pregnant heifers, and analyzed by logistic regression using the LOGISTIC procedure of SAS.

Diagnosis of multicollinearity between the predictor variables was performed by analyzing Pearson correlation matrix and the measures of variance inflation fator, condition index, eigenvalues (λ), and variance proportions associated with each λ (Freund and Littell, 1991). From this analysis, the set of covariates to be used in the models were selected by significance of each covariate obtained from the

Table 1 - Heifer distribution by genetic group, percentage of Charolais, and mature body weight (BW) in the first breeding season year

Genetic group	Charolais (%)	Mature BW	First mating year									
			2003	2004	2005	2006	2007	2008	2009	2011	2012	Total
3/4 Charolais 1/4 Nellore	75	480	5	5	5							15
3/4 Nellore 1/4 Charolais	25	455	3	1	3							7
5/8 Charolais 3/8 Nellore	62.5	500	9	5	5		2					21
5/8 Nellore 3/8 Charolais	37.5	490	14	5	4		4					27
11/16 Charolais 5/16 Nellore	68.8	510	9	8	11	3	8	12	9	1		61
11/16 Nellore 5/16 Charolais	31.2	500	2	3	3	5	5	7		1	1	27
21/32 Charolais 11/32 Nellore	65.2	505	2	3	2	3	1	2	5	6	3	27
21/32 Nellore 11/32 Charolais	34.8	495	1	2	3	7	10	7	1	4	7	42
Total			45	32	36	18	30	28	15	12	11	227
Average mature BW		500										

likelihood ratio test. Several multiple regression models with linear or linear and quadratic effects and their interactions were tested using the stepwise method. The limit probabilities to enter and to remain in the model were 0.25 and 0.30, respectively (Hosmer Jr. et al., 2013). The Hosmer-Lemeshow goodness-of-fit test (Hosmer Jr. et al., 2013) was used to choose the best model.

After adjusting the model (β_i's parameter estimation), the significance of the variables derived from the model was tested to determine if the independent variables were related to calving probability. Wald and Score tests were used to analyze the quality of the adjusted model and individual significance of the set of parameters in the model.

The multiple regression model I and II adjusted for calving rate in the first or second reproductive year is expressed by the following equation:

$$P_i = \frac{\exp(y_{ij})}{1 + \exp(y_{ij})} = [1 + \exp(-y_{ij})]^{-1} ,$$

in which P_i in model I is the calving probability for the i-th heifer in the first reproductive year;

$$y_{ij} = \mu + A_j + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \varepsilon_{ij},$$

in which μ is a constant; A_j is the effect of the j-th year; X_{1i} is the ADG from 7 to 24 months of age; X_{2i} is the ADG of the i-th heifer from 24 months of age and the end of the first breeding season; X_{3i} is the BW of the i-th heifer at 18 months of age; X_{4i} is the BW of the i-th heifer at 24 months of age; X_{5i} is the percentage of individual heterozygosis of the i-th heifer; X_{6i} is the percentage of Charolais genotype of the i-th heifer; X_{7i} is the interaction of the i-th heifer between individual heterozygosis, year, and BW at 24 months of age; and ε_{ij} is the random error associated with the i-th heifer.

For model II, P_i is the calving probability of the i-th cow in the second reproductive year;

$$y_{ij} = \mu + A_j + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \varepsilon_{ij},$$

in which μ is a constant; A_j is the effect of the j-th year; X_{1i} is the gain of BW of the i-th cow from 24 months of age until calving; X_{2i} is the BW of the i-th cow from calving; X_{3i} is the BCS of the i-th cow from calving; X_{4i} is the Julian date of calving of the i-th cow; X_{5i} is the BW of the i-th cow from the end of the second breeding season; X_{6i} is the adjusted BW of the calf at the i-th calf weaning; X_{7i} is the percentage of Charolais genotype of the i-th cow; X_{8i} is the interaction between individual heterozygosis and BW from calving of the i-th cow; and ε_{ij} is the random error associated with the i-th cow.

The odds ratio estimated by OR = exp (b_k) was used to interpret the coefficients which can lead to two possible results, that is, the ratio between calving success (πj) and failure (1 − πj). Odds ratios were based on the mean denominator of the data set for each model. Changing units of regression variables for model I were: 0.100 kg for ADG between 7 and 24 months of age, and 0.100 kg for ADG between 24 months of age and the end of the first breeding season, 10 kg for BW at 24 months of age, 1% for individual heterozygosis. In model II, they were: 10 kg for BW variation of the cow between 24 months of age and calving; 10 days for Julian date of calving; and 10 kg for BW to the end of the second breeding season.

Results

The ADG of heifers from 7 to 24 months of age was 0.367 kg/day, with 0.406 kg/day from 7 to 18 months and 0.276 kg/day from 18 to 24 months of age. The ADG between 24 months of age and the end of the first breeding season was 0.233 kg. Body weight values at 18 months of age (277.7 kg), 24 months of age (327.4 kg), and at the end of the first breeding season (355.2 kg) were approximately 55, 65, and 70% of mature BW, respectively. Individual and maternal heterozygosis were 65.8 and 68.3%, respectively, reflecting the high number of the 4th and 5th generation Charolais and Nellore crossbred animals, respectively. Charolais percentage was 52.3%. Calving rate for heifers in the first reproductive year was 58% (Table 2).

The factors breeding season year (P = 0.0018), ADG from 7 to 24 (P = 0.1696) and from 24 months of age and the end of the first breeding season (P = 0.2764), BW at 24 months of age (P = 0.0136), and individual heterozygosis (P = 0.0143) were significant for calving probability in the first reproductive year (Table 3). An ADG increase of 0.100 kg/day from 7 to 24 months of age, 0.367 kg/day of reference, would allow a 71.4% increase in calving probability. An ADG increase of 0.100 kg/day from 24 months of age and the end of the first breeding season, 0.233 kg/day of reference, would allow a 7.8% increase in calving probability in the first reproductive year. A BW increase of 10 kg at 24 months of age, 327.4 kg of reference, would allow a 24.6% increase in calving probability. An individual heterozygosis increase of 1%, 65.8% of reference, would allow a 7.5% increase in calving probability.

Females that calved in the first reproductive year had a BW of 342.4 kg at 24 months of age, 360.3 kg at first calving, and 377.8 kg at the end of the second breeding season. These values represent 68, 72, and 76% of the BW of fed cattle, respectively (Table 4). Cow BCS at calving was 2.34, and weight difference between 24 months of age and second calving was 17.9 kg. During lactation, the cows lost BW (−0.207 kg/day) and weaned calves weighing 83.4 kg at 75 days of age. After early weaning, cows gained 0.494 kg/day. The Julian date of calving (288.7) is October 17th. Calving rate in the second reproductive year was 49.0%. Individual (66.7%) and maternal (66.6%) cow heterozygosis and percentage of Charolais (50.8%) showed no effect on calving probability in the second reproductive year.

The interaction between year and BW calving (P = 0.0574), BW gain from 24 months to calving (P<0.0001); Julian date of calving (P = 0.0005) and BW and second breeding season (P = 0.0031) were significant for calving probability in the first reproductive year (Table 5). An increase in BW

Table 2 - Characteristics of the animals used in model I

Variable	Model I				
	N	Mean	SD	Minimum	Maximum
ADG (kg of BW/day)					
7 to 18 months of age	227	0.406	0.09	0.147	0.641
18 to 24 months of age	227	0.276	0.267	−0.288	1.213
7 to 24 months of age	227	0.367	0.096	0.184	0.694
24 months of age to EBS	227	0.233	0.301	−0.566	0.950
BW (kg)					
18 months of age	227	277.7	40.8	189.0	401.2
24 months of age	227	327.4	51.5	248.0	508.2
End of 1st breeding season	227	355.2	50.5	243.2	495.5
Genetic effects					
Individual heterozygosis (%)	227	65.8	7.0	50.0	75.0
Maternal heterozygosis (%)	227	68.3	14.0	50.0	100
Percentage of Charolais (%)	227	52.3	17.3	25.0	75.0
Calving rate (%)	227	58.1	4.9	-	-

ADG - average daily gain; BW - body weight; EBS - end of breeding season; N - number of observations; SD - standard deviation.

Table 3 - Estimates between regression variable odds ratio for calving rate of heifers in the first breeding season

	Estimate	Odds ratio	95% CI	P-value
Intercept	−14.9724	-	−23.33 to 6.6115	0.0004
Year	1.7926	-	0.6679 to 2.9176	0.0018
ADG				
7 to 24 months of age	5.3859	1.714	−2.2994 to 13.0711	0.1696
24 months to EBS	0.7551	1.078	−0.6046 to 2.1148	0.2764
BW, 24 months of age	0.0220	1.246	0.0045 to 0.0394	0.0136
Heterozygosis (%)	7.2651	1.075	1.4517 to 13.0785	0.0143

ADG - average daily gain; BW - body weight; CI - confidence interval; EBS - end of breeding season; P - probability.

Table 4 - Characteristics of the animals used in model II

Variable	Model II				
	N	Mean	SD	Minimum	Maximum
Body weight					
24 months (kg)	95	342.4	61.8	249.8	508.2
Calving (kg)	95	360.3	39.6	282.9	476.5
End of 2nd breeding season (kg)	95	377.8	43.7	293.0	492.4
BCS (points)	95	2.34	0.26	1.5	3.0
BW from 24 months to calving (kg)	95	17.9	47.8	−94.8	145.5
Average daily gain					
Calving to weaning (kg/day)	95	−0.207	0.399	−1.121	0.880
Weaning to end of mating (kg/day)	95	0.494	0.581	−0.511	1.533
Julian date of calving (days)	95	288.7	24.7	246	337
Calf weight at weaning (kg)	95	83.4	11.7	54.7	110.0
Genetic effects					
Individual heterozygosis (%)	95	66.7	5.0	50.0	75.0
Maternal heterozygosis (%)	95	66.6	10.1	50.0	100
Charolais (%)	95	50.8	16.8	31.3	75.0
Calving rate (%)	95	49.0	5.0	-	-

BCS - body condition score; BW - body weight; N - number of observations; SD - standard deviation.

Table 5 - Estimates between regression variable odds ratio for calving rate of cow in the second breeding season

	Estimate	Odds ratio	95% CI	P-value
Intercept	21.2923	-	5.6144 to 37.9703	0.0083
BW calving *years	−0.0225		0.0458 to 0.00071	0.0574
BW gain 24 months age to calving	0.0593	1.810	0.0315 to 0.0871	<0.0001
Julian date of calving	−0.0956	0.385	−0.1489 to −0.0422	0.0005
BW, 2nd breeding season	0.0274	1.315	0.00922 to 0.0456	0.0031

BW - body weight; CI - confidence interval; P - probability.

gain of 10 kg from 24 months of age to calving, 17.9 kg of reference, would allow an increased calving probability by 81.0%. A 10-day increase in Julian date of calving, 288.7 day of reference, reduced calving probability by 61.5%. An increase in BW at second breeding season of 10 kg, 377.8 kg of reference, increased calving probability by 31.5%.

Discussion

Heifers showed good development in the first year postweaning (7 to 18 months of age), with satisfactory BW gain and adequate BW at 18 months of age as a consequence of the feeding management in cultivated pasture. The intensity of BW gain before the first breeding season is a determinant for the occurrence of first estrus and is inversely related to age and puberty (Eborn et al., 2013). Roberts et al. (2009) reported older age at puberty and low pregnancy rates in heifers mated at 14 months of age and under food restriction in the first 140 days after weaning when compared with heifers under no feed restriction. According to these authors, an increase in BW gain of 0.100 kg/day during these 140 days would promote a 3.4% increase in pregnancy rate in the first reproductive year.

Crossbred heifers showed adequate BW to start reproductive activity at 24 months of age (NRC, 2000). However, ADG from 18 to 24 months of age was low and affected reproductive performance. However, by logistic regression, it was evident that higher BW than observed would respond positively to the calving probability in the first breeding season. This result is associated with low ADG from 18 to 24 months of age, which compromised the continuity of ADG observed in the previous phase (7 to 18 months).

Extensive cow-calf systems with limited feeding commonly result in compensatory BW gain, which may be interesting for reproduction, since the greatest BW gain occurs close to or during the breeding season period (Roberts et al., 2009; Funston and Larson, 2011; Endecott et al., 2013; Cardoso et al., 2014). However, this phenomenon was not observed in the present study, which may be related to the reduced nutritional value of pastures in autumn and winter, thereby decreasing heifer development in the previous stage (7 to 18 months of age).

Feeding management changes from cultivated pastures to natural pasture after 18 months of age was the main factor that affected performance until 24 months of age. The period from May to November is a critical stage in terms of feeding in south Brazil, when the summer cultivated and natural pastures reduce nutritional value and winter cultivated pastures are not ready. After this stage, low winter temperatures negatively impact natural pasture growth. High standard deviation values for ADG from 18 to 24 months of age (0.267 kg) reflect management variations during the ten-year research period, showing the importance of this stage for the development of heifers, which has relatively high nutritional requirements.

Body weight at the end of the first breeding season and calving rate in the first reproductive year were also affected by the decreased diet quality provided to heifers after 18 months of age. As already mentioned, BW at the end of breeding season was below the required values of approximately 75% of mature BW to obtain good reproductive results (Rovira, 1996), considering the correlation with the occurrence of estrus (r = 0.58) and pregnancy rate (r = 0.48; Vaz et al., 2012).

The low development from 24 months of age to the end of breeding season was associated with low nutritional quality of natural pasture and high lovegrass infestation, which reduces pasture quality because of its reduced crude protein and high neutral detergent fiber values (Souza et al., 2012). This species is currently considered a threat to pasture quality in different regions of Brazil (Cicconet et al., 2015). Normally, heifers present BW gains of 0.30 to 0.40 kg/day when grazing in natural pasture without lovegrass infestation during the pasture growth period (spring/summer) in regions where weather conditions are similar to those of the present study (Pio de Almeida and Lobato, 2004).

Reduced nutritional intake after a period of great BW gain near breeding season results in considerably decreased levels of leptin and insulin-like growth factor 1 (IGF-1), responsible for activating neuroendocrine pathways that lead the physiological system to the onset of puberty (Allen et al., 2012), with consequent reduction of pregnancy probability. Endecott et al. (2013) explained that seeking increased BW gain in premating periods may reduce age at puberty and first calving and increase herd longevity and productivity, showing the importance of improved dry matter intake for females near the breeding season period, independent of their previous performance. Different feeding conditions during growth stage and adult life may affect reproductive performance because of increased BW development and difficult adaptation to environments with feed deficits (Roberts et al., 2015).

Individual and maternal heterozygosis values are consequence of the great number of the 4th and 5th generation Charolais and Nellore crossbred animals. These parameters were not significant for the regression equation because of similar heterozygosis values between generations and low heritability of reproductive genetic factors. Heterozygosis is related to the genetic distance between breeds, gene frequencies in the population, and their interactions with the environment (Artmann et al., 2014), which shows high correlation with heterotic effects. Therefore, heterozygosis is used to estimate the degree of heterosis of a genotype (Koger et al., 1975).

Body weight gain during rearing and year effects affected calving probability of heifers in the first reproductive year. This result is due to pasture grazing, which is dependent on environmental factors that may vary over the years. Low performance in the first breeding season and pregnancy resulted in low BW and BCS at calving, which should be approximately 3.0 to avoid long postpartum interval and low pregnancy rates (Fontoura Junior et al., 2009). Considering the BW at 24 months of age and the minimum recommended BW at calving of 80 to 85% of mature BW (Larson, 2007), an increase of approximately 80 kg until calving would be necessary, that is, heifers should reach a BW above

425 kg of BW; however, the increase was only of 17.9 kg. It is important to meet BW goals of heifers at first breeding season and first calving, especially with the genotypes used in this study (Charolais and Nellore). It is important that the primiparous cows keep growing to reach adequate conditions at calving and to improve pregnancy rates in the second reproductive year (Colazo et al., 2009; Johnson and Funston, 2013).

Body weight gain between calving and weaning was negative because of the combined growth and lactation effect, which increase nutritional requirements, leading to low cow performance during nutritional deficit. According to Rovira (1996), heifers weighing 80% of adult BW should have an ADG above 0.400 to 0.500 kg/day in the first 60 days postpartum to have improved performance in the second reproductive year. An increased calving rate as a strategy to increase productivity in the second reproductive year is one of the main challenges for cow-calf systems in Brazil. Comparing to subtropical conditions, our results are similar to those reported by Pilau and Lobato (2009) who reported 53% for summer pastures, and 85% for cultivated pastures.

In the present study, early weaning did not affect cow reproductive performance in the second breeding season despite its potential to improve this trait. However, the no use of early weaning could result in even lower pregnancy rate, which is common in cow-calf systems that exclusively use natural grazing and seven-month-old weaning (Pio de Almeida et al., 2002). Early weaning is recognized for its beneficial effect on BCS recovery and occurrence of postpartum estrus, resulting in pregnancy rates above 89% when cows have adequate BCS (Lobato et al., 2000).

Calf BW is usually inversely related to pregnancy rate, but in this study, the result was the opposite. Although lactation is highly demanding for cows, with negative consequences on performance, the milk produced seemed to be enough to meet the nutritional demands of calves up to 75 days of age. According to Silveira et al. (2014), a calf BW variation of up to 58%, weaned at 75 days of age, is related with milk production, which in turn is associated with the cow's pre and postpartum feeding conditions. The average from weaning to end of breeding season was a consequence of the compensatory gain after weaning and the reduced nutritional requirement during lactation, a result that shows the importance of early weaning as a strategy to improve cow reproductive performance.

The Julian date of calving showed cows calved in the beginning of January. This can be considered late and shows a considerable margin reducing the calving period, which can be reduced by anticipating breeding season or even by improving heifer nutrition before breeding season, as discussed earlier. Other management practices such as fixed-time artificial insemination can also be used. Cows that calve earlier in the breeding season have more time to recover before the next calving season and show higher productivity and longevity (Cushman et al., 2013).

Conclusions

The current live-weight recommendations for first-breed beef heifers are only valid if under low mean daily gains in the rearing period; otherwise, reproductive performance is impaired. Mean daily gain during growing season is critical for increase in calving rates in the first breeding year. This includes maintaining linear gains after 18 months of age until the end of the breeding season. The effect of the year and individual heterozygosis cannot be disregarded when seeking for improved reproductive efficiency in beef heifers.

Animal performance throughout gestation and Julian date of birth influence calving probability in the second breeding year. If it is low, weight and body condition score at birth and weight at the end of the second mating season are impaired, and even management practices such as early weaning may not be enough to obtain suitable calving rates in the second year.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

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