Pesquisa Agropecuária Brasileira

Animal Science/ Original Article

ISSN 1678-3921

Journal homepage: www.embrapa.br/pab

For manuscript submission and journal contents, access: www.scielo.br/pab

Productive factors associated with pregnancy in beef cows at different ages

Abstract – The objective of this work was to evaluate productive variables that can affect the reproductive performance for odds-ratio, in order to increase or reduce the pregnancy rate in beef cows at different ages. A logistic regression model was used to analyze the response variable "rate of pregnancy". The productive variables were lactation period, milk production, interval between calving and end of reproductive season, weight, body score, and daily gain. The variables in the regression equation were tested for multicollinearity, and the parameters were evaluated by odds-ratio statistics. Adjusting the lactation period by seven days significantly influenced the pregnancy rate of three-year-old cows, since an extension of seven days increased the pregnancy rate by 27.3%, while a reduction of 7 days decreased it by 21.4%. During the reproductive period, changes in mean daily weight gain was the most consistent variable for pregnancy, with a significant effect on cows of three, four, and five years of age. Reproductive success is a result of different variables that depend on the age of the cow. For adult beef cattle, early calving and adequate weight gain are essential during the reproductive period. For younger categories, a short lactation period is essential.

Index terms: body condition scoring, body weight, lactation duration, perinatal period.

Fatores produtivos associados à prenhez de vacas de corte em diferentes idades

Resumo – Avaliaram-se variáveis produtivas que podem afetar o desempenho reprodutivo quanto à razão de chances, para mudar a taxa de prenhez de vacas de corte em diferentes idades. Um modelo de regressão logística foi usado para a análise da variável responsável pela taxa de prenhez. As variáveis produtivas foram período de lactação, produção de leite, intervalo entre parto e o fim da estação reprodutiva, massa, escore corporal e ganho diário. As variáveis da regressão foram testadas quanto à multicolinearidade, e os parâmetros foram avaliados pela estatística de razão de chances. O ajuste do período de lactação de sete dias influenciou significativamente a taxa de prenhez de vacas de três anos de idade; a extensão de sete dias aumentou a taxa de prenhez em 27,3%, enquanto a redução de sete dias a diminuiu em 21,4%. Durante o período reprodutivo, a mudança de ganho médio diário foi a variável mais consistente da prenhez, com efeito significativo em vacas de três, quatro e cinco anos de idade. O sucesso reprodutivo depende de diversos fatores que variam com a idade da vaca. Para bovinos de corte adultos, o parto precoce e o ganho de peso adequado são essenciais durante o período reprodutivo. Para bovinos mais jovens, é essencial um curto período de lactação.

Termos para indexação: escore de condição corporal, peso corporal, duração da lactação, período perinatal.

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Received
July 9, 2024

Accepted
August 3, 2025

How to cite
SANTOS, G.L.A. dos; LOBATO, J.F.P.; BETHANCOURT-GARCIA, J.A.; SÁ, H.A.O.M. de; PACHECO, R.F.; RESTLE, J.; VIEIRA, V.C.; VAZ, R.Z. Productive factors associated with pregnancy in beef cows at different ages. **Pesquisa Agropecuária Brasileira**, v.61, e03836, 2026. DOI: https://doi.org/10.1590/S1678-3921.pab2026.v61.03836.

Introduction

The global demand for beef has grown in recent years, reaching about 77.2 million megagrams in 2024 (FAO, 2024). In 2022, Brazil was responsible for more than 10 million megagrams of meat, which 80% was produced on pastures (FAO, 2024). Increase the productive and reproductive efficiency of beef cattle herds, avoiding the opening of new areas, is an important goal in order to meet the meat demand (ABIEC, 2024).

Several factors determine the reproductive success of a cow. It includes general aspects as genetics (Lacerda et al., 2018; Pardo et al., 2018; Pacheco et al., 2022), nutritional status (D'Occhio et al., 2019), body weight (Eloy et al., 2022), size of the cow (Vara et al., 2020; Vaz et al., 2022), and body condition (Bohnert et al., 2013; Carvalho et al., 2022). Furthermore, it includes related aspects of reproduction, such as calving time, precocity during the calving season (Bitencourt et al., 2020), and milk production (Vaz & Lobato, 2010). On the top is an interaction between these aspects and the age of the animal. A prime example is the different nutritional requirements of young and adult cows (Lobato et al., 2021).

In cattle, the reproductive efficiency is characterized by one calf per year (Lobato et al., 2021). Therefore, precocity results in a greater chance of remaining in the herd and leaving a large number of descendants (Diskin & Kenny, 2016).

The aim of this work was to evaluate productive variables that can affect the reproductive performance, in terms of odds-ratio, for increasing or reducing the rate of pregnancy in beef cows at different ages.

Materials and Methods

All animal handling and procedures were approved by the Ethics Committee for Animal Use (CEUA) of the Universidade Federal de Santa Maria, under nº 2388280122.

The experiment was carried out in the municipality of Itaqui (29°12'S, 55°36'W), in the state of Rio Grande do Sul, Brazil. The deep soils in the region are naturally acidic and classified as Latossolo Vermelho dystrophic (Santos et al., 2018), i.e., Ferralsol. According to the Köppen-Geiger's classification, the region's climate is subtropical Cfa, that is, humid subtropical, without dry season, with hot summer (Alvares et al., 2013). The precipitation in the region is about 1,300 to 1,600 mm per year. The experimental unit is one cow.

Development and reproductive performance were evaluated in postpartum Bradford cows of three different ages, as follows: 139 primiparous three-year-old cows; 89 multiparous four-year-old cows; and 68 multiparous five-year-old cows. The cows were managed as a single group, on pasture, with 320 kg body weight (BW) ha^{-1} animal load. The calving dates, weaning age of the calves, weights, and body condition scores of the cows were not controlled. The mean dry matter mass of forage available for grazing during the experimental period was 1,550 kg ha^{-1}. The variation of dry matter (DM) availability ranged from 1,430 to 1,830 kg ha^{-1}. The mean values on DM basis of crude protein and neutral detergent fiber were 7.4% and 70.2%, respectively. For bromatological analysis, forage samples were obtained cutting the aerial part of the plant close to the ground, instead of using any grazing simulation technique. Along the evaluation period, since natural pastures were used, summer cycle species predominated (*Andropogon lateralis, Desmodium incanum, Paspalum dilatatum, Paspalum Notatum*, and *Trifolium polymorphum*), with infestation of weed (*Eragrostis plana*).

The reproductive period was from November 15, 2006, to February 5, 2007. The bull:cow ratio was 1:25. Bulls were previously tested for libido and subjected to an andrological examination. Pregnancy was diagnosed by ultrasound 45 days after the end of the reproductive period.

Calving took place in 2006, from September 7 to December 1. Cows were weighed within the first 24 hours after calving, and their body condition scores were assessed. Weaning was from December 2006 to March 2007, and it was carried out in stages. Lactation period varied between 55 and 178 days and was distributed across the three ages studied. Calves were permanently separated from cows and kept in pens, in groups of four, on a diet consisting of concentrate formulated to meet their requirements. From the 5th to the 10th day after weaning, calves were kept in pens, but released for one hour on a pasture, in order to adapt to grazing, albeit maintaining their concentrate intake. From the 11th day, calves were maintained exclusively on pasture and supplemented at 1% of their body weight.

Milk yields were estimated at early weaning dates by the difference of calf weight before and after suckling (Melton et al., 1967). Calves were separated from their dams, from 12:00 h to 18:00 h, and reunited later with their dams to breastfeed, to empty the udder. After breastfeeding, calves were separated from their mothers for 12 hours. At the end of this period, they were weighed and allowed to breastfeed again until satisfied, and weighed again. The daily milk production was estimated by the difference in weight between the calves' weighing.

Weighing and assessments of the body condition score of the animals were carried out at weaning, at the beginning of the reproductive period, and at the end of the reproductive period. In addition to the periodic weighing, subjects were weighed every 28 days, to adjust the grazing pressure and maintain the forage stocking. Daily weight gains were determined by the difference of the cow weight between each weighing divided by the number of days. To evaluate the body condition score, a 5-point scale was used, where "1" represents "very thin" and "5", "obese" (Rasby et al., 2014).

Cows had free access to a mineral mixture of 80 ppm of phosphorus, comprising common salt and dicalcium orthophosphate. In order to control foot-and-mouth disease and clostridiosis, vaccination was carried out according to the calendar recommended by the Ministry of Agriculture and Livestock (MAPA), Brazil. Endoparasites and ectoparasites (ticks, botflies, and myiasis) were controlled using specific products.

The traits assessed at different ages were: lactation period (days); milk production (L day^{-1}); interval from calving to the end of the reproductive season (days); body weight (kg); body scores (points); and mean daily weight gains (kg). Body score was measured at calving, at 75 days postpartum, and at end of the reproductive period. Daily gain was measured from postpartum up to 75 days after, and during the reproductive period.

The statistical analysis was performed with the SAS statistical software (Statistical Analysis System, v9.2). A logistic regression model was applied to analyze the response variable 'probability of pregnancy'. Data were not subjected to outliers and linearity checking because the data used are from zootechnical collection under a rigorous experimental control. The assumption of independence of residuals was not checked, since each animal was treated as an independent observation, without repeated measures or hierarchical clustering. Predictor variables were checked for multicollinearity using pairwise methods, the Pearson's correlation matrix, and the variance inflation factor (VIF), as well as a per predictor basis, using eigenvalues (λ), the correspondent condition index (CI) (Khalaf & Iguernane, 2016), and proportion of variance (Belsley et al., 1980). Once multicollinearity was checked, the logistic regression model was calibrated using the Hosmer-Lemeshow's goodness-of-fit test (HLT) at 5% probability (Hosmer Jr. et al., 2013). After fitting the model (estimating of βi parameters), the regression coefficients were tested using likelihood ratio test (LRT), the Wald's test, and the Lagrange's multiplier test.

The logistic model fitted for 'probability of pregnancy' of the cow "i" is expressed as follows (Equation 1):

$$P_i = \frac{e^{yi}}{1+e^{yi}} = (1 + e^{-yi})^{-1} \quad (1)$$

where: P_i is the pregnancy probability of the cow "i"; and y_i is the pregnancy linear predictor.

The pregnancy linear predictor for three-year-old cows is described in the Equation 2, as follows:

$$y_i = \mu + \beta_i LP_i + \beta_i BWR_i + \beta_i BCR_i + \beta_i WDR_i + \beta_i WCR_i + \varepsilon_i \quad (2)$$

where: y_i is the predicted log-odds of pregnancy of the cow "i"; μ is the constant; LP_i is the lactation period (days) of the cow "i"; BWR_i is the body weight (kg) of cow "i", at the end of the reproductive period; BCR_i is the body condition score (points) of cow "i", at the end of the reproductive period; WDR_i is the mean daily weight gain (kg), during the reproductive period of cow "i"; WCR_i is the mean daily weight gain (kg), from calving to the end of the reproductive period of cow "i"; and ε_i is the = random error associated with cow "i".

The linear pregnancy predictor for four-year-old cows is described in the Equation 3, as follows:

$$y_i = \mu + \beta_i DCR_i + \beta_i BWR_i + \varepsilon_i \quad (3)$$

where: y_i is the predicted log-odds of pregnancy of the cow "i"; μ is the constant; DCR_i is the number of days between calving and the end of the reproductive period of cow "i"; WDR_i is the mean daily weight gain (kg)

during reproductive period of cow "i"; and ε_i is the random error associated with cow "i".

The pregnancy linear predictor for five-year-old cows is described in the Equation 4, as follows:

$$y_i = \mu + \beta_i DCR_i + \beta_i BWR_i + \beta_i WCR_i + \beta_i WDR_i + \varepsilon_i \quad (4)$$

where: y_i is the predicted log-odds of pregnancy of the cow "i"; μ is the constant; DCR_i is the number of days between calving and the end of the reproductive period of the cow "i"; BWR_i is the body weight (kg) of cow "i" at end of reproductive period; WCR_i is the mean daily weight gain (kg) from calving to the end of reproductive period of cow "i"; WDR_i is the mean daily weight gain (kg) during the reproductive period of cow "i"; and ε_i is the random error associated with cow "i".

The odds ratio (OR) is estimated in the Equation 5, as follows:

$$OR = e^{\beta K} \quad (5)$$

where: OR represents the ratio between two possible outcomes, that is, the success (p) and failure (1 - p); OR is an exponential function of the product of the regression coefficient (β) and the independent variable (K). Odds-ratios were based on the mean denominator of the data set for each model. After finding the regressor variables affecting the probability of the pregnancy of cows at different ages (presented in the previous models), increases and reductions were applied to the variables to estimate de respective OR. The quantities and units used for each variable were: 7 days for DCR; 7 days for LP; 0.100 kg for WCR and WDR; 15 kg for BWR; 0.15 points for BCR.

Results and Discussion

The mean probabilities of pregnancy were 66.53, 80.53, and 83.58% for three, four, and five-year-old cows. In the beginning, the variables "milk production" and "body condition score" were inserted into the model, but they were removed later. There were multicollinearity and high correlations between these variables (Table 1) and "age of the cow". After the multicollinearity diagnosis, three adjusted linear predictor equations were obtained for each log-odds of probability of pregnancy of cows of three, four, and five-year-old cows (Table 2). Among the included variables, several ones were consistent factors for pregnancy of beef cows, some of them becoming apparent at different ages, and others influencing pregnancy, depending on the maturity of the animal.

The length effects of cow lactation period (LP), body weight (BWR) and body condition score (BCR), at the end of the reproductive period, and mean daily weight gains from calving to 75 days postpartum (WCR) and during the reproductive period (WDR) were included in the logistic regression equation, to explain the probability of pregnancy of three-year-old cows. The interval between calving and the end of the reproductive period (DCR), and the mean daily weight gain during the reproductive period (WDR) were included in the model of probability of pregnancy for four-year-old cows. Calving interval at end of the reproductive period (DCR), body weight at end of the reproductive period (BWR), mean daily weight gain from calving to 75 days postpartum (WCR), and mean daily weight gain during the reproductive period (WDR) were included in the model of probability of pregnancy for five-year-old cows. Based on the HLT statistics, there was no evidence for a lack of models fit with $p = 0.4440$, $p = 0.4197$, and $p = 0.7828$, for cows of three, four, and five-year-old cows, respectively (Table 2). The linear predictor equations for cows at different ages show that pregnancy in beef cows is influenced by nutritional, physiological, and environmental factors.

The parameters LP and BCR affected pregnancy only in three-year-old cows (Table 3). During the lactation period, an increase of seven days in LP reduced the probability of pregnancy (1 - IOR) by 21.4%. A reduction of seven days increased the probability of pregnancy (1-ROR) by 27.3%. The greater probability of pregnancy in three-year-old cows (in the present study still growing), with shorter lactation periods, is due to the reduction of the demand for milk production, which is a consequence of the early weaning of the calves (Vaz & Lobato, 2010). Furthermore, the stimulus of lactation caused by calves affects the duration of postpartum anoestrus (Orihuela & Galina, 2019), which becomes more pronounced in growing cows (Vaz & Lobato, 2010). Early weaning is an alternative to increase pregnancy rates, due to the longer recovery time and less energy spent in milk

Table 1. Pearson's correlation[1] (p-value) matrix of the regression variables[2] of the pregnancy linear predictors of in three, four, and five-year-old beef cows.

Variable	WCR	WDR	BCR	BWR	BCC	BWC	DCR	LP
				Three-year-old cows				
MP	0.0244 (0.8446)	0.1417 (0.2526)	-0.0981 (0.4296)	-0.0093 (0.9404)	-0.0248 (0.8421)	-0.0142 (0.9095)	-0.0739 (0.5521)	-0.0783 (0.5287)
LP	-0.2938 (0.0004)	-0.2942 (0.0004)	-0.1883 (0.0264)	-0.1704 (0.0449)	0.0440 (0.6067)	-0.0032 (0.9704)	0.2994 (0.0003)	
DCR	-0.0596 (0.4857)	0.0439 (0.6079)	0.0227 (0.7905)	0.0323 (0.7059)	0.0907 (0.288)2	-0.045 (0.5992)		
BWC	0.0626 (0.4639)	0.2536 (0.0026)	0.4803 (<.0001)	0.7505 (<.0001)	0.5667 (<.0001)			
BCC	-0.1427 (0.0938)	0.0191 (0.8233)	0.4356 (<.0001)	0.3190 (0.0001)				
BWR	0.6963 (<.0001)	0.6379 (<.0001)	0.6953 (<.0001)					
BCR	0.5334 (<.0001)	0.4057 (<.0001)						
WDR	0.6779 (<.0001)							
				Four-year-old cows				
MP	0.0311 (0.7856)	0.2325 (0.0390)	0.3786 (0.0009)	0.3246 (0.0040)	0.3118 (0.0050)	0.3060 (0.0061)	0.0873 (0.4439)	-0.5016 (<.0001)
LP	-0.2061 (0.0683)	-0.4359 (<.0001)	-0.5926 (<.0001)	-0.1909 (0.0919)	-0.1085 (0.3412)	-0.0309 (0.7871)	0.0131 (0.9085)	
DCR	0.0536 (0.6387)	0.3120 (0.0051)	0.0595 (0.6024)	0.0004 (0.9973)	-0.3380 (0.0023)	-0.2129 (0.0596)		
BWC	-0.3712 (0.0008)	-0.2391 (0.0338)	0.3272 (0.0032)	0.6592 (<.0001)	0.5136 (<.0001)			
BCC	-0.2800 (0.0125)	-0.3228 (0.0037)	0.1289 (0.2577)	0.2305 (0.0409)				
BWR	0.4318 (<.0001)	0.1793 (0.1138)	0.6592 (<.0001)					
BCR	0.4085 (0.0002)	0.4215 (0.0001)						
WDR	0.4457 (<.0001)							
				Five-year-old cows				
MP	0.1561 (0.2106)	0.2425 (0.0498)	0.0398 (0.7513)	0.0701 (0.5759)	0.0407 (0.7453)	-0.0692 (0.5807)	0.2936 (0.0168)	-0.0109 (0.9305)
LP	0.1813 (0.1451)	-0.0684 (0.5851)	-0.1067 (0.3939)	-0.0968 (0.4393)	-0.1833 (0.1407)	-0.2269 (0.0669)	0.2776 (0.0239)	
DCR	0.6925 (<.0001)	0.5340 (<.0001)	0.2424 (0.0499)	0.1921 (0.1223)	-0.4568 (0.0001)	-0.3877 (0.0013)		
BWC	-0.4747 (<.0001)	-0.2001 (0.1073)	0.4762 (<.0001)	0.6722 (<.0001)	0.4883 (<.0001)			
BCC	-0.4617 (<.0001)	-0.3250 (0.0078)	0.2176 (0.0792)	0.1234 (0.3234)				
BWR	0.3274 (0.0073)	0.3580 (0.0032)	0.7294 (<.0001)					
BCR	0.2498 (0.0431)	0.2831 (0.0212)						
WDR	0.6613 (<.0001)							

[1]Significant at 5% probability. [2]Parameters: MP, milk production; LP, lactation period; DCR, number of days from calving to the end of the reproductive period; BWC, weight at calving; BCC, body condition score at calving; BWR, body weight of cow at the end of the reproductive period; BCR, body condition score at the end of the reproductive period; WDR, daily weight gain during the reproductive period; WCR, daily weight gain from calving to 75 days postpartum.

Table 2. Regression estimates, standard deviation (SD), confidence limits (CL), p-value, and Hosmer-Lemeshow's goodness-of-fit test (HLT) of the variables, in the linear predictor equations for pregnancy rate of three, four, and five-year-old beef cows.

Variable[1]	Estimate	Standard deviation	Confidence limits[2]		p-value[3]	HLT[4]
			Lower	Upper		
Three-year-old cows						
Intercept	3.8174	0.1316	1.8108	5.8241	0.0002	0.4440
LP	-0.0068	0.0010	-0.0470	0.0219	< 0.0001	
BWR	0.0153	0.0066	0.0024	0.0282	0.0198	
BCR	1.2173	0.7412	-0.2354	2.6700	< 0.0001	
WCR	4.8126	1.4140	2.0412	7.5839	< 0.0001	
WDR	2.5942	0.9010	0.8281	4.3602	0.0040	
Four-year-old cows						
Intercept	-4.6072	2.5289	-9.5637	0.3493	0.0685	0.4197
DCR	0.0487	0.0205	0.00842	0.0890	0.0178	
WDR	2.4027	1.9891	-1.4958	6.3012	0.2271	
Five-year-old cows						
Intercept	-9.0567	3.3646	-15.6512	2.4621	0.0071	0.7828
DCR	5.2575	1.9075	1.5190	8.9961	0.0058	
BWR	1.8238	1.0101	-0.1561	3.8036	0.0710	
WCR	0.0233	0.0135	0.00127	0.0453	0.0382	
WDR	0.0824	0.0268	0.0299	0.1348	0.0021	

[1]Parameters: LP, lactation period; BWR, body weight of cow at of reproductive period; BCR, body condition score at the end of the reproductive period; WCR, daily weight gain from calving to 75 days postpartum; WDR, daily weight gain during the reproductive period; DCR number of days from calving to the end of the reproductive period. [2]Confidence interval of 95%. [3]Significant at 5% probability. [4]Significant at 5% probability.

Table 3. Results of point estimate (PE), confidence limit (CL), increase and reduction units, increase odds-ratio (IOR), reduction odds-ratio (ROR), and p-value of the variables in the linear predictor equations for pregnancy rate of three, four, and five-year-old beef cows.

Variable[1]	PE	Confidence limit[2]		Unit	IOR	ROR	p-value[3]
		Lower	Upper				
Three-year-old cows							
LP	-0.0068	-0.0470	0.0219	7 days	0.786	1.273	< 0.0001
BWR	0.0153	0.0024	0.0282	15 kg	1.258	0.795	0.0198
BCR	1.2173	-0.2354	2.6700	0.15 points	1.200	0.833	< 0.0001
WDR	2.5942	0.8281	4.3602	0.100 kg	1.296	0.772	0.004
WCR	4.8126	2.0412	7.5839	0.100 kg	1.618	0.618	< 0.0001
Four-year-old cos							
DCR	0.0487	0.00842	0.0890	7 days	1.406	0.711	0.0178
WDR	2.4027	-1.4958	6.3012	0.100 kg	1.272	0.786	0.0271
Five-year-old cows							
DCR	0.0824	0.0299	0.1348	7 days	1.780	0.562	0.0021
BWR	0.0233	0.0013	0.0453	15 kg	1.177	0.850	0.0382
WCR	5.2575	1.5190	8.9961	0.100 kg	1.692	0.591	0.0058
WDR	1.8238	-0.1561	3.8036	0.100 kg	1.200	0.833	0.0310

[1]Parameters: PLP, lactation period; BWR, body weight of cow at the end of the reproductive period; BCR, body condition score at the end of the reproductive period; WDR, daily weight gain during the reproductive period; WCR, daily weight gain from calving to 75 days postpartum; DCR, number of days from calving to the end of reproductive period. [2]Confidence interval of 95%. [3]Significant at 5% probability.

production, until the end of the reproductive period (Vaz & Lobato, 2010; Orihuela & Galina, 2019).

The body condition score is related to herd nutrition, directly influencing the reproductive physiology of female bovines (Sartori & Guardieiro, 2010). The increase of 0.15 points in the BCR of primiparous three-year-old cows increased by 20.0% the probability of pregnancy. A decrease of 0.15 points reduced by 16.7% the probability of pregnancy. Albeit highly correlated with other characteristics, the influence of the body condition score on the pregnancy, at the end of the reproductive period, indicates how nutritionally demanding this primiparous cow is, requiring a differentiated production management.

BWR influenced the probability of pregnancy in cows of three and five years of age. In three-year-old cows, the increase of 15 kg of the body weight reflected in the increase by 25.8% of the probability of pregnancy, while reduction of 15 kg decreased by 20.5% the probability of pregnancy. In five-year-old cows, the 15 kg increase reflected in an increase by 17.7% of the probability of pregnancy, while the 15 kg reduction was related to a decrease by 15.0% of the probability of pregnancy. The increase of the probability of pregnancy, due to higher body weights at the end of the reproductive period, indicates the importance of the nutritional aspect when cows are calving, proportionating them satisfactory hormone levels in accordance with their reproductive success (Vaz et al., 2023). When evaluating the probability of pregnancy in cows from three-year-old to twelve-year-old, the increase of 10 kg in body weight, at the end of the reproductive period, increased the rate of pregnancy by 7.0% (Pacheco et al., 2022). The results indicate that body weight is important. Thus, herd nutrition must be closely monitored, since larger cows are more demanding, and poor nutrition leads to a low animal performance (Vaz et al., 2020, 2022).

An effect of DCR was observed on the probability of pregnancy in four-year-old and five-year-old cows. In four-year-old cows, the increase of seven days in DCR was related to the increase by 40.6% of the probability of pregnancy, while a decrease of seven days was related to a decrease by 28.9% of the probability of pregnancy. In five-year-old cows, the increase of seven days was related to the increase by 78.0% of the probability of pregnancy, while a decrease of seven days was related to a decrease by 43.8% of the probability of pregnancy. The increase of the probability of pregnancy observed in such cows, due to early calvings, indicates the importance of correctly planning the production system. The better reproductive performance in cows, due to early calving, is a consequence of a longer period for recovery and early returning to the reproductive phase (Castilho et al., 2018; Reis et al., 2023; Vaz et al., 2023). This longer period from calving to reproduction also allows of the peak of milk production to have passed (Montiel & Ahuja, 2005; Orihuela & Galina, 2019).

These findings indicate that breeding herds should aim for calving to take place when nutrition in the system is at its best, since lactation is the most demanding and exhausting stage of the production cycle for cows. In pasture-based breeding systems, cows with early calving consume better quality forage for a longer postpartum period than cows with later calving during the calving season (Castilho et al., 2018; Bitencourt et al., 2020). In the present study, the absence of calving effect on the probability of pregnancy of three-year-old cows is due to the primiparous condition. They require different management, such as early weaning of their calves, a better body condition score, and greater postpartum daily weight gains.

In the present study, the WDR was the only variable that showed potential for changing the probability of pregnancy at different ages. The increase of 0.100 kg in WDR resulted in increases of the probability of pregnancy by 29.6%, 27.2%, and 20.0%, in cows of three, four, and five years of age, respectively. However, the decrease of 0.100 kg in WDR reduced the probability of pregnancy by 22.8%, 21.4%, and 16.7% in cows of three, four, and five years of age, respectively. In order to recover properly, lactating animals require ideal nutritional conditions, to meet the demands of maintenance, growth, and weight gain (Reis et al., 2023). Cows with nonideal levels of nutrition experience weight loss and, consequently, a reduction of the body condition score, reflecting negatively on the rates of pregnancy (Eloy et al., 2022).

The WCR of the tthree-year-old and five-year-old cows influenced the probability of pregnancy. Increases of 0.100 kg resulted in the increases by 61.8% and 69.2% of the probability of pregnancy in three-year-old and five-year-old cows, respectively. However, a reduction of 0.100 kg reduces the probability of pregnancy in three-year-old and five-

year-old cows by 38.2% and 48.9%, respectively. The influence of daily gain in the period from calving to the end of the reproductive period, in three-year-old and five-year-old cows, indicates the importance of good nourishment during postpartum period.

The results indicate that milk production is an obstacle to pregnancy in younger primiparous cows, which should be managed to accumulate body reserves. Furthermore, early pregnancy during the mating season, resulting in earlier calving during the calving season, is a key determinant of reproductive success. It is also important to note that a better productive performance, at postpartum and during the reproductive period, determines a higher probability of pregnancy in pasture-fed beef cows. These results are relevant because they express different ages of beef cows, with a significant number of replications at each age. Herds with animals at different ages is a common situation in most of the Brazilian farms of pasture-fed herds. However, the present study has a limitation in terms of period of analysis. The experiment evaluated just one year, not accounting environmental changes in the long-term, which have known effects on reproductive performance. Therefore, more studies should be performed, accounting for seasonal environmental changes, different genetic groups, and behavioural aspects of the animals.

Conclusions

1. Milk production is an obstacle to pregnancy in younger primiparous cows, which should be managed to accumulate body reserves.
2. Early calving is essential for the reproductive success of beef cows.
3. Increases of daily weight gain, during the reproductive period, are determinant of better reproductive performance in beef cows of different ages.

References

ABIEC. Associação Brasileira das Indústrias Exportadoras de Carnes. **Beef report 2024**: perfil da pecuária no Brasil. São Paulo, 2024. 105p.

ALVARES, C.A.; STAPE, J.L.; SENTELHAS, P.C.; GONÇALVES, J.L. de M.; SPAROVEK, G. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift,** v.22, p.721-728, 2013. DOI: https://doi.org/10.1127/0941-2948/2103/0507.

BELSLEY, D.A.; KUH, E.; WELSCH, R.E. **Regression diagnostics**: identifying influential data and sources of collinearity. New York: J. Wiley & Sons, 1980. DOI: https://doi.org/10.1002/0471725153.

BITENCOURT, M.F.; CERDÓTES, L.; RESTLE, J.; COSTA, P.T.; FERNANDES, T.A.; FERREIRA, O.G.L.; SILVEIRA, D.D.; VAZ, R.Z. Age and calving time affects production efficiency of beef cows and their calves. **Anais da Academia Brasileira de Ciências,** v.92, e20181058, 2020. Suppl.1. DOI: https://doi.org/10.1590/0001-3765202020181058.

BOHNERT, D.W.; STALKER, L.A.; MILLS, R.; NYMAN, A.; FALCK, S.J.; COOKE, R.F. Late gestation supplementation of beef cows differing in body condition score: effects on cow and calf performance. **Journal of Animal Science**, v.91, p.5485-5491, 2013. DOI: https://doi.org/10.2527/jas.2013-6301.

CARVALHO, R.S.; COOKE, R.F.; CAPPELLOZZA, B.I.; PERES, R.F.G.; POHLER, K.G.; VASCONCELOS, J.L.M. Influence of body condition score and its change after parturition on pregnancy rates to fixed-timed artificial insemination in *Bos indicus* beef cows. **Animal Reproduction Science**, v.243, art.107028, 2022. DOI: https://doi.org/10.1016/j.anireprosci. 2022.107028.

CASTILHO, E.M.; VAZ, R.Z.; FERNANDES, T.A.; CONCEIÇÃO, V.G.D. da; BRUM, O.B. Precocidade de parto na estação de parição sobre a eficiência produtiva de vacas primíparas aos 24 meses de idade. **Ciência Animal Brasileira**, v.19, e46667, 2018. DOI: https://doi.org/10.1590/1809-6891v19e-46667.

D'OCCHIO, M.J.; BARUSELLI, P.S.; CAMPANILE, G. Influence of nutrition, body condition, and metabolic status on reproduction in female beef cattle: a review. **Theriogenology**, v.125, p.277-284, 2019. DOI: https://doi.org/10.1016/j.theriogenology.2018.11.010.

DISKIN, M.G.; KENNY, D.A. Managing the reproductive performance of beef cows. **Theriogenology**, v.86, p.379-387, 2016. DOI: https://doi.org/10.1016/j.theriogenology.2016.04.052.

ELOY, L.R.; BREMM, C.; LOBATO, J.F.P.; PÖTTER, L.; LACA, E.A. Direct and indirect nutritional factors that determine reproductive performance of heifer and primiparous cows**. PLoS ONE**, v.17, e0275426, 2022. DOI: https://doi.org/10.1371/journal.pone.0275426.

FAO. Food and Agriculture Organization of the United Nations. **Faostat**: Food and agriculture data. 2024. Available at: <https://www.fao.org/faostat/en/#home>. Accessed on: Jan. 27 2025.

HOSMER JR., D.W.; LEMESHOW, S.; STURDIVANT, R.X. (Ed.). **Applied logistic regression**. 3rd ed. New York: J. Wiley & Sons, 2013. (Wiley Series in probability and statistics). DOI: https://doi.org/10.1002/9781118548387.

KHALAF, G.; IGUERNANE, M. Multicollinearity and a ridge parameter estimation approach. **Journal of Modern Applied Statistical Methods**, v.15, p.400-410, 2016. DOI: https://doi.org/10.22237/jmasm/1478002980.

LACERDA, V.V.; CAMPOS, G.S.; ROSO, V.M.; SOUZA, F.R.P.; BRAUNER, C.C.; BOLIGON, A.A. Effect of mature size and body condition of Nelore females on the reproductive

performance. **Theriogenology**, v.118, p.27-33, 2018. DOI: https://doi.org/10.101j.theriogenology.2018.05.036.

LOBATO, J.F.P.; CADÓ, L.M.; POLI, C.H.E.C.; JACONDINO, L.R.; SOUZA, C.B. de O. de; OLIVEIRA, A.B. de; PÖTTER, L.; ELOY, L.R.; VAZ, R.Z. Suplementação e desempenho produtivo e reprodutivo de vacas primíparas aos 24 meses de idade. **Research, Society and Development**, v.10, e28510111748, 2021. DOI: https://doi.org/10.33448/rsd-v10i1.11748.

MELTON, A.A.; RIGGS, J.K.; NELSON, L.A.; CARTWRIGHT, T.C. Milk production, composition and calf gains of Angus, Charolais and Hereford cows. **Journal of Animal Science**, v.26, p.804-809, 1967. DOI: https://doi.org/10.2527/JAS1967.264804X.

MONTIEL, F.; AHUJA, C. Body condition and suckling as factors influencing the duration of postpartum anestrus in cattle: a review. **Animal Reproduction Science**, v.85, p.1-26, 2005. DOI: https://doi.org/10.1016/j.anireprosci.2003.11.001.

ORIHUELA, A.; GALINA. C.S. Effects of separation of cows and calves on reproductive performance and animal welfare in tropical beef cattle. **Animal**, v.9, art.223, 2019. DOI: https://doi.org/10.3390/ani9050223.

PACHECO, R.F.; VAZ, R.Z.; RESTLE, J.; SILVEIRA, M.F. da.; CERDOTES, L.; TEIXEIRA, J.S.; MILANI, L.; PACHECO, P.S. Probability of pregnancy in beef cows with early-weaned calves. **Livestock Science**, v.257, art.104854, 2022. DOI: https://doi.org/10.1016/j.livsci.2022.104854.

PARDO, A.M.; VILLARREAL, E.L.; PAPALEO MAZZUCCO, J.; MELUCCI, O.G.; SANTAMARÍA, S.; FERRARIO, J.; MELUCCI, L.M. Sexual precocity and productivity of beef cattle female under grazing conditions. **Animal Production Science**, v.59, p.757-766, 2018. DOI: https://doi.org/10.1071/AN17804.

RASBY, R.J.; STALKER, A.; FUNSTON, R.N. **Body condition scoring beef cows**: a tool for managing the nutrition program for beef herds. Lincoln: University of Nebraska-Lincoln, 2014. 14p. (EC281). Available at: <https://extensionpubs.unl.edu/publication/ec281/2014/pdf/view/ec281-2014.pdf>. Accessed on: July 31 2025.

REIS, N.P.; LOBATO, J.F.P.; RESTLE, J.; PACHECO, R.F.; NUÑEZ, A.J.C.; SARTORI, D.B.S.; VAZ, R.Z. Effect of the performance, calving date and lactation period on the probability of pregnancy in beef cows. **Scientia Agricola**, v.80, e20220088, 2023. DOI: https://doi.org/10.1590/1678-992X-2022-0088.

SARTORI, R.; GUARDIEIRO, M.M. Fatores nutricionais associados à reprodução da fêmea bovina. **Revista Brasileira de Zootecnia**, v.39, p.422-432, 2010. Supl. especial. DOI: https://doi.org/10.1590/S1516-35982010001300047.

SANTOS, H.G. dos; JACOMINE, P.K.T.; ANJOS, L.H.C. dos; OLIVEIRA, V.Á. de; LUMBRERAS, J.F.; COELHO, M.R.; ALMEIDA, J.A. de; ARAÚJO FILHO, J.C. de; OLIVEIRA, J.B. de; CUNHA, T.J.F. **Sistema brasileiro de classificação de solos**. 5.ed. rev. e ampl. Brasília: Embrapa, 2018. 356p.

VARA, C.C. da; SILVEIRA, M.F. da; VAZ, R.Z.; RESTLE, J.; MACHADO, D.S.; MACARI, S. Body size in beef cows and its influence on calf production. **Semina: Ciências Agrárias**, v.41, p.3299-3310, 2020. Supl.2. DOI: https://doi.org/10.5433/1679-0359.2020v41n6Supl2p3299.

VAZ, R.Z.; CERDÓTES, L.; NUÑEZ, A.J.C.; SARTORI, D.B.S.; PACHECO, R.F.; SILVA, H.R. da.; BETHANCOURT-GARCIA, J.A.; RESTLE, J. Body mass index at calving on performance and efficiency of Charolais cow herds. **Tropical Animal and Health and Production**, v.54, art.168, 2022. DOI: https://doi.org/10.1007/s11250-022-03108-8.

VAZ, R.Z.; LOBATO, J.F.P. Effects of the weaning age of calves on somatic development and on reproductive performance of beef cows. **Revista Brasileira de Zootecnia**, v.39, p.1058-1067, 2010. DOI: https://doi.org/10.1590/S1516-35982010000500016.

VAZ, R.Z.; LOBATO, J.F.P.; BETHANCOURT-GARCIA, J.A.; PACHECO, R.F.; REIS, N.P.; SARTORI, D.B.S.; JAPPE, S.A.; RESTLE, J. Environmental factors on the probability of pregnancy in early or conventionally weaned beef cows. **Animal Reproduction**, v.20, e20230054, 2023. DOI: https://doi.org/10.1590/1984-3143-AR2023-0054.

VAZ, R.Z.; SILVEIRA, M.F. da; RESTLE, J.; MACHADO, D.S.; SILVA, H.R. da.; BETHANCOURT-GARCIA, J.A.; CONCEIÇÃO, V.G.D. da. Época de parto e produção de leite na eficiência bioeconômica de rebanhos de vacas de corte. **Research, Society and Development**, v.9, e216997240, 2020. DOI: https://doi.org/10.33448/rsd-v9i9.7240.

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Chief editor: Edemar Corazza
Edited by: Daniel Kinpara

Data availability statement

Data available upon request: research data are only available upon reasonable request to the corresponding author.

Declaration of use of AI technologies

No generative artificial intelligence (AI) was used in this study.

Conflict of interest statement

The authors declare no conflicts of interest.

Acknowledgments

To Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), for financial support (grants 308963/2021-0, 142602/2019-1, and 310987/2020-2).

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