BIA
BOLETIM DE INDÚSTRIA ANIMAL

RUMINANT PRODUCTION

MANAGEMENT OF DAIRY CALVES AND HEIFERS AND THE ECONOMIC IMPACT ON FIRST LACTATION

Isadora de Ávila Caixeta
Universidade Federal de Uberlândia, Uberlândia, MG, Brazil,

Natascha Almeida Marques da Silva
Universidade Federal de Uberlândia, Uberlândia, MG, Brazil,

Erica Beatriz Schultz
Universidade Federal de Viçosa, Viçosa, MG, Brazil,
https://orcid.org/0000-0003-1916-2117
Email correspondente:
ericabeatrizschultz@gmail.com

Camila Raineri
Universidade Federal de Uberlândia, Uberlândia, MG, Brazil,
https://orcid.org/0000- 0003-1916-2117

Received: 18/05/2021
Approved: 11/07/2022

Abstract

Management of calves and heifers directly influence the future productivity of dairy animals. However, the pre-production stage is often neglected by farmers, as young cows do not yet produce milk and, therefore, revenue, while representing an important part of the total cost of the property. This study aimed to identify and determine the economic value of factors influencing the production in the first lactation of heifers in a herd. This was a case study carried out on a family property in the municipality of Patrocínio, state of Minas Gerais, using data from 54 heifers. Qualitative characteristics (sire, maternal grandsire, amount of colostrum consumed, antibiotics use on the first day of life; application of prostaglandin to induce estrus, application of prostaglandin for resynchronization, use of progesterone implant for resynchronization, occurrence of retention of placenta and/or abortion, induction of lactation) and quantitative characteristics (weight at 90 days, average daily gain at 90 days and age at first mating) were evaluated. Variables influencing the production in the first lactation were the application of antibiotics, retained placenta, induction of lactation and age at mating. The differences in milk revenue were -R$ 2,381.21 for the use of antibiotics in each female, -R$ 299.85 for each heat loss for the first mating, -R$ 5,043.11 for each lactation induction, -R$6,841.16 for each retained placenta with abortion and -R$1,060.96 for each case of retained placenta without abortion. Knowing the productive and economic consequences of each of these items provides the producer with subsidies for decision making, such as planning management strategies that avoid such losses, and choosing options to maximize the economic efficiency of production.

Key words Cattle farming, dairy farming, primiparous.

MANEJOS DE BEZERRAS E NOVILHAS LEITEIRAS E SEU IMPACTO ECONÔMICO NA PRIMEIRA LACTAÇÃO

Resumo

O manejo e os cuidados com as bezerras e novilhas influenciam diretamente a produtividade futura das fêmeas leiteiras. No entanto, muitas vezes a fase pré-produtiva é negligenciada pelos produtores, pois ao mesmo tempo que representam uma parcela importante do custo total da propriedade, as fêmeas jovens ainda não produzem leite e, portanto, receita. Objetivou-se identificar e determinar o valor econômico de fatores que influenciam na produção na primeira lactação de novilhas em um rebanho. O estudo de caso foi realizado em uma propriedade familiar na cidade de Patrocínio/MG, utilizando os dados de 54 novilhas. Foram avaliadas características qualitativas (pai, avô materno, quantidade de colostro consumida, uso de antibiótico no primeiro dia de vida; aplicação de prostaglandina para indução do cio, aplicação de prostaglandina para ressincronização, uso de implante de progesterona para ressincronização, ocorrência de retenção de placenta e/ou aborto, indução de lactação) e quantitativas (peso aos 90 dias, ganho médio diário aos 90 dias e idade à primeira cobertura). As variáveis que influenciaram a produção na primeira lactação foram a aplicação de antibióticos, retenção de placenta, indução à lactação e idade à cobertura. As diferenças na receita do leite foram de -R$ 2.381,21 para o uso de antibióticos em cada fêmea, -R$ 299,85 para cada cio perdido para a primeira cobertura, -R$ 5.043,11 para cada indução de lactação, de -R$ 6.841,16 para cada ocorrência de retenção de placenta com aborto e de -R$ 1.060,96 para cada caso de retenção de placenta sem aborto. Conhecer as implicações produtivas e econômicas de cada um destes itens fornece ao produtor tem subsídios para tomadas de decisão, como planejar estratégias de manejo que evitem tais prejuízos, e escolher as opções que maximizem a eficiência econômica da produção.

Palavras-chave Bovinocultura, pecuária leiteira, primíparas.

INTRODUCTION

The dairy production chain has economic and social importance, generating jobs, taxes and income, through the use of labor and the survival of several families in rural areas. Milk is an important income generator, with production and productivity varying between small and large producers (SIMÕES et al., 2015).

The milk agribusiness chain in the state of Minas Gerais is characterized by the concentration of activities in raising cattle and manufacturing dairy products. With regard to the producing regions of the state, the highest production growth occurs in the Triângulo Mineiro/Alto Paranaíba mesoregion, to the detriment of production in more traditional dairy basins (AZEVEDO et al., 2011). Among them, the municipality of Patrocínio ranks fourth in production in Brazil, being an important dairy basin, responsible for the production of 173.1 million liters of milk (IBGE, 2019).

The productive performance of the animals is conditioned by the genetic potential and by factors related to the environment and the breeding system (SANTOS and LOPES, 2014). Thus, the development of dairy activity depends on the management used mainly in the breeding and rearing phase of the animals, which are not always taken into account by producers (ROCHA, 2018). Thus, calf management is crucial for the heifer to be able to express its full potential and achieve good production.

Rearing replacement heifers represents an important part of the total cost of milk production, and it is common that the return on investment allocated between birth and the first lactation is not fully recovered until the end of the first lactation. Furthermore, as emphasized by Heinrichs et al. (2013), the management and care of females in the pre-productive stage directly influence the productivity and the potential to generate income of these animals not only in the first lactation, but also in the following ones. In this way, daily heifer management decisions can have a great effect on the immediate and future profitability of the property, especially in the form of hidden expenses and lost productivity (ADLER et al., 2019).

Clarifying the associations between the developmental characteristics of replacement heifers, their health, their reproductive efficiency, their management in general and their production is essential for the management of production systems.

This information can be used to quantify the costs of each factor and support decision-making on the properties, in order to seek more efficient measures. Thus, the goal was to assign economic values, in kilograms of milk and in Reais, to each factor influencing the amount of milk produced during the first lactation of heifers on a family property in the Alto Paranaíba region.

MATERIAL AND METHODS

This was a case study, in which primary data of routine zootechnical control were collected from a cattle milk production property in the municipality of Patrocínio, state of Minas Gerais. Individual information was collected from 54 cows, from their birth to the end of the first lactation. Animals had a genetic composition of 92% Holstein and 8% Dairy Gyr, daughters of Holstein bulls, from semen from insemination centers. Animals born between November 2015 and March 2017, with the first lactation completed and corrected for 305 days, were included in the study.

Qualitative characteristics evaluated were: i) sire, ii) maternal grandsire, iii) amount of colostrum consumed, iv) antibiotic use on the first day of life; v) application of prostaglandin to induce estrus for the first artificial insemination, vi) application of prostaglandin during lactation for reconception, vii) application of progesterone implant during lactation for reconception, viii) occurrence of retained placenta without abortion, ix) occurrence of retained placenta with abortion and x) pharmacological induction of lactation. Quantitative variables addressed were: i) weight at 90 days of life, ii) average daily gain at 90 days of life and iii) age at first mating.

For the evaluation of paternal and maternal effects, Pedigree data of the animals in zootechnical spreadsheets on the farm were accessed. The average birth weight of the calves was 40 kg, and two groups receiving 3 or 4 liters of colostrum per day were evaluated. Colostrum was given individually in bottles twice a day for three days.

As for the use of the supplement, Feedtech ™, which, because of its pasty consistency, was orally administered to a group of calves, for 21 days at a dose of 20g per day for each calf. The solid feed of the calves up to 90 days was composed of concentrate with ground corn, soybean meal and mineral mixture. The forage used was corn silage, and the forage: concentrate ratio was 70: 30.

The fixed-time artificial insemination (FTAI) protocol was performed with the use of a progesterone implant plus application of 1.5 mL synthetic prostaglandin (Ciosin™) on day zero, removal of the progesterone implant and reapplication of 1.5 mL synthetic prostaglandin (Ciosin™) after eight days. In the evaluation on the use of antibiotics, this was applied to part of the animals to prevent respiratory problems, through the subcutaneous administration on the first day of age of the calves of 1 mL for every 30 kg body weight (10 mg/kg) as a single dose, according to information in the drug package insert.

Data normality was assessed using the Kolmogorov-Smirnov test. Two different statistical techniques were used in the analyses, with milk production in the first lactation, in liters, as the dependent variable. Qualitative variables were individually tested by analysis of variance, and the F-test was used to compare the estimates of each variable. When a significance level of 5% was detected, the Tukey's test was applied to compare the means. Quantitative variables were individually analyzed by simple linear regression, with significance tested by the T statistic. When a significance level of 5% was detected, the model estimates provided the effect of the variable on production.

RESULTS AND DISCUSSION

3.1 Factors that did not interfere with first-lactation production of heifers

The variables sire, maternal grandsire, colostrum intake, supplementation, application of prostaglandin and progesterone for synchronization and resynchronization, weight at 90 days of age and average daily gain at 90 days had no influence ($P>0.05$) on the average production throughout lactation (Table 1).

Both the sires and maternal grandsires are Holstein bulls, whose semen was acquired from insemination centers, since the property does not have males. Artificial insemination aims to genetically improve the herd in order to increase the production of their offspring. In this study, there was no statistical difference between the productions of the daughters or granddaughters of each bull. This is because they are of the same breed, with similar genetic potential for dairy production.

The average production of the studied heifers was 7,856.22 liters milk, which represents a daily average yield of 25.76 liters. Rocha (2018) demonstrates that for the

Table 1 – Continuous and binary variables with no effect on milk production in the first lactation of heifers.

Variable	F-value	Factors	Average production (liters/ lactation)
Sire	0.2033	Sire 1	8,495.90
		Sire 2	6,559.40
		Sire 3	6,972.00
		Sire 4	7,515.40
		Sire 5	8,070.45
Maternal grandsire	0.2445	Grandsire 1	6,901.29
		Grandsire 2	8,884.33
		Grandsire 3	8,054.00
		Grandsire 4	7,843.08
Colostrum intake[1]	0.2959	3 liters	8,354.45
		4 liters	7,728.77
Vitamin supplement[2]	0.2959	Without supplement	8,354.45
		With supplement	7,728.77
Application of PGF2α	0.8496	With PGF2α	7,746.00
		Without PGF2α	7,875.39
Progesterone implant for resynchronization	0.1829	With implante	7,979.74
		Without implante	7,026.86
PGF2α for resynchronization	0.5725	With PGF2α	7,965.18
		Without PGF2α	7,685.00
Weight at 90 days	0.839	-	-
ADG[3] at 90 days	0.975	-	-

[1]Daily amount of colostrum offered to each animal; [2]Injection or not of a vitamin supplement for calves; [3]Average daily gain.

animal to express all its production genetic potential, they require healthy development in the early stages. In addition, the author emphasizes the importance of environmental factors for the expression of certain characteristics.

Colostrum is important to ensure the transfer of nutrients from the dam to the newborn, in order to assist in the quality of the ruminal microbiota and its health (SIGNORETTI, 2015). Azevedo et al. (2014) state that when offered in the first hours of life in a restricted way, offering 10% animal body weight. In this study, the average birth weight of the calves was 40 kg, so they should ingest 4 liters of milk daily. However, the use of up to 3 liters colostrum had no influence on future milk production. This is because colostrum has a greater effect on morbidity up to 30 days of life, calves acquire active immunity to combat environmental challenges (TEIXEIRA et al., 2017).

In order to improve the results, a vitamin supplement containing vitamin A, B,

C, D, E and K (Feedtech™) was given until the twenty-first day of life of the animals, in order to improve immunity, mainly in stressful periods. The vitamin supplement was administered orally for 21 days at a dose of 20g per day for each calf. There was no difference (P>0.05) in the production of heifers that received or not the supplement (Table 1). Gelsinger et al. (2016) in a meta-analytic study showed that management aspects in growing are more important than the intake rate of weight gain for production performance in the first lactation.

Neither the variation in the amount of colostrum consumed nor the administration of a vitamin supplement affected milk production in the first lactation. However, it is possible that these factors influenced other variables not considered in this study, such as survival rate, disease incidence and weight gain.

Prostaglandin (PGF2α) is used through an insemination protocol in order to regulate the intensity and duration of estrus, in order to reduce errors in estrus detection in females (RODRIGUES et al., 2018).

The use of progesterone implant is intended to suppress estrus, ovulation and also change the entire follicular dynamics of the animals, by acting in the hypothalamus regulating the release of gonadotropin (GnRH), and consequently, LH. In this way, progestogens are used in the form of implants for a period sufficient to allow the natural regression of the corpus luteum, thus being able to induce synchronized estrus. When progestogen treatment is discontinued, LH peaks and ovulation occurs (BURALLI et al., 2019).

One of the advantages of using implants to assist artificial insemination (AI) or fixed-time artificial insemination (FTAI) is the reduction in the interval between resynchronization, because on the day of pregnancy diagnosis referring to transfer, the animals that are already identified as empty and have a corpus luteum, they may already receive a next embryo, as well as, advantages as reduce the calving interval and days in milk of the herd (CONSENTINI et al., 2021).

The use of progesterone implants had no influence on heifer milk production, despite being crucial for their reproductive management. Thus, protocols used for the reproduction of heifers did not interfere with milk production and proved to be safe in this sense to be used for the reproductive management of heifers.

PGF2α may be used for resynchronization due to problems, such as retained placenta, which generate a delay in uterine involution processes in the resumption of

ovarian activity in the postpartum period. With retained placenta, there is also an increased likelihood of uterine infections, such as metritis, the main reason for reduced fertility in dairy cows (DJURICIC et al., 2012).

Zootechnical records, such as weight at 90 days and average daily gain (ADG) at 90 days, are extremely important for the producer to be able to monitor the development and weight gain of the animals. In the herd studied, the average values found for these variables were: weight at 90 days of 124.68 kg and ADG at 90 days of 0.941 kg.

One of the factors related to weight and weight gain at 90 days is birth weight. In this study, the average value was 40 kg. Aghakeshmiri et al. (2017) reported that calves with higher birth weights produced more milk at 305 days of lactation. Heifers weighing less than 35 kg at birth produced an average of 506-518 kg less milk compared to heifers born weighing 40-45 kg. Also in this same study, they noticed that birth weight is related to weight gain, and heifers that gained weight up to approximately 800g/day to reach 477 to 550 kg body weight at the first service tend to increase milk production.

From a sanitary point of view, calves that are born weighing less than 35 kg have a higher occurrence of neonatal diarrhea. Underdeveloped animals tend to indicate management and health problems, diseases, malnutrition or some other pathology that can prevent their development according to their genetic potential (HEWITT et al., 2020).

3.2 Factors interfering with the production at first lactation of heifers and economic impact

The variables related to antibiotic use, retained placenta, induction of lactation, age at mating significantly changed ($P<0.05$) the average lactation production and income from milk sales (Table 2).

In the herd studied, the application of antibiotics refers to a drug indicated for the treatment of pneumonia and bronchopneumonia in cattle, resulting from the high number of cases of respiratory problems on the property and was adopted as a prophylactic method. Complex respiratory diseases in cattle are considered a major animal health problem, as they have a multifactorial etiology, involving environmental factors, handling conditions, and infectious

Table 2 – Effects of binary and continuous variables with economic impact on milk production in the first lactation of heifers.

Variables	F-value	Estimate	Factors	Average production (liters/ lactation)	Difference in milk revenue [1]
Application of antibiotic	0.0225 **	-	Without antibiotic	8,303.28	-
		-	With antibiotic	7,205.95	-R$ 2,381.21
Retention of placenta	9.7683 e-09 ***	-	Without retention	8,513.73	-
		-	With retention	7,955.33	-R$ 1,211.73
		-	Retention + abortion	4,913.12	-R$ 7,813.32
Induction of lactation	7.6608 e-07 ***	-	Without induction	8,396.91	-
		-	With induction	5,742.64	-R$ 5,759.76
Age at mating	0.0060 **	-7.515	447 days[2]	-	-
			447 days + 21 days[3]	-157.81	-R$ 342.45

[1] Considering the value practiced in November 2020 by the dairy plant, R$ 2.17/liter; [2] Average age at first mating in the herd; [3] Average age at first mating + one estrous cycle.

agents. They mainly affect young animals (SMITH, 2021).

Respiratory problems and other diseases can lead to significant economic losses due to high mortality, reduced growth rate and milk production, older age at first birth, medication costs and treatment labor (RASHID et al., 2018).

Antibiotics can be used to prevent or treat secondary infections caused by bacteria. The impact caused by respiratory diseases is high and reflects on the entire productive life of the animal, due to irreversible lesions to lung parenchyma, thus limiting its complete development and the total expression of its productivity (SMITH, 2021).

A negative effect on milk production was soon found in the group of animals that received antibiotics, with a reduction of about 1,097 liters compared to the non-treated group. However, it is possible that the reduction in production was not a consequence of the drug, but rather due to the presence of respiratory diseases in the treated groups, which motivated the application of the antibiotic.

Retained placenta (RP) is characterized by failure to expel fetal membranes after parturition and there are several causes of RP, which may be the result of nutritional, infectious and management factors (LEBLANC, 2008).

However, RP is an indication of failure in the management of cows in the transition period, which consists of the final phase of pregnancy and the beginning of lactation. It may not cause any impact on the cow life, or even impair their productive life, due to low reproductive performance and losses in milk production (LEBLANC,

2008; RESENDE, 2013). Predisposing factors include twin pregnancy, dystocia, stillbirth, obstetric interventions, duration of gestation, induction of parturition with PGF2α, abortion, postpartum hypocalcemia, age of the animal, and seasonal effects (LEBLANC, 2008).

Heifers affected by retained placenta showed lower production than those not affected, by 558.4 liters milk, being possible to note the importance of retained placenta occurrence and the great impact on animal production (Table 2).

The occurrence of abortion with retained placenta is another undesirable condition in production, as it causes problems for the heifer milk production. Abortion is the expulsion of the fetus from the uterus, which may still be alive or dead, between days 42 and 280 of gestation and this occurs when the fetus is unable to have an independent life in the extrauterine environment. Abortion is possible at any time during gestation. The main causes are neosporosis, brucellosis, leptospirosis, campylobacteriosis, herpes virus complex, bovine viral diarrhea, mycotic abortions and can still be caused by multifactorial problems (DEREJE et al., 2018).

Comparing animals that did not have retained placenta with those that had abortion followed by retention, there was a reduction in the average production of approximately 3,600 liters per lactation (Table 2). According to Wang et al. (2019) cows that had an abortion do not show the hormonal changes expected for the beginning of lactation, and do not mobilize lipid reserves for milk production, as observed in animals that did not undergo abortion.

Retained placenta has multifactorial causes, which may result from nutritional, infectious and management factors, which makes its treatment difficult. When combined with abortion, it can occur due to placental immaturity, with no detachment of the placentomes, and not generating the necessary intensity of uterine contractions for their expulsion (WANG et al., 2019).

Lactation is induced to reduce the involuntary culling of cows due to reproductive problems, and it consists of inducing the animal with hormones, causing it to start secreting milk without having become pregnant (MELLADO et al., 2011). The application of induction protocols has the intention of increasing the possibility of recovering the reproductive activity of the cows and prolonging their productive life (FERREIRA et al., 2018).

Variations in the response to lactation induction, such as milk production and

the success rate of induction, occur according to physiological changes at the time of the procedure (stage of gestation or if the female was empty, if there were complications in parturition or abortion), and variables such as breed, age, body condition score and absorption of administered hormones (RAMGATTIE et al, 2014)

When analyzing the volume of milk produced, Luz et al. (2020) found that cows induced to lactation produced 75% milk of animals that were not induced. Milk production of induced cows is lower due to incomplete proliferation of mammary tissue and inadequate differentiation of secretory cells.

In the herd studied, in induced cows, compared to the other animals, there was a reduction in the average production by 2,654 liters per lactation, that is, by more than 68%. Thus, when evaluating the possibility of inducing lactation, it should be analyzed whether this alternative will be more profitable than a normal lactation, which occurs after reproductive delay.

For each day of delay in mating heifers, there was a reduction of 7.5 liters in their production in the first lactation. That is, with the loss of an estrous cycle (21 days), either due to failure to observe estrus or delay in puberty, there would be a reduction in the production of 158 liters during lactation. In this study, the average mating age of females was 447 days or approximately 14.9 months of age. According to Bonamy et al. (2019), heifers fit for breeding between 14 and 16 months of age are considered precocious, and should reach around 340-400 kg at this age, aiming for the first calving before 28 months. For this to occur, it is important to carefully monitor the development of these animals from weaning to the first insemination, taking into account the average daily gain during the growth phase and the body condition score.

Nor et al. (2013) found that Holstein heifers that calved before 24 months produced an average of 7,830 liters and those that calved between 24 and 27 months produced an average of 7,356 liters, demonstrating that animals that calved younger produced a greater number of liters of milk. Wondossen et al. (2018) showed the age at first mating does not depend only on the precocity of the female, but also on the efficiency of estrus detection. The detection of heat is directly related to the reproductive efficiency of the animal, so when estrus is not detected, the animal will be empty for more days and, consequently, fewer days in production.

Thus, to support technical decision-making in a dairy farm, it is necessary to consider not only the production data. Economic data are essential, as

economic efficiency is ultimately what determines the viability of the activity.

Regarding the preventive administration of antibiotics against respiratory diseases, as previously presented, animals that received the antibiotic had a production 1,097.33 liters lower compared to animals that did not receive the drug. Each calf received around one mL of the drug in a single dose, and each dose cost about R$5.40. Thus, in addition to the loss of revenue in milk production, the producer also had an expense with the drug, which would total a loss of R$ 2,383.61 for each heifer treated with the drug. Once again, it is important to note that this negative effect may not be a consequence of the drug itself, but of the respiratory diseases, making its use necessary. It would be interesting to investigate the issue in detail, in order to determine which management measure is the most recommended: if the loss caused by the observed situation is lower than the loss caused if the antibiotic were not applied (when the mortality rate increases, for example), the ideal would be to maintain preventive treatment. Otherwise, it would be better to find alternatives for the treatment and prophylaxis of respiratory diseases in the herd.

In economic terms, retained placenta causes losses of around R$ 1,211.73, and abortion followed by retention, R$ 7,813.32 per affected heifer. These values only consider the reduction in milk production, not taking into account any resulting reproductive or health problems. In other words, the losses are likely to be even greater. Quantification of losses caused by retained placenta, combined or not with abortions, determines the size of the investment that is worth making to avoid these problems. Thus, investments in vaccination, food management in the transition period and other measures that do not exceed these values are likely to be adopted in breeding.

Slight increases in age at first mating can have important economic impacts on decision making. The 21-day delay caused by the failure to identify an estrus would imply a reduction in production by 158 liters in the first lactation. With respect to females with minimum (308 days) and maximum (615 days) ages at mating, there would be a difference of 2,307 liters. This is relevant to assess the feasibility of investing in practices such as fixed-time insemination or improving heat identification practices.

The lowest milk revenue for lactation induced-cows combined with the cost of

the lactation induction protocol, about R$ 342.45 per heifer, adds up to R$ 5,759.76 per head. Thus, the producer should compare the viability of this management to other alternatives, such as making a new attempt at conception. All factors that are directly related to the cyclicity of animals in the postpartum period are directly related to reproductive efficiency, which has a great influence on property costs.

CONCLUSION

The kinship, feeding, use of hormones for synchronization and average daily gain at 90 days did not influence the production in the first lactation of heifers. Nevertheless, antibiotic application, age at mating, retained placenta, abortion and lactation induction had significant effects on production in the first lactation. These factors had a negative economic impact of R$2,381.21, R$342.45, R$1,060.96, R$6,841.16 and R$5,043.11, respectively.

Knowing the economic consequences of each of these items, the producer has subsidies to recognize how much they can spend on management to prevent such losses, in order to improve the result and viability of production.

Acknowledgments

We would like to thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financil support nº. 02/2019 PIBIC CNPq of the Federal University of Uberlândia.

REFERENCES

ADLER, F.; CHRISTLEY, R.; CAMPE, A. Invited review: Examining farmers' personalities and attitudes as possible risk factors for dairy cattle health, welfare, productivity, and farm management: A systematic scoping review. **Journal of dairy science**, v. 102, p. 3805-3824, 2019. https://doi.org/10.3168/jds.2018-15037

AGHAKESHMIRI, F.; AZIZZADEH, M.; FARZANEH, N.; GORJIDOOZ, M. Effects of neonatal diarrhea and other conditions on subsequent productive and reproductive performance of heifer calves. **Veterinary Research Communications**, v. 41, p. 107-112, 2017. https://doi.org/10.1007/s11259-017-9678-9

AZEVEDO, R. A.; FELIX, T. M.; JÚNIOR, O. D. S. P.; ALMEIDA, A. C.; DUARTE, E. R. Perfil de propriedades leiteiras ou com produção mista no norte de minas gerais. **Revista Caatinga**, v. 24, p. 153-159, 2011.

AZEVEDO, R. A. D.; RUFINO, S. R. D. A.; DUARTE, D. V. L.; SOARES, A. C. M.; GERASEEV, L. C. Desempenho de bezerros leiteiros em aleitamento artificial convencional ou fracionado. **Revista Brasileira de Saúde e Produção Animal**, v. 15,

n. 1, p. 237-247, 2014. http://dx.doi.org/10.1590/S1519-99402014000100023

BONAMY, M.; KLUSKA, S.; PERIPOLLI, E.; DE LEMOS, M. V. A.; AMORIM, S. T.; VACA, R. J.; BALDI, F. Genetic association between different criteria to define sexual precocious heifers with growth, carcass, reproductive and feed efficiency indicator traits in Nellore cattle using genomic information. **Journal of Animal Breeding and Genetics**, v. 136, p. 15-22, 2019. https://doi.org/10.1111/jbg.12366

BURALLI, P. H. B.; CAVALIERI, F. L. B.; ANDREAZZI, M. A.; COLOMBO, A. H. B.; MOROTTI, F. Uso de implantes reutilizáveis de progesterona: uma biotecnologia reprodutiva sustentável. **Revista Valore**, v.4, p.324-335, 2019. https://doi.org/10.22408/reva402019334324-335

CARDOSO CONSENTINI, C. E.; WILTBANK, M. C.; SARTORI, R. Factors that optimize reproductive efficiency in dairy herds with an emphasis on timed artificial insemination programs. **Animals**, v. 11, p. 301, 2021. https://doi.org/10.3390/ani11020301

DEREJE, T.; BENTI, D.; FEYISA, B.; ABIY, G. Review of common causes of abortion in dairy cattle in Ethiopia. **Journal of Veterinary Medicine and Animal Health**, v. 10, p. 1-13, 2018. https://doi.org/10.5897/JVMAH2017.0639

DJURICIC, D.; VINCE, S; ABLONDI, M.; DOBRANIC, T.; SAMARDZIJA, M. Effect of preventive intrauterine ozone application on reproductive efficiency in Holstein cows. **Reproduction in Domestic Animals**, v. 47, p. 87-91, 2012. https://doi.org/10.1111/j.1439-0531.2011.01805.x

FERREIRA, R. M.; CONTI, T. L.; GONÇALVES, R. L.; SOUTO, L. A.; SALES, J. N. D. S.; SÁ FILHO, M. F. D.; BARUSELLI, P. S. Synchronization treatments previous to natural breeding anticipate and improve the pregnancy rate of postpartum primiparous beef cows. **Theriogenology**, v. 114, p. 206-211, 2018. https://doi.org/10.1016/j.theriogenology.2017.11.022

GELSINGER, S. L.; HEINRICHS, A. J.; JONES, C. M. A meta-analysis of the effects of preweaned calf nutrition and growth on first-lactation performance. **Journal of Dairy Science**, v. 99, p. 6206-6214, 2016. https://doi.org/10.3168/jds.2015-10744

HEINRICHS, A. J.; JONES, C. M.; GRAY, S. M.; HEINRICHS, P. A.; CORNELISSE, S.A.; GOODLING, R.C. Identifying efficient dairy heifer producers using production costs and data envelopment analysis. **Journal of Dairy Science**, v. 96, p. 7355–7362, 2013. https://doi.org/10.3168/jds.2012-6488

HEWITT, A.; OLCHOWY, T. W. J.; JAMES, A. S.; FRASER, B.; RANJBAR, S.; SOUST, M.; ALAWNEH, J. I. Linear body measurements and productivity of subtropical Holstein–Friesian dairy calves. **Australian veterinary journal,** v. 98, n. 7, p. 280-289, 2020. https://doi.org/10.1111/avj.12950

IBGE. Instituto Brasileiro de Geografia e Estatística. **Pesquisa trimestral do leite** – 4º trimestre de 2018. IBGE, 2019.

LEBLANC, S.J. Postpartum uterine disease and dairy herd reproductive performance: a review. **The Veterinary Journal**, v.176, p. 102-114, 2008. https://doi.org/10.1016/j.tvjl.2007.12.019

LUZ, G. B.; MAFFI, A. S.; XAVIER, E. G.; CORREA, M. N.; GASPERIN, B. G.; BRAUNER, C.

C. Induction of lactation in dairy heifers: milk production, inflammatory and metabolic aspects. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 72, p. 371-378, 2020. http://dx.doi.org/10.1590/1678-4162-11246

MELLADO, M.; ANTONIO-CHIRINO, E.; MEZA-HERRERA, C.; VELIZ, F. G.; AREVALO, J. R.; MELLADO, J.; SANTIAGO, A. Effect of lactation number, year, and season of initiation of lactation on milk yield of cows hormonally induced into lactation and treated with recombinant bovine somatotropin. **Journal of Dairy Science**, v.94, p.4524-4530, 2011. https://doi.org/10.3168/jds.2011-4152

NOR, N. M.; STEENEVELD, W.; VAN WERVEN, T.; MOURITS, M. C. M.; HOGEVEEN, H. First-calving age and first-lactation milk production on Dutch dairy farms. **Journal of Dairy Science**, v. 96, p. 981-992, 2013. https://doi.org/10.3168/jds.2012-5741

RAMGATTIE, R.; SIEW, N.; DIPTEE, M.; STOUTE, V.; KNIGHTS, M. Effect of mammary stimulation on dairy cows and heifers exposed to a lactation induction protocol. **Open Journal of Animal Sciences**, v. 2014, 2014. https://doi.org/10.4236/ojas.2014.41001

RASHID, M.; RASHID, M. I.; AKBAR, H.; AHMAD, L.; HASSAN, M. A.; ASHRAF, K.; SAEED, K.; GHARBI, M. A systematic review on modelling approaches for economic losses studies caused by parasites and their associated diseases in cattle. **Parasitology**, v. 146, p. 129-141, 2019. https://doi.org/10.1017/S0031182018001282

RESENDE, J.C.; MARTINS, P.C. **Juiz de Fora:** Embrapa Gado de Leite, 2018. 62 p. (Embrapa Gado de Leite. Documentos, 212.) 2013.

ROCHA, D.T. Evolução tecnológica da atividade leiteira no Brasil: uma visão a partir do Sistema de Produção da Embrapa Gado de Leite. In: ROCHA, D.T. da; RESENDE, J.C.; MARTINS, P.C. **Juiz de Fora**: Embrapa Gado de Leite, 2018.62 p. (Embrapa Gado de Leite. Documentos, 212.).

RODRIGUES, A. S.; SILVA, M. A.A. BRANDÃO, T. O.; NASCIMENTO, A. B.; BITTENCOURT, R. F.; CHALHOUB, M.; BITTENCOURT, T. C.B.S.C.; RIBEIRO FILHO, A. DE L. **Pesquisa Veterinária Brasileira**. v. 38, p. 1518-1527, 2018. https://doi.org/10.1590/1678-5150-pvb-5371

SANTOS, G.; LOPES, M. A. Custos de produção de fêmeas bovinas leiteiras do nascimento ao primeiro parto. **Ciência Animal Brasileira**, v. 15, p. 11-19, 2014.

SIGNORETTI, R. D. Práticas de manejo para correta criação de bezerras leiteiras. Artigo Técnico. **Consultoria Avançada em Pecuária**., v. 21, 2015.

SIMÕES, A.R.P.; OLIVEIRA, M.V.M.; LIMA-FILHO, D.O. Tecnologias sociais para o desenvolvimento da pecuária leiteira no Assentamento Rural Rio Feio em Guia Lopes da Laguna, MS, Brasil**. Interações**, v. 16, p. 163-173, 2015.

SMITH, D. R. Risk factors for bovine respiratory disease in beef cattle. **Animal Health Research Reviews**, v. 21, p. 149-152, 2020. https://doi.org/10.1017/S1466252320000110

TEIXEIRA, V. A.; NETO, H. D. C. D.; COELHO, S. G. Efeitos do colostro na transferência de imunidade passiva, saúde e vida futura de bezerras leiteiras. **Nutritime Revista Eletrônica**. Viçosa, v.14, p.7046-7052, 2017.