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Influence of the calving season of Girolando calves on development in the initial phase after birth, reproductive performance, and productive performance

Influência da estação de nascimento de bezerras girolando no desenvolvimento na fase de cria e desempenho reprodutivo e produtivo

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Abstract: Raising heifers is one of the most important activities in dairy farming because heifers eventually replace the herd. This study was performed to evaluate how the calf's birth season affects its early development and its reproductive and productive performance. The experiment was conducted at the Glória Experimental Farm of the Federal University of Uberlândia, Minas Gerais, Brazil. In total, 74 female calves born from January 2018 to March 2020 were evaluated from the first day of life to the end of their first lactation. The animals were classified according to their season of birth: spring/summer (October–March) or fall/winter (April–September). During the initial phase of life, the animals' weights were assessed on days 0, 30, and 60 after birth and at weaning. The rectal temperature, fecal score, feed intake, and animal behavior were recorded daily. In the mature phase of life, the dates of conception and calving were evaluated, and milk production during the first lactation was monitored. The following variables were analyzed according to season of birth: weight gain and occurrence of diseases during the initial phase, percentage of heifers that calved, age at first calving, and average milk production during the first lactation. Continuous variables were analyzed by analysis of variance, and binomial variables were analyzed by logistic regression using the Minitab software program. Calves born in fall/winter had a higher weight at 30 days; however, this difference was compensated for during the initial phase and did not interfere with reproductive and productive performance.

Keywords: age at first calving; dairy cattle; first lactation; weaning

Resumo: A criação de bezerras é uma das atividades mais importantes na bovinocultura leiteira, visto que estas serão os animais de reposição do rebanho. Objetivou-se avaliar o efeito da estação de nascimento da bezerra no desenvolvimento na fase de cria e desempenho reprodutivo e produtivo. O experimento foi conduzido na Fazenda Experimental Glória, da Universidade Federal de Uberlândia. Foram avaliadas 74 bezerras nascidas de janeiro/2018 a março/2020, desde o primeiro dia de vida ao final da sua primeira lactação. Os animais foram categorizados de acordo com a estação de nascimento: primavera/verão (outubro a março) e outono/inverno (abril a setembro). Durante o aleitamento foi avaliado o peso dos animais nos dias: 0, 30, 60 após o nascimento e no desaleitamento. A temperatura retal, o escore de fezes, a ingestão de alimento e o comportamento animal foram monitorados

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diariamente. Na vida adulta foram avaliadas data da cobertura fértil, do parto e monitorada a produção de leite durante a primeira lactação. As variáveis analisadas foram: ganho de peso durante o aleitamento, ocorrência de doenças na fase de aleitamento, porcentagem de novilhas que pariram, idade ao primeiro parto e média de produção de leite da primeira lactação de acordo com a estação de nascimento. As variáveis contínuas foram analisadas por análise de variância e as variáveis binomiais por regressão logística no programa MINITAB. As bezerras nascidas na estação outono/inverno apresentam maior peso aos 30 dias, porém esta diferença foi compensada durante o aleitamento, não interferindo no desempenho reprodutivo e produtivo.

Palavras-chave: bovinocultura leiteira; desaleitamento; idade ao primeiro parto; primeira lactação.

1. Introduction

Success in dairy calf husbandry requires proper health control, nutrition, adequate housing, and welfare. The nutrition of the pregnant cow is crucial for the calf's development during the final third of pregnancy[1]. The nutrition and metabolism of prepartum cows affect not only their health but also the fetus[2], likely due to physiological changes in the uterus and properties of the colostrum[3].

The colostrum produced at the end of pregnancy is the main factor determining the calf's performance and immune system development[3]. The nutrition of the pregnant cow is crucial during the dry period because it determines whether a healthy cow will produce high-quality colostrum and decreases the risk of complications during and after calving[4]. Silva[5] reported that undernutrition in pregnant cows is one of the major causes of weak and small calves.

The bovine placenta is classified as syndesmochorial, and it protects the fetus against infectious agents such as bacteria and viruses; however, it also prevents the passage of immunoglobulins by the mother to the fetus during pregnancy[6]. In addition, calves are born with an immature immune system, making them susceptible to infections. Therefore, colostrum ingestion in the first few hours of life is required to provide antibodies and protection against pathogenic microorganisms[7] and to activate the immune system[8].

Colostrum is the first secretion of the mammary gland after calving. Its production is stimulated by maternal immunoglobulins transferred into the mammary gland at the end of gestation and completed by the action of prolactin after calving[9]. Colostrum consists of immunoglobulins (specifically immunoglobulin G), nutrients, hormones, and growth factors[10]. Therefore, it provides essential initial nutrition for the calf, helps maintain body temperature immediately after birth, and ensures the delivery of growth factors and immune cells. Additionally, it stimulates the secretion of important hormones for development of the gut and villi[8,9].

For proper colostrum management, it is essential to consider the amount offered, the time of ingestion after birth, and the quality of the colostrum. These factors are crucial for successful transfer of passive immunity (TPI)[11]. TPI can be evaluated via calf blood samples collected within 7 days of colostrum ingestion. Total proteins are measured in the animal's serum using a protein refractometer, and animals with total protein levels of >5.5 d/dL are considered to have proper TPI[12]. Failure of TPI is defined when animals evaluated 24 to 48 hours after birth have blood immunoglobulin G concentrations of <10 mg/mL[8]. To reduce TPI failure, it is important to maintain a colostrum bank on the farm to address shortages when a newly calved cow does not produce enough colostrum or produces low-quality colostrum.

The most common diseases affecting calves during the initial phase after birth are diarrhea, tick-borne disease, pneumonia, and umbilical problems[13]. During this phase, the average mortality rate is 10.8%, with 60.5% of deaths caused by diarrhea or other digestive problems, 24.5% by respiratory problems, and 15.0% by other conditions[14]. Diseases that affect calves during the pre-weaning phase have an adverse economic impact due to the loss of calves and the cost of medication, and they may also negatively impact long-term production and reproductive performance[13].

The production and survival of an animal depend on its ability to maintain its body temperature within narrow limits (homeothermy); i.e., the ability to maintain the body temperature at constant levels regardless of environmental temperature variations[15]. In extreme cold or heat, animals mobilize their energy to maintain a normal body temperature[16]. Heat stress and hypothermia influence animals' physiological responses, including water and food consumption, and affect their productive and reproductive performance[17]. Therefore, understanding the animal's interaction with and adaptability to the environment is important for managing dairy cattle to minimize problems and enhance performance.

Calves are influenced by environmental conditions even during their time in the uterus. Cows experiencing heat stress during pregnancy, especially in the last 45 days, are more likely to give birth to lightweight calves because of a shortened gestation period[18]. Soon after birth, calves have no ability to regulate their own temperature; therefore, abrupt temperature changes can lead to increased mortality[19].

Therefore, several aspects must be considered to achieve success in calf husbandry. Based on the above facts, our hypothesis was that when calves are born in spring and summer, with high temperatures and average humidity, both pregnant cows and newborn calves experience greater stress. This leads to increased susceptibility to disease, lower weaning weights, and consequently lower reproductive efficiency and milk production during the first lactation. This study was performed to evaluate the influence of the calving season of crossbreed dairy calves on their development, disease occurrence in the initial phase after birth, and reproductive and productive performance.

2. Materials and methods

2.1 Study location and animals

All animal procedures in this study were conducted in accordance with the ethical principles of animal experimentation established by the Ethics Committee on the Use of Animals (CEUA) of the Federal University of Uberlândia (UFU).

Data were collected at the Glória Experimental Farm of the Federal University of Uberlândia, located in Uberlândia, Minas Gerais, Brazil (18º 55' 07" S, 48º 16' 38" W). The herd consisted of 243 animals, including lactating cows, dry cows, heifers, and calves. The animals were Girolando crossbreds with breed compositions of 1/2, 3/4, and 7/8 Holstein and Gir.

In total, 74 female calves born from January 2018 to March 2020 were evaluated. The calving season was divided into spring/summer (S/S) (October–March) and fall/winter (F/W) (April–September). Of the 74 female calves, 37 were born in S/S and 37 were born in F/W. All calves were monitored from birth until the end of their first lactation.

2.2 Calf management, diet, and facilities

After birth, the calves were separated from their mothers and given a 10% iodine umbilical treatment. The cows were milked by hand to obtain their colostrum, which was evaluated using a Brix refractometer (Model IPB 32KT; SPLABOR, Presidente Prudente, São Paulo, Brazil) before being given to the calves. High-quality colostrum (refractometer value of >21 degrees Brix) was given to the calf via bottle or esophageal tube if necessary. After receiving initial care, the calves were moved to individual calf pens. The management from after birth to weaning was performed by trained staff, and the master's student in charge of data collection for the study assisted and monitored the management.

The calf pens were of the Argentinean type, featuring wire flooring and strings to which the calves were tied. The calves were kept in the pens for 72 days until weaning. Water and feed were supplied *ad libitum*. The feed was a commercial concentrate (ground corn, soybean meal, wheat bran, corn germ meal, corn bran, calcitic limestone, sodium chloride, and vitamin and mineral premix with guaranteed levels of 14.0 g raw protein, 2.0 g ether extract, 12.0 g mineral matter, 1.5 g calcium, 0.5 g phosphorus, and 12.0 g crude fiber). The calves were fed twice a day (at 7:00 AM and 4:00 PM) with milk replacer (Nattimilk; Auster Animal Nutrition, São Paulo, Brazil) at a dilution of 8 L of water for every 1 kg powder of milk replacer.

Newborn calves were given transition milk, then fed as follows: 0–40 days, 6 L of milk replacer per day; 41–65 days, 4 L of milk replacer per day; and 66–72 days, gradually weaned (for the first 5 days, 2 L of milk replacer was given in the morning, and for the last 2 days, 1 L of milk replacer was given in the morning).

2.3 Heifer and lactating cow management, diet, and facilities

There were 3 grazing paddocks (2 with Mombaca grass and 1 with Brachiaria grass), all divided into 24 sections. During the dry season, the heifers received silage and feed supplementation at the feeder. During the rainy season, they were managed in the paddocks and continued to receive feed supplementation at the feeder.

The feed supplementation was produced at the farm's own factory and consisted of citrus pulp (75.2%), corn (20.0%), and mineral salt (4.8%). When the heifers reached a body weight of 300 kg, they were transferred to the insemination group. In this group, estrus observation was conducted daily, and heifers found to be in estrus were artificially inseminated. Pregnancy was diagnosed 32 ± 4 days after insemination by transrectal ultrasound, and pregnancy was confirmed 45 ± 4 days after insemination by rectal palpation.

The milk production system was semi-confined. In the rainy season (S/S), the lactating cows received concentrate supplementation in the feeder before milking, and after milking, they remained in the pasture until the next milking. In the dry season (autumn/winter), the cows were fed a mixture of silage (produced on the property) and concentrate supplementation in the feeder for the entire day.

The farm's milking parlor was of the fishbone type, with eight cows on each side and eight milkers, two of which were mechanically extracted. The cows were milked twice a day, with pre-dipping and post-dipping procedures repeated at each milking using the mug test. The milk was weighed every 15 days. The cows were treated with bovine somatotropin every 15 days starting at 60 days after calving, and the treatment was suspended either when the cow produced <15 L/day or at 30 days before drying off.

2.4 Variables evaluated in calves, heifers, and primiparous cows

During the initial phase, weight data were collected at birth, at 30 days, at 60 days, and at weaning using a weighing tape (Bovitec, São Paulo, Brazil). The tape was positioned firmly behind the shoulder blades to measure the chest circumference.

The incidence of diseases such as tick-borne disease, pneumonia, and diarrhea was also evaluated. For this purpose, the body temperature was measured every day before feeding the morning milk, the mucous membranes were examined, and the fecal score was obtained[20]. The animals' condition (alert or apathetic) and consumption of milk, feed, and water were also monitored daily. When any of these characteristics were altered, the females were considered to be ill and the appropriate treatment was administered.

The following data were collected from heifers in the reproductive phase: fertile insemination date, first calving date, milk production throughout the first lactation, and milk production closest to 60, 100, 150, 200, and 250 days during lactation.

2.5 Statistical analysis

The data collected during the study were recorded in Excel (2016) files. For the statistical analyses, the data on the calves' season of birth were divided into S/S and F/W. The data were tested for normality. Continuous variables [weight (birth, 30 days, 60 days, and weaning), age at first fertile insemination, and milk production (60, 100, 150, 200, and 250 days of lactation)] were analyzed by analysis of variance, and the binomial variable percentage of heifers that calved during the study period was analyzed by logistic regression. Both analyses were performing using Minitab software (Minitab LLC, State College, PA, USA), and only the season effect was included in the model. Statistical differences were defined by $P \leq 0.05$, and trends were indicated by $0.05 < P < 0.10$.

3. Results

In total, 37 calves born in each birth season category (S/S vs. F/W) were evaluated. Although the calves born in F/W had numerically higher average body weights throughout the initial phase (Table 1), a statistically significant difference was observed only at 30 days; i.e., calves born in F/W had higher average body weights at 30 days than those born in S/S (P = 0.01). However, the calves in both groups had similar performance throughout the initial phase.

Table 1. **Weight of dairy calves at birth, 30 days, 60 days, and weaning according to birth season**

Birth season	Body weight, kg			
	Birth	30 days	60 days	Weaning
Spring/summer	42.76 ± 5.59	60.58 ± 2.21[a]	81.68 ± 2.20	95.73 ± 2.25
Fall/winter	42.84 ± 5.68	68.49 ± 2.00[b]	85.00 ± 2.25	97.04 ± 2.71
P value	0.951	0.010	0.295	0.711

Data are presented as mean ± standard error.
[a,b]Means followed by different letters in the same column differ between themselves (P < 0.05).

The calves were monitored throughout the initial phase, and the number of each calf's illnesses was recorded on a worksheet. There was no effect of the season of birth on the occurrence of diseases during the initial phase (P = 0.886) (Figure 1). Calves born in F/W had an average of 1.946 health problem events, while calves born in S/S had an average of 1.919 events. The occurrence of diarrhea was the most prevalent event, followed by tick-borne disease.

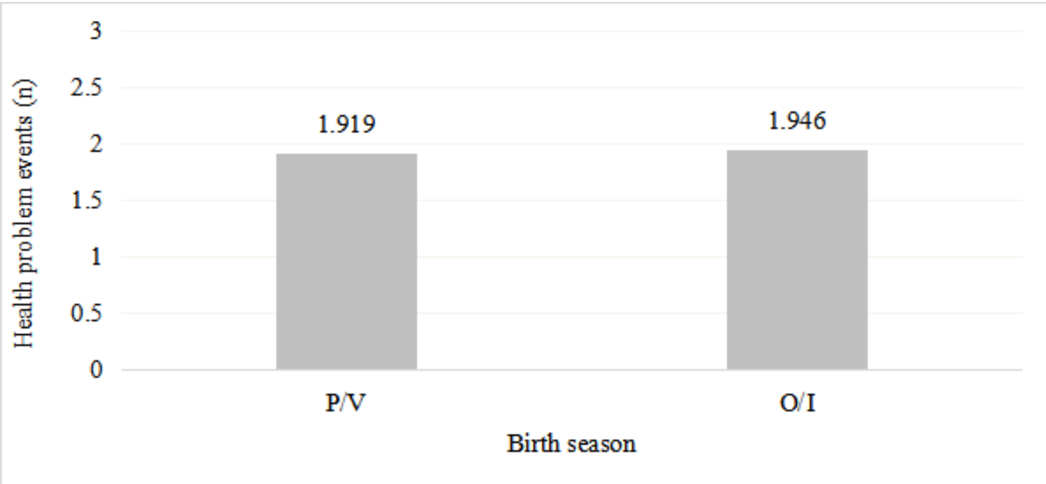

Figure 1 **Mean incidence of health problem events in dairy calves during the initial phase according to birth season. S/S, spring/summer; F/W, fall/winter.**

Of the calves born in F/W, 94.59% calved, and of those born in S/S, 83.78% calved. The birth season had no effect on this parameter (P = 0.153) (Figure 2). One calf born during F/W and six calves born during S/S did not calve during the study period because of death after weaning or culling.

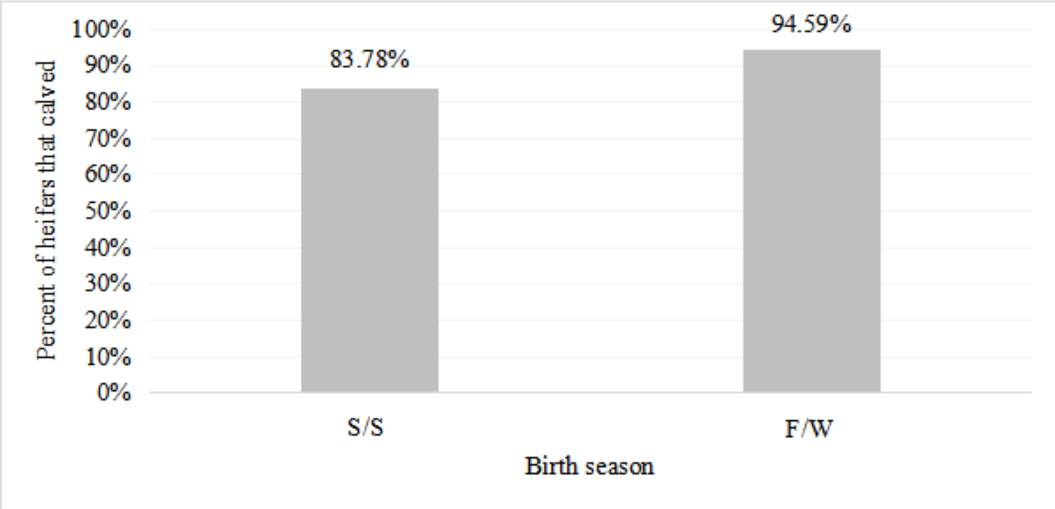

Figure 2 Percentage of dairy heifers that calved during the study period according to birth season. F/W, fall/winter; S/S, spring/summer.

The mean age at first calving of the 31 heifers born in S/S was 32.71 ± 1.09 months, and that of the 35 heifers born in F/W it was 32.34 ± 0.94 months. Thus, no effect of birth season on age at first calving was detected (P = 0.798) (Figure 3).

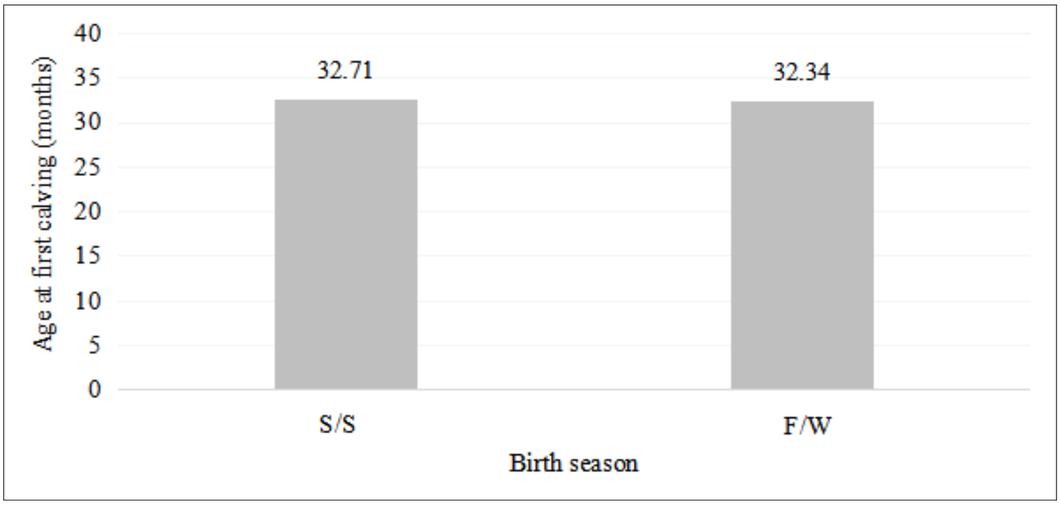

Figure 3 Mean age at first calving of dairy heifers according to birth season. F/W, fall/winter; S/S, spring/summer.

Figure 4 shows the average milk production during the first lactation of the cows evaluated. Although the females born in F/W presented a numerically higher average milk production throughout their lactation, no significant effect of birth season on production was observed (P > 0.10).

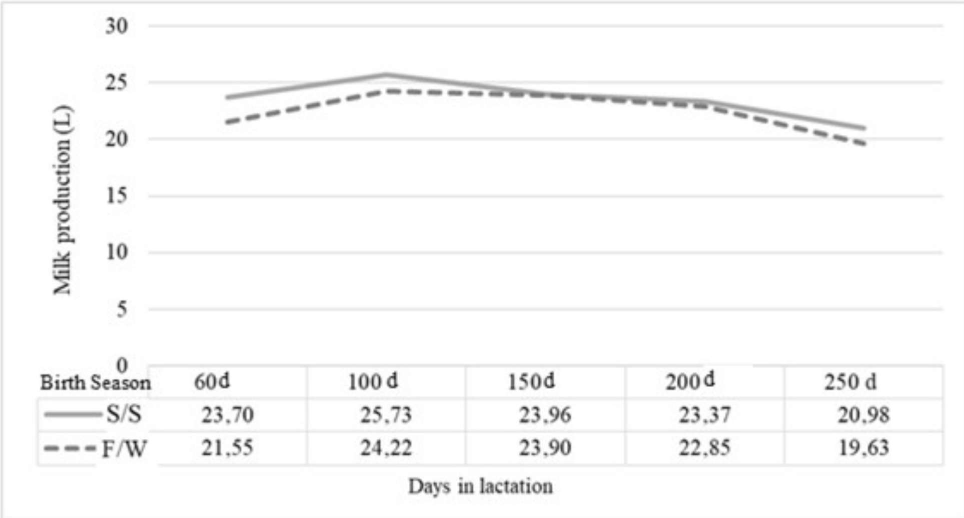

Figure 4 **Average milk production in the first lactation of dairy females according to birth season. F/W, fall/winter; S/S, spring/summer.**

4. Discussion

Verde[21] evaluated the influence of birth season on the development and reproductive efficiency of Holstein calves and found no influence of birth season on birth weight. However, the study showed that calves born in summer had lower body weights at 30 days than those born in winter[21].

Santos[22] evaluated the change in weight from birth to weaning of Girolando calves raised in an Argentine-type nursery system and fed with milk replacer. The study showed no influence of birth season on the performance of the calves from birth to weaning[22]. Rodrigues[23] evaluated the effect of season (summer and winter) on the development of Holstein calves and found no influence of birth season on either birth weight or body weight at 30 and 60 days.

By contrast, Lima[24] evaluated the influence of the birth season, the occurrence of diseases, and PTI in Holstein calves in the initial phase after birth and found that animals born in winter presented lower body weight gain than calves born in other seasons.

The variety of results reported in the literature on the effect of birth season on calves' performance is probably due to the different breeds, regions, management, food availability, and food quality used in the experiments. Any of these factors can alter calves' performance, making it difficult to compare the results of the birth season effect between the data reported in the literature.

In the present study, the cows consumed silage during the dry season and then grazed Brachiaria grass during the rainy season; throughout both seasons, they consumed the same amount of concentrate supplementation in the same proportion. The cows were exposed to climatic variations, with one season being warmer with high humidity and the other colder with low humidity. However, these variations in roughage consumption and seasonal changes only influenced the weight of the calves at 30 days after birth (Table 1).

One possible explanation for this difference in weight at 30 days according to the birth season could be the difference in TPI. Because TPI was not evaluated in this study, which group of animals was more efficiently colostrum-fed is unknown. Calves with colostrum feeding failure experience negative effects in the initial phase of life; therefore, TPI failure in calves born in S/S may have reduced the average weight at 30 days. However, this reduction was compensated for in subsequent periods.

Silva[5] evaluated the impact of maternal factors on the health profile, productive performance, and reproductive performance from birth to the first calving of Holstein dairy calves fed milk replacer. Their results differed from ours in that the birth season influenced the frequency of diarrhea in the calves; specifically, 18.75% born in the summer became ill, while 47.36% and 50.00% born in the fall and winter, respectively, became ill[5]. According to these authors, calves born in the coldest months were 4.04% more likely to be treated for diarrhea, indicating that cold stress was a risk factor for developing disease during the initial phase after birth[5]. One possible explanation for this finding is that thermoregulation in neonates is not fully mature. Only 2% of birth weight is composed of brown adipose tissue, which is responsible for heat production[25]. The stress caused by failure to regulate the body temperature in low environmental temperatures increases the cortisol concentration; this has a negative effect on the immune system under stressful conditions, and a depressed immune system can increase animals' susceptibility to disease[26].

This variation in results can be explained by several existing risk factors (prepartum and newborn management), differences in climate and feed on the farms, and the difference between the breeds studied. The present study involved Girolando calves with 1/2, 3/4, and 7/8 Holstein and Gir, whereas the study by Silva[5] involved Holstein calves. According to some studies, crossbred calves tend to have stronger immunity than purebred calves[27,28]. Weigel and Barlass[29] conducted a series of surveys of dairy farmers and found a lower mortality rate in the early stages of life in crossbred calves than in purebred Holstein calves.

In the present study, the diseases developed by the calves were monitored and treated in the same way throughout the year despite climatic variations in some months, ranging from extreme heat to cold and from low to high humidity. These changes were not sufficient to cause a significant variation in the incidence of diseases according to the birth season.

Vannucchi et al.[26] and Martins et al.[18] evaluated the effects of bioclimatological conditions and birth season on the reproductive efficiency of milk-fed Holstein calves. As in the present study, the authors found no effects of birth season on the reproductive efficiency of heifers.

In this study, the birth season had no influence on birth weight or weaning weight. Based on this fact, we can assume that the females also had similar performance until puberty, resulting in the similar reproductive efficiency seen between females born in S/S and F/W.

Guimarães et al.[30] evaluated which reproductive and productive indexes can influence the reproductive efficiency of Holstein–Zebu crossbred animals and found that the birth season was not correlated with the indexes studied.

Hawk et al.[31] evaluated the effects of inbreeding, diarrhea, and birth season on age at first estrus in Holstein heifers, and Roy et al.[32] evaluated the effect of season on puberty and conception in Holstein dairy heifers. Both studies showed that heifers born in the summer and spring reached puberty earlier than those born in the fall and winter. Therefore, those born in the summer and spring had higher chances of conception and consequently calved earlier.

The nutritional, health, and environmental management of heifers can determine their body weight gain and consequently affect their age at first calving. In this study, all the calves and heifers were managed in the same way throughout the year, and despite the climatic changes and variations in food availability that occurred during the year, the birth season did not affect the age at first calving.

Chester-Jones et al.[11] evaluated the correlation between early life parameters (body weight, milk replacer intake, and birth season) and first lactation performance in Holstein animals fed milk replacers. The authors found that heifers born in the summer produced 276 kg more milk in 305 days of lactation than those born in the fall and winter. Similarly, Silva[33] evaluated the correlation of nutrient intake from milk replacer and the pre- and post-weaning growth rate with performance in the first lactation in a dairy herd. The author found that summer-born heifers produced 556 kg more milk in the first lactation than winter-born heifers. This result may have been due to winter-born heifers exhibiting lower average daily weight gain (ADG) and a higher requirement for maintenance due to the lower ambient temperature[33]. By contrast, Barash et al.[6] evaluated the effect of the birth season of Holstein heifers on milk, fat, and protein production and observed that milk production was lower in heifers born in early spring than in fall.

Despite the difference in feeding between the seasons (one being based on corn silage and the other on pasture) and the climate and humidity variations during the year, no factors were sufficient to impact milk production in the first lactation according to the calves' birth season.

5. Conclusion

Under the conditions of the present study, calves born in F/W weighed more at 30 days of age than those born in SS, although this difference was recovered during the initial phase and did not interfere with their reproductive and productive performance during the first lactation.

Conflict of interest statement

The authors declare that there is no conflict of interest.

Author contributions

Conceptualization: R.M. dos Santos. *Data curation:* R.M. dos Santos. *Formal analysis:* R.M. dos Santos, F.S. Oliveira, and N.S. Reis. *Funding acquisition:* R.M. dos Santos. *Project management:* R.M. dos Santos. *Methodology:* R.M. dos Santos, F.S. Oliveira, and N.S. Reis. *Supervision:* R.M. dos Santos. *Research:* R.M. dos Santos and F.S. Oliveira. *Visualization:* R.M. dos Santos and F.S. Oliveira. *Writing (original draft):* F.S. Oliveira. *Writing (review and editing):* N.S. Reis.

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