

Effects of the Bull on Conception Rate of Dairy Cows in Different Seasons and According to AI Type

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ABSTRACT

Background: Reproductive efficiency is one of the most important factors affecting the performance dairy cattle, and fixed-time artificial insemination (TAI) is an important biotechnology factor employed in bovine livestock. The achievement of satisfactory results in TAI protocols depends of several factors, such as health and body condition, milk yield, environmental temperatures, ovulation time, semen manipulation, as well as semen quality. The goal of this study was to evaluate the conception rate of heifers and multiparous cows based on different Holstein bulls used for artificial insemination (AI). The effects of the type of management AI, animal category, and season of the year were also examined.

Materials, Methods & Results: A three-year database on the reproductive management of a dairy farm was formed. All the cows and heifers were of the Holstein breed, in semi-intensive nutritional management, milked twice a day, and received a total mix ration. After 45 days in milk, when cows were observed twice daily with estrus signs, posterior artificial insemination occurred 12 h after estrus visualization was made. However, cows that were not observed in estrus were submitted to a timed artificial insemination (TAI). In this study, these fixed factors were considered: bulls utilized for the AI (totalizing 10 animals with at least 100 inseminations in each season, denoted by the letter B and a number - B1, B2, B3, B4, B5, B6, B7, B8, B9, B10); the season of the insemination (spring/summer being from November to April and autumn/winter from May to October), category animal (heifers, animals that never have been calved, or multiparous, animals that have already given birth more than once), and the type of AI (which included TAI using a protocol for synchronization, but cows having not necessarily shown estrus signs at the AI; ETAI: using protocol of synchronization, cows showing estrus signs at the AI; and AI with estrus visualization, without protocol of synchronization when animals were observed in estrus and were inseminated 12 h later. The fertility parameter of the bulls and reproductive performance in AI was based on conception rate. There was a statistical difference among different bulls in the same season ($P \leq 0.05$). There was also a difference in reproductive performance of the same bulls between seasons, autumn/winter and spring/summer; B8 37.8% vs. 32.0% ($P = 0.05$) and B10 35.1% vs. 20.7% ($P = 0.003$). Regarding the individual animal category, only one bull (B6) demonstrated higher reproductive performance when utilized in the AI of heifers than multiparous 39.2% vs. 27.2% ($P = 0.01$). Similarly, regarding the effect of the type of AI, only one bull (B8) exhibited different results, obtaining better results for conception rate when utilized in fixed TAI with estrus visualization (35.5%) and in the AI with estrus visualization (39.0%) compared with that of TAI [19.9%] ($P < 0.05$).

Discussion: From these results, it was observed that some bulls exhibited better performance in situations of greater challenge. In addition, some animals presented variation in efficiency with the demonstration of estrus or not. Therefore, bulls that present semen with higher fertility in certain types of AI could be utilized on a larger scale for to increase the reproductive rates in artificial insemination. The results of this study indicate that despite the tests indicating the semen that is submitted is adequate, there are still variations in quality and the reproductive efficiency of each bull. With the effects varying based on fertility and on different environmental and management situations.

Keywords: dairy cattle, estrus visualization, fertility, fixed-time artificial insemination, reproductive management.

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INTRODUCTION

The reproductive efficiency is one of the most important factors affecting the performance and profitability of dairy cattle [3]. Fixed-timed artificial insemination (TAI) is an important biotechnology factor employed in cattle [7], which is used for improvement and genetic advances [8].

The achievement of satisfactory results in TAI protocols depends of several factors, such as health and body condition, milk yield, environmental temperatures, insemination time in relation to ovulation time, semen manipulation and placing, as well as semen quality [12-14].

Temperature is an important environmental factor that has a substantial effect on reproductive results, particularly in high producing dairy cows, which are extremely sensitive to climatic conditions [5,9]. In addition, the physiological functions within the dairy cow are quite complex, and it is known that bulls also have a fundamental and determinant role in conception rate. Semen utilized in artificial insemination is provided by specialized companies; however, even proven bulls showing satisfactory reports in seminal quality, some factors remain to be evaluated. Therefore, these unknown effects could potentially interfere with the results of conception.

Because of individual variation in the bull and the semen used, there are potential limitations based on season (autumn/winter or spring/summer), and also the productivity capacity of the herd. The goal of this study was to evaluate conception rate of heifers and multiparous cows based on different Holstein bulls used in artificial insemination, and also related with the type of AI, animal category (heifers or multiparous), and season of the year.

MATERIALS AND METHODS

Experimental design

The data for this study were obtained retrospectively from a reproductive database of 9488 inseminations of dairy cows and heifers mated with 10 bulls, in a dairy farm with 800 cows in milk, localized in Rio Grande - RS (Brazil) coordinates 32°16 S, 52°32 W. This includes information for inseminations conducted during 2012-2014.

All the cows and heifers were of the Holstein breed, in semi-intensive nutritional management, milked twice a day, and received a total mix ration. After 45 days in milk, when cows were observed twice daily with

estrus signs, posterior artificial insemination occurred 12 h after estrus visualization was made. However, cows that were not observed in estrus were submitted to a TAI.

TAI protocol

During the TAI protocol, on day 0, the animals received 2 mg of estradiol benzoate (Gonadiol®, im)¹ and a vaginal device containing 1.9 g of progesterone (CIDR®)¹. On day 7, the devices were removed, and 5 mg of dinoprost (Lutalyse®)¹ was administered. On day 8, 0.5 mg of estradiol cypionate (E.C.P®)¹ was administered, and on day 10 the AI was performed whether estrus was detected or not. Pregnancy status was determined by ultrasonography at 28 to 35 d after AI. Examinations with and ultrasound (5-0-MHz, Weld 3000, B-mode)² and transrectal linear probe were performed for the diagnosis of pregnancy at 30 days after artificial insemination.

Artificial insemination

In this study, these fixed factors were considered: bulls utilized for the AI (totalizing 10 animals with at least 100 inseminations in each season); the season of the insemination (spring/summer being from November to April and autumn/winter from May to October), category animal (heifers, animals that never have been calved, or multiparous, animals that have already given birth more than once), and the type of AI, which included TAI (using a protocol for synchronization, but cows having not necessarily shown estrus signs at the AI); ETAI (using protocol of synchronization, cows showing estrus signs at the AI), and AI with estrus visualization, without protocol of synchronization (when animals were observed in estrus and were inseminated 12 h later). The semen were provided from specialized centrals, and mating was previously professionally conducted to improve the genetic and phenotypic characteristics. As a criterion of inclusion, only bulls that presented at least 100 AI in each variable evaluated, and were denoted in this study by the letter B and a number (B1, B2, B3, B4, B5, B6, B7, B8, B9, B10) for identification in the results without exposing the commercial name.

Statistical analysis

Statistical analysis was performed using the program NCSS 2005. The data were analyzed using the cross tabulation and/or chi-square tests for percentage of conception, considering significant results those with probability values equal or less than 0.05.

RESULTS

In this study, the fertility parameter for the bulls, and the reproductive performance in the TAI, was based on conception rate. Different bulls in the same season were compared, and under same conditions of presence or absence of estrus at the time of AI. Furthermore, the performance of the same bull in relation to different factors (season, estrus presentation) was evaluated.

Table 1 shows the bulls' performance throughout the seasons. It can be observed for the season, in the spring/summer, some animals stood out, showing a good performance despite other adverse conditions. Regarding autumn/winter, when the environmental conditions were more favorable to reproduction, the performance was similar among the animals. Furthermore, some animals (B8 and B10) exhibited differences in their performance between the two seasons, having better results in autumn/winter.

For spring/summer, the conception rate for bulls B8 and B9, 32.0% and 36.8%, respectively, exhibited better performance (greater percentages) than bulls B2 (20.5%), B5 (27.4%), B7 (16.8%), and B10 (20.7%).

Regarding the reproductive performance of the same bull across seasons, only two bulls, of the six utilized with multiple seasons (autumn/winter and spring/summer), exhibited a significant difference. B8 exhibited 37.8% and 32.0% ($P = 0.05$) and B10 was successful 35.1% and 20.7% ($P = 0.003$) in autumn/winter and spring/summer, respectively.

Comparing the effect of the bull in the TAI of heifers and multiparous females with high yield (Table 2), no significant difference among categories was detected; however, when the effect between the categories (heifers vs. multiparous) was analyzed, B6 exhibited better performance when utilized in the AI of heifers than in multiparous cows ($P = 0.01$), with 39.2% vs. 27.2%, respectively.

Regarding the type of AI, TAI, ETAI, or AI with observed estrous, no differences between the bulls utilized were detected (Table 3) However, when comparing the same bull in different types of AI, only B8 presented significant differences in reproductive performance, being lower when utilized in the TAI relative to that of ETAI and AI with estrous observed ($P = 0.000013$).

Table 1. Conception rate following AI with a comparison of bulls in the same and different seasons.

Bull	Spring/Summer	Autumn/Winter	<i>P</i> (between seasons)
B1	30.3 (46/162) ^{abcA}	31.6 (80/253) ^{aA}	0.77
B2	20.5 (38/185) ^{bc}	-	
B3	-	41.5 (103/248) ^a	
B4	30.3 (69/228) ^{abc}	-	
B5	27.4 (120/460) ^{bcA}	33.1 (140/243) ^{aA}	0.06
B6	34.3 (46/134) ^{Aa}	32.6 (173/531) ^{aA}	0.70
B7	16.8 (28/167) ^{bc}	-	
B8	32.0 (198/618) ^{aA}	37.8 (168/445) ^{aA}	0.05
B9	36.8 (148/402) ^{aA}	37.6 (67/178) ^{aA}	0.84
B10	20.7 (50/242) ^{bcB}	35.1 (40/114) ^{aA}	0.003
Overall	28.59 (743/2598)	38.32 (771/2012)	< 0.001

Means followed by different lowercase letter ^{a,b,c} indicate differences between rows (Bulls), at $P < 0.05$ using the chi-square test. Means followed by different capital letters ^{A,B} indicate differences between columns (Spring/Summer Autumn/Winter), at $P < 0.05$ using the chi-square test.

Table 2. Conception rate comparing different bulls in the AI of heifers and multiparous females with high yield.

Bull	Heifers	Multiparous	<i>P</i> (heifers vs. multiparous)
B1	-	31.4 (61/194) ^a	
B2	-	22.6 (26/115) ^a	
B3	-	-	
B4	-	28.8 (42/146) ^a	
B5	32.5 (95/292) ^{aA}	29.4 (100/340) ^{aB}	0.39
B6	39.2 (60/153) ^{aA}	27.2 (76/279) ^{aB}	0.01
B7	-	-	
B8	36.8 (100/272) ^{aA}	30.8 (151/491) ^{aA}	0.09
B9	40 (78/195) ^{aA}	35.2 (74/210) ^{aA}	0.32
B10	-	23.5 (31/132) ^a	
Overall	36.51 (333/912)	29.41 (561/1907)	< 0.001

Means followed by different lowercase letter ^{a,b,c} indicate differences between rows (Bulls), at $P < 0.05$ using the chi-square test. Means followed by different capital letters ^{A,B} indicate differences between columns (Heifers vs. Multiparous), at $P < 0.05$ using the chi-square test.

Table 3. Conception rate comparison for different bulls and types of AI.

Bull	TAI	ETAI	AI observed	P (types of AI)
B1	-	-	35.4 (40/113) ^a	
B3	-	-	41.5 (44/106) ^a	
B4	-	-	-	
B5	25.5 (39/153) ^{Aa}	34.2 (65/190) ^{aA}	31.5 (91/289) ^{aA}	0.21
B6		41.7 (58/139) ^{aA}	32.0 (63/197) ^{aA}	0.06
B8	19.9 (41/206) ^{Ab}	35.5 (75/211) ^{aA}	39.0 (135/346) ^{aA}	0.000013
B9	-	45.1 (55/122) ^{aA}	38.3 (74/193) ^{aA}	0.23

Means followed by different lowercase letters ^{a,b,c} indicate differences between rows (Bulls), at $P < 0.05$ using the chi-square test. Means followed by different capital letters ^{A,B} indicate differences between columns (Type of AI), at $P < 0.05$ using the chi-square test.

DISCUSSION

In this study, the fertility parameters of the bulls and the reproductive performance with TAI, was considered based on conception rate. The results showed differences in bulls within the same season, and with the presence or absence of estrus at the time of AI. Furthermore, beyond what was evaluated is the performance of the same bull in relation to different situations (season, estrus presentation).

As can be observed in the results, season had an effect on the reproductive performance of the bulls. In particular, comparison in the same season revealed large difference in conception rate, where the bull with lesser performance exhibited 16.5% (B7) and the bull with better performance exhibited (36.8%), demonstrating that despite having been utilized with females under the same management conditions, the effect of fertility of the bull was a determinant factor for better results in TAI during the same season. As in this study, another study in 2015 [14] evaluating 4 different bulls, reported differences of up to 15.6% between the bulls in the conception rate of the cows.

Seasonal variation also occurred and could reduce the conception rate, because of the semen of the bull utilized or the female inseminated, which are exposed and susceptible to thermal stress and adverse environmental conditions, as seen in the comparison of the same bulls in different seasons (autumn/winter or spring/summer) in this study. Only two bulls showed an effect. B8 and B10 had better reproductive performance in autumn/winter than in spring/summer: 37.8% vs. 32.0% (B8, autumn/winter vs. spring/summer) [$P = 0.05$] and 35.1% vs. 20.7% (B10, autumn/winter vs. spring/summer) [$P = 0.003$]. Thus, one could speculate there is variation in the seminal quality between the seasons, demonstrating the susceptibility of individuals to seasonal thermal stress.

The hotter months of the year are usually the months with lower reproductive performance; factors related to thermal stress reduce the fertility in dairy herds [9]. This effect occurs mainly because of thermal stress, and the probability that the insemination results in a viable embryo decreases as the body temperature increases. The oocytes, the spermatozoids, and the embryo are unable to maintain normal functions when submitted to high temperatures, and thus, the pregnancy is interrupted when these cells are exposed to maternal hyperthermia [4].

In a recent study evaluating seasonal variation in semen quality of different bulls [6], through the use of computer-assisted sperm analysis and flow cytometry to detect seasonal variations, the effect of thermal stress in the summer on spermatid quality after frozen was variable between the bulls. That is, not all bulls exhibited seasonal alterations in their functional spermatid parameters.

When the effect of the bull was evaluated with the variable animal category, i.e., heifers and multiparous cows with high milk yield, one bull (B6) exhibited a difference between the categories, exhibiting a higher conception rate in heifers, 39.2% ($P = 0.01$). In this case, when analyzing the conception rate of heifers vs. multiparous cows, it is not just the influence of the bull that is examined, but also the physiological status and the endocrine challenge to which the cow (multiparous) was submitted. Cows in lactation have inferior reproductive performance, and conception rate is lower in the trait associated with the genetic selection of this animal for high milk yield, whereas the fertility of Holstein heifers remains relatively stable and markedly higher than that of cows in lactation. Associated with this, it is suggested that the low fertility of cows in lactation of high milk yield, may be the result of possible differences in the oocyte quality and the levels of follicular steroids [1,11].

In the farm where the animals in this research were utilized, three types of AI, depending the case, were used. Thus, the effect of the bull on the AI variable was evaluated: ETAI, TAI, or just AI with estrus detection, without synchronization protocol. An attempt to identify bulls with better performance in a given AI method or situation was made; however, only one bull (B8) exhibited a difference in the type of AI, being better in the ETAI and the AI with estrus detection ($P = 0.000013$). Perhaps this parameter is not a limiting factor for the performance reproductive bulls.

The set of interactions between ovulation of the female, fertility of the spermatozoids, and the viable time of the oocyte in the female genital tract after ovulation becomes extremely decisive and dependent on the ideal moment of insemination [2]. Thus, the spermatozoid being considered qualitatively viable and potentially fertile, it is necessary that it has morphology, metabolic activity, and normal membranes. The pre-requisites for the events related to the process of fertilization are: spermatid capacitation, penetration into oocyte coatings, connection to the zona pellucida, and melting with the oolemma may occur [10,15]. Therefore, bulls that present semen with higher fertility in certain types of AI could be utilized on a larger scale for to increase the reproductive rates in artificial insemination.

The implantation of artificial insemination into the productive system, is a biotechnology of high

applicability, favoring genetical enhancement of the herd. Thus, more studies are needed to investigate the possible variables that could interfere with the results. It is worth mentioning that most of the research conducted up to now was related to the effects of the bull in TAI programs for beef cattle. The results of this study indicate that despite the tests indicating the semen that is submitted is adequate, there are still variations in quality and the reproductive efficiency of each bull. With the effects varying based on fertility and on different environmental and management situations.

CONCLUSIONS

The period of the year, the animal category, and the type of AI used interfered with the reproductive performance of Holstein bulls based on conception rate of heifers and multiparous cows under the same management conditions.

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