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Conception rate according to sire, body condition score and estrus occurrence of suckled *Bos taurus* beef cows submitted to timed artificial insemination

[*Taxa de concepção de acordo com o touro, escore de condição corporal e ocorrência de estro em vacas de corte* Bos taurus *lactantes submetidas à inseminação artificial em tempo fixo*]

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ABSTRACT

The objective of this study was to investigate the effect of estrus expression, body condition score (BCS), different sires and semen batches on the conception rate of suckled Bos taurus beef cows submitted to timed artificial insemination (TAI). Data from 7,737 TAI were obtained from five farms in South Brazil. Cows received an estradiol plus progesterone-based estrous synchronization protocol. Only sires (n = 13) with at least two semen batches and 50 AI in two different lots were included in the study. Conception rate was higher for cows in estrus (66.8% vs. 26.3%) or with BCS ≥ 3 (57.2% vs. 51.6%) than in cows without estrus or BCS < 3, respectively ($P \leq 0.001$). Conception rate per sire ranged from 42.6% (Sire L) to 74.3% (Sire K). Conception rate in cows with BCS ≥ 3 and estrus occurrence varied from 47.4% (Sire L) to 86.1% (Sire A) among sires. Conception rate differed among semen batches of the same sire (B1 = 58.5%, B2 = 62.5%, and B3 = 83.2%). In conclusion, there was individual variation in conception rate among AI sires and semen batches within sires. The conception rate was increased by estrus occurrence and greater BCS.

Keywords: conception, fertility, bovine, semen batches

RESUMO

O objetivo deste estudo foi investigar o efeito da manifestação de estro, o escore de condição corporal (ECC), os diferentes touros e partidas de sêmen na taxa de concepção de vacas Bos taurus *lactantes de corte submetidas à inseminação artificial em tempo fixo (IATF). Dados de 7.737 IATF foram obtidos em cinco fazendas do sul do Brasil. As vacas receberam um protocolo de sincronização de estro à base de estradiol e progesterona. Somente touros (n=13) com no mínimo duas partidas e 50 inseminações em dois lotes diferentes foram incluídos no estudo. A taxa de concepção foi maior nas vacas em estro (66,8%* vs. *26,3%) ou com ECC ≥ 3 (57,2%* vs. *51,6%) do que em vacas sem estro ou com menor ECC, respectivamente (P≤0,001). A taxa de concepção por touro variou de 42,6% (Touro L) a 74,3% (Touro K). A taxa de concepção em vacas que demonstraram estro e com ECC ≥3 variou de 47,4% (Touro L) a 86,1% (Touro A) entre os touros. A taxa de concepção diferiu entre partidas de um mesmo touro (B1=58,5%, B2=62,5% e B3=83,2%). Em conclusão, houve variação individual na taxa de concepção entre touros e entre as partidas de sêmen de um mesmo touro. A taxa de concepção foi aumentada pela ocorrência de estro e maior ECC.*

Palavras-chave: concepção, fertilidade, bovino, partida de sêmen

INTRODUCTION

Artificial insemination (AI) is the common biotechnology used to increase productivity and profitability in cattle. Ovulation synchronization programs for timed AI (TAI) intensify the use of this biotechnology as well as improve the reproductive efficiency of beef herds (Meneghetti *et al.*, 2009; Sá Filho *et al.*, 2009, 2013; Baruselli *et al.*, 2018; Pessoa *et al.*, 2018).

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In addition, the TAI protocols satisfactorily synchronize follicular growth, corpus luteum regression and ovulation, that result in better reproductive performance, because all females are inseminated without estrus detection before TAI (Colazo and Mapletoft, 2014).

Several factors may influence the success of ovulation synchronization programs for TAI in beef cattle. Factors related to the cows such as breed, estrus occurrence, body condition and parity have been the subject of various research studies (Perry *et al.*, 2007; Meneghetti *et al.*, 2009; Sá Filho *et al.*, 2009; Baruselli *et al.*, 2012; Pessoa *et al.*, 2016). However, bovine fertility is a multifactorial process that is not only related to the female but also to adequate herd management, timing to use the AI, and semen quality (Sá Filho *et al.*, 2009; Sellem *et al.*, 2015).

In dairy cows, a significant percentage of reproductive failures was attributed to subfertile sires (Dejarnette *et al.*, 2004), resulting in financial losses. In *Bos indicus* beef cows, variations in conception rates (7.2 to 77.3%) were observed, according to the sires used in the TAI programs (Sá Filho *et al.*, 2009). In contrast, similar research does not exist in *Bos taurus* beef cows to verify the magnitude of variation in conception rate using different sires in TAI programs.

Considering this scenario, the objectives of this study were to: (1) evaluate the conception rate of suckled Bos taurus beef cows submitted to timed artificial insemination (TAI) with different sires and batches of commercial semen, and (2) investigate the association of conception rate with estrus occurrence and body condition score (BCS) of cows.

MATERIAL AND METHODS

All animal procedures involved in this trial were approved by the Ethics Committee on Animal Use of the Federal University of Santa Maria, Santa Maria, Brazil (protocol 8876160217). The data of this study were obtained during a three-year period (2015 through 2017) on five commercial farms of Rio Grande do Sul state, Brazil, using TAI in multiparous *Bos taurus* cows during the reproductive season (August to December). Herds were in the same biome of natural pastures and in the same climatic region. Farms had the same mating system, sanitary management, and pattern of racial selection. Cows were maintained in a native pasture with free access to water and mineralized salt.

During the study period, 15,632 inseminations were performed. To control for inseminator expertise influence, only 11,734 inseminations conducted by one experienced veterinarian were retained in the data set. In addition, 1,132 insemination records were discarded because of incomplete data (no information available for BCS, estrus occurrence, sire, or semen batch), leaving a total of 10,602 complete insemination records. Thus, the obtained data from 153 batches from 36 sires conformed to the criterion of uniform distribution among lots of cows to TAI. For the comparison among sires and semen batches within the same sire, only sires with data from at least two different batches and at least 50 inseminations of each sire in minimum two different lots of cows were included, totaling 7,737 inseminations, which included 57 semen batches obtained from 13 sires (Fig. 1).

The semen doses were obtained from a single semen processing center according to mating criteria and distributed in the breeding group of farms. Sires and semen batches were randomly distributed in lots of cows according to BCS on the D0 and estrus presence or absence at TAI. In addition, all semen batches were previously analyzed and only semen meeting minimum post-thaw of requirements of 30% sperm motility, vigor 3 and 70% of normal morphology were used (Manual…, 2013).

Suckled *Bos taurus* cows, between 40 and 70 days postpartum and overall body condition score (BCS) of 2.82±0.02, based on a 1- to 5-point scale (1 = emaciated, 5 = obese), were submitted to ovulation-synchronization program for the first insemination of the season. On Day 0, all cows had the BCS evaluated, and the synchronization protocol consisted of the insertion of a new intravaginal P4-releasing device (CIDR®, 1.9 g of P4, Zoetis, Campinas, SP, Brazil) and 2 mg of intramuscular (IM) estradiol benzoate (EB, Gonadiol®, Zoetis, Campinas, SP, Brazil). On Day 8, the P4 device was removed, and 12.5 mg of dinoprost tromethamine IM (Lutalyse®, Zoetis, Campinas, SP, Brazil) plus 1 mg of estradiol cypionate IM

(EC, E.C.P.®, Zoetis, Campinas, SP, Brazil) and 300 IU of Equine Chorionic Gonadotropin IM (eCG, Novormon®, Zoetis) were administered to all cows. Moreover, tail heads of the cows were marked with chalk (Raidl-Maxi, RAIDEX GmbH, Dettingen/Erms, Germany), and the occurrence of prior estrus was evaluated at the time of AI based on chalk removal. Timed AI was performed at 48 h after P4 device removal (Fig. 2). All inseminations were conducted by one experienced veterinarian and was used the same synchronization protocol to TAI.

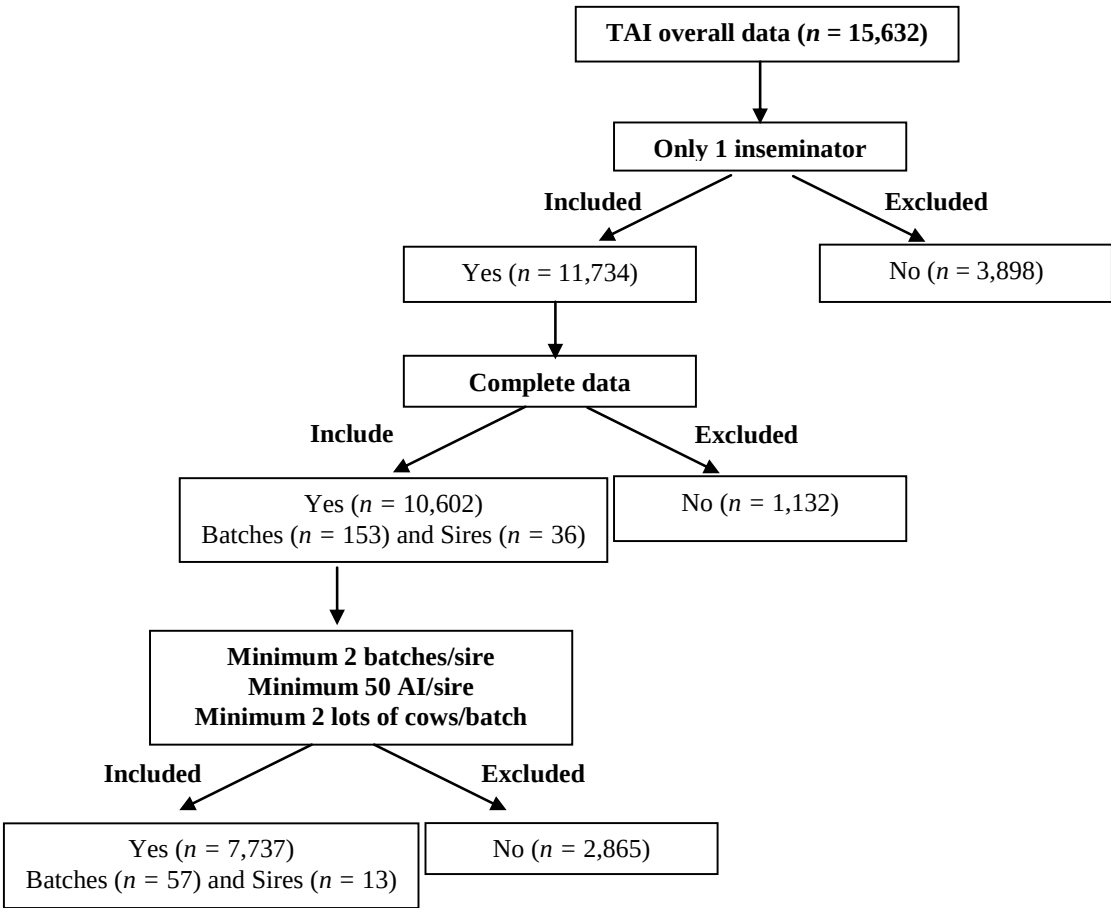

Figure 1. Schematic diagram of inclusion or exclusion of study data.

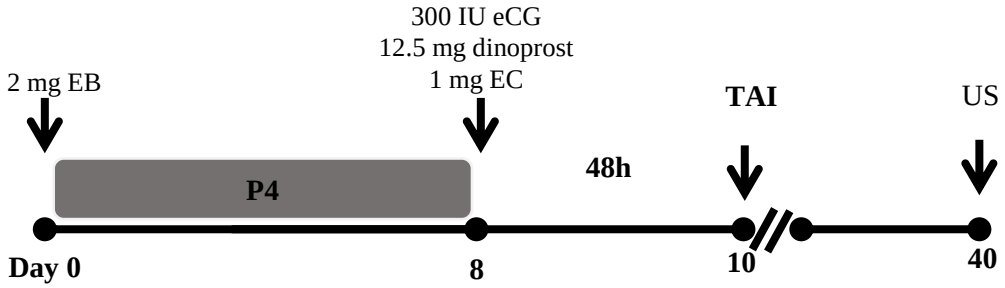

Figure 2. Schematic representation of the experimental design. EB = 2 mg of estradiol benzoate; eCG = 300 IU of equine chorionic gonadotropin; EC = 1 mg of estradiol cypionate; dinoprost = 12.5 mg of dinoprost tromethamine; TAI = timed artificial insemination performed 48 h after removal of the progesterone (P4) device; US = ultrasound examination (pregnancy diagnosis).

Transrectal ultrasound examinations (Mindray DP 220 with 5MHz linear-array transducer, Shenzhen, China) were performed in all cows to evaluate uterine and ovarian health at the insertion of the P4 device (Day 0). Pregnancy diagnosis was performed by transrectal ultrasound 30 days after TAI. Pregnancy was characterized by visualization of an embryo with heartbeat, and conception rate was defined as the number of pregnant cows divided by the number of cows submitted to TAI in each treatment.

The statistical analysis included the data: BCS, occurrence of estrus on TAI, sire, sire batches, year, farm, cow breed, identification of cows, lots of cows, parity, AI month, pregnancy diagnosis at 30 days. Only BCS, occurrence of estrus on TAI, sire and sire batches showed significant effect.

The conception rate was analyzed as a response with binary distribution (0 = negative and 1 = positive) with the use of PROC GLIMMIX of the statistical software SAS 9.3®. The factors included in the model as fixed effects were as follows: sire, semen batches, BCS, and estrus expression. BCS was included in the model as two classes (BCS≥3 and BCS<3). The interactions between BCS, estrus occurrence, sire and batches of sires were considered. The LS Means was applied to obtain adjusted means of the variables. Differences with $P<0.05$ were considered significant.

A descriptive analysis of conception rates per sire in all 7,737 cows will be presented followed by data considering sires with at least two semen batches and cows with estrus expression and BCS≥3 (n=2,062) were included to avoid possible negative effects of these factors on conception rate. Only the sire presenting the highest number of inseminations in the same farm was considered to verify the effect of the sire semen batches, excluding cows with BCS<3.

RESULTS

Considering the 13 sires with at least two semen batches and 50 inseminations, the mean of conception rate was 55.8% (Table 1) and ranged from 42.6% (Sire L) to 74.3% (Sire K). Among the 7,737 inseminations, 65.5% (5,069/7,737) of the cows presented estrus.

Table 1. Number of AI and pregnancy rate (mean ± SD) in suckled *Bos taurus* beef cows (n = 7,737) inseminated with semen from 13 different sires (A to M)

Sire	No. of AI*	Pregnancy per AI % (n/n)**
A	821	60.53 ± 1.66^{bc} (496/821)
B	1654	65.05 ± 1.17^{ab} (1076/1654)
C	756	51.45 ± 1.73^{d} (389/756)
D	110	48.18 ± 4.55^{cd} (53/110)
E	303	56.10 ± 2.74^{bcd} (170/303)
F	377	52.51 ± 2.46^{cd} 198/377)
G	789	50.31 ± 1.70^{d} (397/789)
H	224	51.78 ± 3.19^{cd} (116/224)
I	420	46.90 ± 2.33^{d} (197/420)
J	282	44.68 ± 2.84^{d} (126/282)
K	335	74.32 ± 2.61^{a} (249/335)
L	195	42.56 ± 3.42^{d} (83/195)
M	1471	52.27 ± 1.24^{d} (769/1471)
Overall	7737	55.83 ± 0.56 (4319/7737)

Means with different letters (a,b,c,d) within the column are different ($P < 0.05$). * Number of inseminations per sires (A to M). ** Number of pregnant cows per number of inseminations at 30 days after timed artificial insemination.

The overall conception rate was higher in cows that showed estrus than in those not showing estrus ($P<0.0004$; Table 2). The superiority in conception rate for cows in estrus was observed for all sires except for sires D and L (Table 2). The variation in conception rate among sires (Table 2) was great regardless of the expression of estrus (46.1 to 83.1% and 29.0 to 51.1% for cows in estrus and not expressing estrus, respectively).

Table 2. Pregnancy per AI (mean ± SD) in suckled *Bos taurus* beef cows that expressed estrus (n = 5,069) and without estrus (n = 2,668) at the timed artificial insemination. The cows are inseminated with semen from 13 different sires (A to M)

Sire	Estrus	Without estrus
	P/AI % (n/n)*	P/AI % (n/n)*
A	83.07 ± 1.9$^{a\ A}$ (324/390)	40.0 ± 4.9$^{bc\ B}$ (172/430)
B	77.58 ± 1.29$^{a\ A}$ (810/1044)	43.6 ± 4.96$^{bc\ B}$ (266/610)
C	62.09 ± 2.26$^{b\ A}$ (285/459)	35.0 ± 4.77$^{c\ B}$ (104/297)
D	46.15 ± 6.23$^{b\ A}$ (30/65)	51.1 ± 5.05$^{ab\ A}$ (23/45)
E	57.56 ± 3.00$^{b\ A}$ (156/271)	43.7 ± 5.04$^{bc\ B}$ (14/32)
F	56.66 ± 3.02$^{b\ A}$ (153/270)	42.0 ± 4.95$^{bc\ B}$ (45/108)
G	54.93 ± 1.95$^{b\ A}$ (356/648)	29.0 ± 4.55$^{c\ B}$ (41/141)
H	55.37 ± 4.53$^{b\ A}$ (67/121)	47.6 ± 5.0$^{bc\ B}$ (49/103)
I	51.32 ± 3.07$^{b\ A}$ (136/265)	39.3 ± 4.9$^{bc\ B}$ (61/155)
J	54.63 ± 5.08$^{b\ A}$ (53/97)	39.4 ± 4.9$^{bc\ B}$ (73/185)
K	80.34 ± 2.63^{aA} (184/229)	61.3 ± 4.9^{aB} (65/106)
L	46.29 ± 4.8^{bA} (50/108)	37.9 ± 4.8$^{bc\ A}$ (33/87)
M	53.72 ± 1.50^{bA} (592/1102)	47.9 ± 5.0$^{bc\ B}$ (1*77/369)
Overall	63.04 ± 0.67^{A} (3196/5069)	42.1 ± 4.93^{B} (1123/2668)

Means with different lowercase letters (a,b,c) within each column are different (P < 0.05). Means with different uppercase letters (A,B) within each row are different (P < 0.5). * Number of pregnant cows per number of inseminations at 30 days after TAI.

Cows with BCS≥3 had higher conception rate (63.5%; 1,717/2,703) than cows with BCS<3 (51.7%; 2,602/5,034; P=0.001) (Fig.3). When analyzing the conception rate of cows with BCS≥3 and that expressed estrus at the TAI, a significant individual variation in the conception rate among the sires was observed, ranging from 47.4% to 86.1% (Table 3).

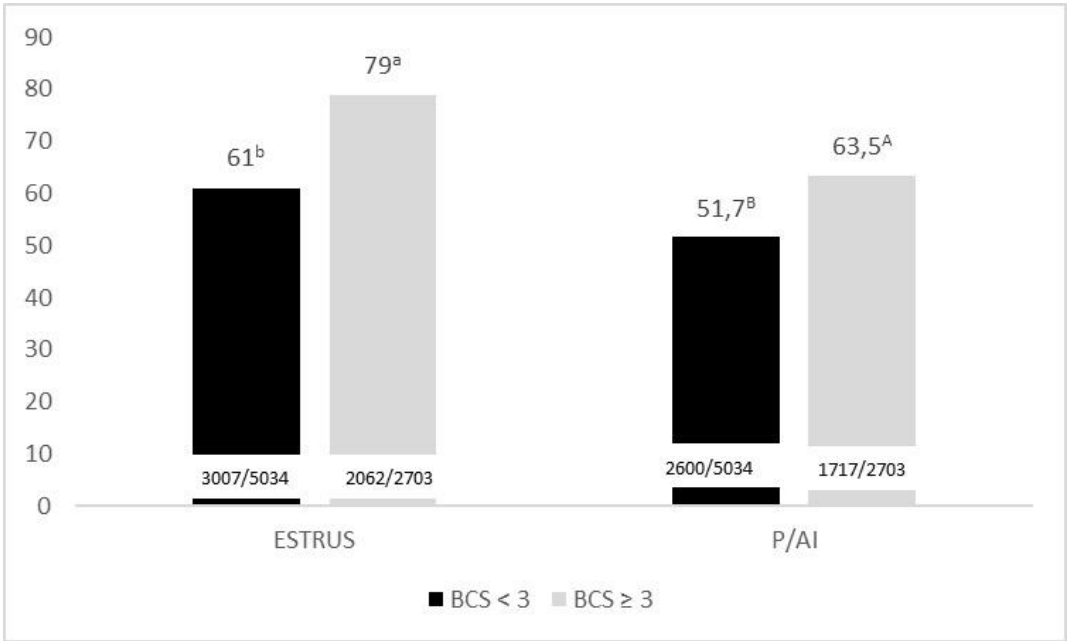

Figure 3. Pregnancy (%) and estrus occurrence (%) rate related to Body Condition Score (BCS; <3 or ≥3) of suckled *Bos taurus* beef cows inseminated with semen from 13 different sires. $^{a,\ b,\ A,\ B}$ Different letters indicate statistical difference.

Table 3. Pregnancy per AI (mean±SD) in suckled *Bos taurus* beef cows (*n*=2,062) that demonstrated estrus and BCS≥3 inseminated with semen from 10 different sires

Sire	No. of AI	P/AI % (*n/n*)*
A	108	86.11 ± 3.34[a] (93/108)
B	501	81.63 ± 1.73[a] (409/501)
C	290	69.65 ± 2.70[b] (202/290)
E	122	64.75 ± 4.34[bc] (79/122)
F	122	63.93 ± 4.36[bc] (78/122)
G	195	65.64 ± 3.40[bc] (128/195)
I	81	51.85 ± 5.58[cd] (42/81)
K	168	83.92 ± 2.84[a] (141/168)
L	97	47.42 ± 5.09[d] (46/97)
M	378	62.69 ± 2.49[bc] (237/378)
Overall	2062	70.56 ± 1.00 (1455/2062)

Means with different letters (a,b,c,d) within the column are different (P<0.05). Sires D, H and J are not on the table because they presented few inseminations in cows with estrus and BCS≥3. BCS=body condition score. P/AI= number of pregnant cows per number of inseminations at 30 days after timed artificial insemination.

Sires A, B and K had higher conception rate than other sires, both in the evaluation of the general data (A= 60.5%; B= 65.0% and K= 74.3%), as in cows with estrus (A= 83.1%; B= 77.6% and K= 80.3%), as well as in the females that presented BCS ≥ 3 (A= 86.1%; B= 81.6% and K=83.9%). Sires I and L resulted in low conception rates in the general evaluation (I= 46.9% and L= 42.6%), in cows with estrus (I= 51.3% and L= 46.3%), as well as in cows with both estrus expression and BCS≥3 (I= 51.8% e L= 47.4%). The sire that showed the highest number of semen batches used in cows with BCS≥3 in the same farm lot resulted in different conception rates among the batch processing date batches (P<0.0001; Tab. 4).

Table 4. Pregnancy rate at FTAI (mean ± SD) in suckled *Bos taurus* beef cows (*n* = 620) with BCS ≥ 3 of a single farm lot, inseminated with 3 different batch processing dates (B1, B2 and B3) from a single sire (Sire B).

Sire batch	Batch processing date	No. of AI	P/AI % (*n/n*)*
B1	November 04, 2015	312	62.50 ± 2.74[b] (195/312)
B2	June 02, 2016	123	58.54 ± 4.46[b] (72/123)
B3	June 13, 2016	185	83.24 ± 2.75[a] (154/185)
Overall		620	67.90 ± 1.87 (421/620)

Means with different letters (a,b) within the column are different (P<0.05).
* Number of pregnant cows per number of inseminations at 30 days after timed artificial insemination.

DISCUSSION

It was shown that there was an individual effect of the sire on the conception rate of Suckled *Bos taurus* cows submitted to the TAI protocol. To the best of our knowledge, this is the first study with *Bos taurus* cows that presents data related to the variation of sire fertility in cows submitted to TAI. This study is an analysis of a large dataset collected during a 3-year period, involving a total of 7,737 TAI of suckled beef cows. The same sire that had a higher conception rate in the general context of the study was also superior in cows that presented estrus at the time of AI, and in those that presented BCS ≥ 3.

TAI programs allow cow insemination regardless of cyclicity and eliminate the need for estrus detection. These programs also provide a systematic approach to the use of TAI, facilitating its use in cattle herds (Baruselli *et al.*, 2012; Pessoa *et al.*, 2016). However, the identification of estrus at the time of insemination is a parameter of fundamental importance and should be evaluated during TAI programs. Beef cows detected in estrus before TAI had improved conception rates (Richardson

et al., 2016; Hall *et al.*, 2017). In the present study, the importance of estrus expression to increase the conception rate was confirmed, independently of the sire used for the TAI. The exception of bulls D and L that presented similar conception rate among cows with or without estrus.

Moreover, management of BCS has a great impact on cycling status and estrus expression (Richardson *et al.*, 2016). In this study, females with BCS≥3 had a higher conception rate than those with BCS<3 at the beginning of the TAI protocol. Previously, Pessoa *et al.* (2018) also reported a significant higher pregnancy rate in suckled beef cows with BCS>2.75 (47.1%, 153/325) than cows with BCS<2.75 (20.8%, 132/635) at the beginning of the breeding season.

Our research corroborates the study developed by Sá Filho *et al.* (2009) with Nelore cows (*Bos indicus*), in which there was a consistently affected pregnancy rate by the sire used in AI, whose results ranged from 7.2% to 77.3%. In another study, different conception rates among sires (16.8% to 36.8%) were also reported in dairy cows submitted to TAI on spring and summer (Luz *et al.*, 2018). Additionally, Hall *et al.* (2017) demonstrated high bull to bull variation (19.3% to 55.6%) in pregnancy rates using sex-sorted semen in cows and heifers during 3 study years. Thus, the success of AI programs is dependent on the quality of the semen used, and better conception rate can be obtained when sires with good fertility are used during the breeding season (Saacke *et al.*, 1994; Dejarnette *et al.*, 2004; Saacke, 2008; Sudano *et al.*, 2011).

Although all semen batches were previously analyzed and released for use in AI with the minimum parameters (Manual…, 2013), there was still a below-average conception rate (50%) in four evaluated sires (D, I, L and J). Also in this study, it was possible to identify differences in the conception rate among different semen batches of the same sire (B1, B2 and B3 of Sire B), although the three batches had a minimum of 50% of motility and vigor 3. The lack of explanations for the difference in fertility potential of a semen batch may be related to the sperm parameters not evaluated in the conventional analysis, or could still be related to age, environmental factors (Brito *et al.*, 2002; Snoj *et al.*, 2013), or nutritional factors (Singh *et al.*, 2018) affecting semen quality.

Additionally, in our study, B2 batch was processed in November 2015 whereas B1 and B3 in June 2016, showing that although the batches were used in the farm lot and in the same breeding season in females with BCS ≥ 3, there was still a change in the conception rate of 24.7% between batches B1 and B3. Similarly, Zhang *et al.* (1999) reported significant variation in conception rates from 61.8 to 67.5% based on the tested three frozen batches of a dairy bull. The wide range of intrinsic and extrinsic factors related to the sire can justify the differences in the sire fertility, which results in different conception rates of females submitted to TAI.

CONCLUSIONS

In conclusion, the data obtained in this study with suckled *Bos taurus* beef cows demonstrate that there is an individual variation in the pregnancy rate per sires used in TAI programs in the south of Brazil. In additional, was observed there is a difference in conception rate with the use of different semen batches from the same bull. The higher conception rates per sire are obtained in females with BCS≥3 and in those with estrus expression at timed artificial insemination.

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