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Inferences of body energy reserves on conception rate of suckled Zebu beef cows subjected to timed artificial insemination followed by natural mating

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ABSTRACT

The influence of body condition score (BCS), rump fat thickness (RFAT), and live weight (LW), and the changes in these parameters during the interval from 165 of prepartum (i.e., 125 days of prior gestation) to 112 postpartum on first service conception and pregnancy rates were investigated in suckled Zebu (*Bos indicus*) beef cows ($n = 266$) subjected to timed artificial insemination (TAI) followed by natural mating. The aforementioned parameters were recorded at 165 ± 14 days (mean ± standard error) prepartum (concurrent with the weaning of previous calf), at parturition, and at 42 ± 7 days (at the onset of the synchronization of ovulation protocol), 82 ± 7 days (30 days after TAI), and 112 ± 7 days (60 days after TAI) postpartum. At the start of the breeding season (BS), cows were subjected to a synchronization of ovulation program for TAI. Bulls were placed with cows 10 days after TAI and remained until the end of the study (112 days postpartum). Cows with the highest BCS at parturition had an increased probability of first service conception rate at 60 days after TAI ($P = 0.02$) and a reduced probability of occurrence of pregnancy loss ($P = 0.05$). Also, cows had a greater likelihood of conceiving postpartum if they had greater RFAT and BCS at 165 ± 14 days prepartum ($P = 0.01$ and $P = 0.03$, respectively) and at parturition ($P = 0.0007$ and $P = 0.003$, respectively). Cows that had an increase in RFAT and BCS during the dry period (i.e., interval from weaning of the previous calf to parturition) also had a greater likelihood of conceiving ($P = 0.03$ and $P = 0.06$, respectively) during the BS. Among the different time points, RFAT and BCS at parturition had the largest impact on risk of conception during the BS. The LW was a poor predictor of conception during the BS ($P = 0.11$–0.68) except for LW at 165 ± 14 days prepartum ($P = 0.01$). Collectively, the findings indicated that the likelihood of conception during the BS was highest in cows that had an improvement in RFAT and BCS during the dry period. Therefore, assuring a good nutritional status in the dry period (BCS $\geq$ 3.0 at 165 ± 14 days prepartum and $\geq$3.25 at parturition) is an important aim to optimize the postpartum conception rate of suckled Zebu beef cows subjected to TAI followed by natural mating.

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1. Introduction

Reproductive traits typically have a low heritability and reproductive performance is strongly influenced by nongenetic factors [1]. Approximately 80% of the variation in fertility is because of the environment, and nutrition often accounts for more than 50% of this variation [2]. An example of the importance of nutrition is the relationship between the nutritional and metabolic status of cows and the duration of the postpartum anestrous period [3–8], particularly in extensively managed Zebu (*Bos indicus*) cows that are reliant on natural forages for most or all of their nutritional requirements [9,10]. In a recent study, Zebu crossbred cows on improved pasture before and after calving had better body condition score (BCS) and greater circulating concentrations of insulin-like growth factor 1 and leptin than cows on standard pasture, and the former cows had an earlier resumption of ovulation [10]. Given the importance of nutrition, it is clearly a major factor in the management of cattle for optimal reproductive performance.

Both objective and subjective measures can be used to assess the nutritional status of cattle and to make inferences of body energy reserves. Live weight (LW) is an objective measure but it is questionable whether LW provides an accurate reflection of nutritional status in cattle as it can show considerable variation depending on breed, frame size, and body composition [11]. Ultrasonographic measurement of rump fat thickness (RFAT), on the other hand, is a highly accurate objective method for determining subcutaneous fat [12] and predicting body energy reserves [13]. Subcutaneous fat can also be assessed subjectively by visually assigning BCS [13–16].

Reproductive technology is being increasingly used in grazed Zebu cows to improve reproductive performance during the postpartum period. The synchronization of ovarian function and timed artificial insemination (TAI) has been found to increase the proportion of suckled Zebu beef cows that conceive within a timeframe postpartum, which is necessary to maintain a 365-day calving interval [17–19]. Several studies reported the positive impact of BCS on the pregnancy response after the TAI in suckled beef cows [19,20]. However, there is limited detailed information on the relationship between body energy reserves from the dry period (at weaning of the previous calf) to the beginning of the breeding season (BS) and reproductive outcome in suckled Zebu cows.

Therefore, the main objectives of the present study were to determine the impact of the LW, RFAT, and BCS, plus changes in these parameters during the interval from 165 ± 14 days prepartum to 112 ± 7 days postpartum on the resumption of cyclicity, first service conception rate, and pregnancy rate through the BS of sucked Zebu cows subjected to a synchronization of ovulation for TAI followed by natural mating. The secondary objective was to establish at which phase of the prepartum and postpartum the LW, RFAT, and BCS are most closely related to these cited response variables. A further objective was to determine if LW, RFAT, or BCS can be used as predictors of the first service conception rate and the pregnancy rate through the BS in sucked Zebu cows. The information obtained in the study would be used to develop strategies to nutritionally manage suckled Zebu cows for an optimal reproductive response during the BS.

2. Materials and methods

2.1. Location, animals, and management

The study was conducted in Mato Grosso do Sul State, Brazil, from May 2005 through July 2006. Nelore cows (*B indicus*, n = 266) used in the study were from a single extensively managed herd that grazed the same pasture (*Brachiaria brizantha*) and received a standard mineral salt supplement. The cows were 7.3 ± 1.5 years old (mean ± standard deviation, range 3–9 years) at the start of the study. The calving interval (days), weaning to calving interval, and number of days postpartum at the start of the synchronization protocol were 407 ± 26 days (338–498 days), 165 ± 14 days (127–195 days), and 42 ± 7 days (29–74 days), respectively.

2.2. Synchronization treatment and TAI

The study was undertaken using two cohorts of cows (breeding groups): cows that calved during mid-spring (n = 156) and cows that calved during late-spring (n = 110). Regardless of the calving period, at around Day 42 postpartum (42 days) all cows underwent a synchronization of ovulation protocol. Cows received 2 mg estradiol benzoate im (EB, Estrogen; Farmavet, Brazil) and a norgestomet ear implant (Crestar; MSD Saúde Animal, Brazil). Eight days later, the ear implant was removed and cows received 400 IU eCG im (Folligon; MSD Saúde Animal) plus 150 μg D-cloprostenol im (PGF, Preloban; MSD Saúde Animal). On the following day, cows received 1 mg EB im and TAI was carried out 54 to 58 hours after norgestomet ear implant removal. Semen from two bulls was randomly distributed for TAI across an equal number of cows. Bulls were introduced to the cows 10 days after TAI. Pregnancy was ascertained by ultrasonography 30 and 60 days after TAI.

2.3. Management of bulls

A total of 11 Nelore bulls, aged between 3 and 5 years, were maintained on pasture with free access to water and mineral supplementation. Bulls were tested and found to be free of brucellosis and tuberculosis. Each bull underwent a breeding soundness evaluation 30 days before the onset of the BS using the guidelines of the Brazilian College of Animal Reproduction [21]. The breeding soundness evaluation included testicular assessment, measurement of scrotal circumference, and evaluation of sperm morphology and motility after electroejaculation. Electroejaculation is the most common means of collecting semen for the breeding soundness evaluation because of improved reliability in obtaining a sample, ease and safety of application in field conditions, and increased likelihood of penile protrusion, thereby improving both the ability to observe penile anatomy and the quality of the semen collected [22,23]. Bulls were selected for mating on the basis of their general clinical health status, absence of any apparent abnormality of the reproductive system, and a sperm profile more than minimum limits (70% progressive sperm motility, category 3 for sperm vigor, and maximum 30% total abnormal sperm cells) stipulated by the Brazilian College of Animal Reproduction [21]. Only bulls classified as potential satisfactory breeders were randomly allocated to a breeding group at a bull-to cow ratio of 1:25.

2.4. Ovarian status, pregnancy per TAI, reproductive efficiency, and pregnancy loss

Ovarian status at the start of the synchronization of ovulation program (42 days postpartum) was ascertained by ultrasonography (Aloka SSD500, Japan) as described by Baruselli et al. [24]. The presence of a corpus luteum (CL) on ultrasound was judged to be indicative of cyclic ovarian activity. The reproductive outcome was determined considering the first service conception rate at 30 days (total number of cows pregnant 30 days after the first TAI service divided by the total number of cows enrolled) and 60 days (total number of cows pregnant 60 days after the first TAI service divided by the total number of cows enrolled) after TAI and the pregnancy rate (total of pregnancies after TAI plus natural mating divided by the total number of cows enrolled) at 60 days after TAI. Nonpregnant cows were reassessed for the presence of a CL as described previously. Because of the use of the same group of cows, the differentiation of origin of pregnancy (i.e., from TAI or from NM) was performed according to the age of pregnancy estimated on the basis of the size of the amniotic vesicle [25].

Pregnancy loss was determined by the difference in the number of cows pregnant at the first (30 days after TAI) and second (60 days after TAI) pregnancy diagnosis. The occurrence of pregnancy loss in those cows that became pregnant after natural mating was not determined.

2.5. Live weight, BCS, and RFAT

Live weight, RFAT, and BCS were recorded for all cows at five times during the prepartum and postpartum period: time 1 = 165 ± 14 days prepartum (at weaning of previous calf); time 2 = parturition; time 3 = 42 ± 7 days postpartum (at the onset of the synchronization protocol); time 4 = 82 ± 7 days postpartum (at pregnancy diagnosis 30 days after TAI); and time 5 = 112 ± 7 days postpartum (at pregnancy diagnosis 60 days after TAI). Throughout the article, 165 days prepartum refers to the respective day ±14 days. Also the 42, 82, and 112 days postpartum refer to the respective days ±7 days.

Live weight was obtained using digital cattle weigh scales without a period of food or water restriction. The BCS was recorded by visual assessment as previously described [13]. Cows were scored using a 1 (very thin) to 5 (very fat) scale with intervals of 0.25 BCS. The same operator recorded BCS throughout the study. For analyses, the BCS was assigned to five categories as follows: the mean BCS at each period (prepartum [time1], parturition [time 2], and 42 days postpartum [time 3]) served as the mid-BCS category, and the other categories were the two BCS below and above the mid-category. Using these criteria, the categories of BCS were prepartum (<3.0, 3.0, 3.25, 3.5, and >3.5), parturition (<3.25, 3.25, 3.5, 3.75, and >3.75), and synchronization (<3.0, 3.0, 3.25, 3.5, and >3.5). The occurrence of pregnancy was evaluated (regression curve) relative to the BCS.

Rump fat thickness is the subcutaneous fat layer located between the skin and the *fascia trunci profunda* above the *gluteus medium* and the *biceps femuris muscles*. An ultrasound unit (Scanner 200 VET; Piemedical, Netherland) with a linear transducer of 3.5 MHz frequency was used to obtain the ultrasonographic images for RFAT measurements as previously described [12], with the exception that, in the present study, RFAT calculations were made at the time of scanning. In brief, cows were restrained and the transducer was linearly positioned between hooks and pins at the sacral examination site and moved until the correct image was obtained, allowing the visualization of the superior limit of *biceps femuris*. The images were immediately analyzed, taking into consideration the distance between the inferior limit of both skin and *fascia trunci profunda*. Therefore, the skin thickness was excluded from the recorded measurement.

2.6. Statistical analyses

The models were fitted using the Statistical Analysis System (SAS, Version 9.1 for Windows; SAS Inst., Cary, NC), and the regression models were generated by Guide Data Analysis of SAS. The data are presented as the mean ± standard error.

The relationships between the presence of a CL, first conception rate at 30 and 60 days after TAI, pregnancy rate, and pregnancy loss after TAI were analyzed using the Bernoulli regression model [26,27]. The covariates used were as follows: (1) LW, RFAT, and BCS (at the five different time periods (1–5) and taking into account the differences between each period); (2) the presence of a CL at the start of the synchronization program; (3) age of cow; (4) period of birth (evaluated twice monthly); (5) breed of bull used in the previous BS; (6) date of birth of the previous calf; (7) characteristics of the previous calf at weaning (breed, sex, LW at 120 and 240 days of life); (8) date of the current parturition; (9) sex of the current calf; (10) conception date of the current calf; (11) breed of the current bull (used for AI); (12) intercalving interval; (13) last interval between parturitions; (14) estimated age of the current calf at weaning; (15) real age of the current calf at weaning (months and days); and interactions. For the continuous covariates, linear and quadratic effects were considered. A correlation was found between LW, RFAT, and BCS, causing multicollinearity. Thus, only the BCS remained in the model.

Additionally, receiver operating characteristic analysis using MedCalc version 9.5.1.0 (MedCalc software Mariakerke, Belgium) was also performed to determine the critical BCS category at different set points to optimize the pregnancy per TAI and the cumulative pregnancy on the basis of the sensitivity and specificity.

3. Results

3.1. General results

Of the 297 cows originally selected for the study, 24 were excluded because data for LW, RFAT, or BCS were not obtained in at least one of the five periods analyzed. A further seven cows were classified as outliers for LW or RFAT (judged by estimating the values for these cows relative to the rest of the data and comparing the estimated value with the observed value) and were also excluded from the analyses leaving 266 cows. Results for LW, RFAT, and BCS are shown in Table 1.

There was no effect of the breeding groups ($P = 0.38$; $P = 0.15$; $P = 0.75$) or semen ($P = 0.77$; $P = 0.35$; $P = 0.11$) on the first service conception rate at 30 and 60 days after TAI or the pregnancy rate, respectively. Also, there was no interaction of breeding groups on any of the variables analyzed herein ($P > 0.15$). The overall presence of a CL at the start of the synchronization program was 38.7% (103 of 266). The first service conception rate at 30 and 60 days after the TAI was 60.5% (161of 266) and 57.5% (153 of 266), respectively. The pregnancy rate was 69.9% (186 of 266), and the occurrence of the pregnancy loss of those cows that become pregnant after first TAI service was 5.0% (8 of 161).

3.2. Influence of LW, RFAT, and BCS on the presence of a CL at the start of the synchronization protocol

Live weight, RFAT, and BCS at 165 days prepartum (time 1) and at parturition (time 2), had no apparent effect on the presence of a CL at the start of the synchronization protocol (42 days postpartum). However, cows without a CL at the start of synchronization protocol presented (3.17 ± 0.03) lower ($P = 0.0002$) BCS than those cows with a CL (3.28 ± 0.04, respectively) at 42 days postpartum (at the onset of the synchronization protocol; time 3).

When cows were separated into groups according to the BCS (≤3.0 or >3.0) or RFAT (≤0.6 cm or > 0.6 cm) at 42 days postpartum (time 3), there were different percentages of cows with a CL at the start of the synchronization protocol. At 42 days postpartum (time 3), 33.8% (44 of 130) of the cows with a BCS less than 3.0, had a CL compared with 43.4% (59 of 136) for cows with a BCS greater than 3.0 ($P = 0.002$). At same time (time 3), 36.0% (54 of 150) of the cows with RFAT less than 0.6 cm had a CL compared with 42.2% (49 of 116) for cows with RFAT greater than 0.6 cm ($P = 0.009$). The probability of a CL at the start of the synchronization protocol increased when RFAT ($P = 0.06$) and BCS ($P = 0.04$), both at 42 days postpartum (time 3), were greater than 0.6 cm and 3.0, respectively.

3.3. Influence of LW, RFAT, and BCS on first service conception rate, pregnancy rate, and occurrence of pregnancy loss

Live weight and RFAT at 165 days prepartum (time 1) and at parturition (time 2) had no effect on first service conception rate at 30 days after TAI or pregnancy loss. However, cows with greater LW and RFAT at 165 days prepartum (time 1) and greater RFAT at parturition (time 2) were associated with increased probability of pregnancy rate (Table 2). Also, cows that had the greatest increase in RFAT during the dry period (i.e., between the weaning of the previous calf and parturition) had a decreased probability of pregnancy loss (Table 2).

Cows with the greater BCS at 165 days prepartum (time 1) were associated with increased probability of pregnancy rate ($R^2 = 1.0$ and $P = 0.006$; Table 2). Furthermore, cows with the highest BCS at parturition (time 2) had an increased probability of first service conception rate at 60 days after the TAI (Fig. 1) and a reduced probability of pregnancy loss (Table 2). However, there was no apparent relationship between BCS at 42 days postpartum (at the onset of the synchronization protocol; time 3) and first service conception rate 60 days after TAI ($R^2 = 0.16$; $P = 0.23$).

Cows with the greatest BCS (3.5, 3.75, and >3.75) at parturition (time 2) were also the cows with the greatest BCS at 165 days prepartum (time 1) and at 42 days postpartum (time 3; Fig. 2). These cows had a greater gain of BCS during the dry period, and also a greater loss of BCS between parturition and the onset of the synchronization protocol 42 days postpartum, compared with cows with the lower BCS (3.25 and <3.25). Cows with the lower BCS had almost no gain or loss of BCS during the dry period or from the parturition to the onset of the synchronization protocol (Table 3). Furthermore, cows with the greater loss of BCS from the parturition to the onset of synchronization protocol presented greater risk to become pregnant than cows that did not lose BCS during this referred period (Fig. 3).

Finally, for the receiver operating characteristic curve analysis, it was found that the critical category of BCS at 165 days prepartum (time 1) that combined the highest

Table 1
Body condition score (1–5 point scale), RFAT (cm), and LW (kg) of suckled Zebu beef cows evaluated at five different times.

Variable	Time	Mean ± SEM	Minimum	Maximum
BCS	165 day prepartum[a]	3.19 ± 0.02	2.50	4.25
	Parturition	3.46 ± 0.02	2.50	4.50
	42 day postpartum[b]	3.21 ± 0.03	2.25	4.50
	82 day postpartum[c]	3.10 ± 0.02	2.50	4.50
	112 day postpartum[d]	3.17 ± 0.02	2.00	4.00
RFAT	165 day prepartum[a]	0.68 ± 0.02	0.3	1.7
	Parturition	0.93 ± 0.02	0.4	2.0
	42 day postpartum[b]	0.65 ± 0.01	0.2	1.7
	82 day postpartum[c]	0.59 ± 0.01	0.2	1.8
	112 day postpartum[d]	0.61 ± 0.01	0.2	1.6
LW	165 day prepartum[a]	390.1 ± 2.67	301	547
	Parturition	421.8 ± 2.47	312	547
	42 day postpartum[b]	401.1 ± 2.57	262	572
	82 day postpartum[c]	405.9 ± 2.45	314	577
	112 day postpartum[d]	415.4 ± 2.50	322	569

Abbreviations: BCS, body condition score; LW, live weight; RFAT, rump fat thickness; TAI, timed artificial insemination.
[a] 165 day prepartum = at weaning of previous calf (time 1).
[b] 42 day postpartum = at the onset of the synchronization protocol (time 3).
[c] 82 day postpartum = at pregnancy diagnosis 30 days after TAI (time 4).
[d] 112 day postpartum = at pregnancy diagnosis 60 days after TAI (time 5).

Table 2
Probability values for the presence of a CL at the start of the synchronization program, first service conception rate at 60 days after TAI, pregnancy rate, and pregnancy loss, relative to BCS, RFAT, and LW evaluated at different times in suckled Zebu beef cows.

Variable	Time	CL[a]	First service conception rate 60 days after TAI	Pregnancy rate	Pregnancy loss
BCS	165 day prepartum[b]	—	—	0.01	—
	Parturition	—	0.02	0.0007	0.05[c]
	42 day postpartum[d]	0.04	—	—	—
	82 day postpartum[e]	—	—	—	0.046[c]
	112 day postpartum[f]	—	—	0.048	0.02[c]
	Difference parturition-42 day postpartum[g]	—	—	0.03[c]	—
RFAT	165 day prepartum	—	—	0.03	—
	Parturition	—	—	0.003	—
	42 day postpartum	0.06	—	—	—
	Difference dry period[h]	—	—	—	0.046[c]
	Difference parturition-42 day postpartum	—	—	0.06[c]	—
LW	165 day prepartum	—	—	0.01	—

Abbreviations: BCS, body condition score; CL, corpus luteum; LW, live weight; RFAT, rump fat thickness; TAI, timed artificial insemination.
[a] Presence of CL at the onset of the synchronization protocol.
[b] 165 day prepartum = at weaning of previous calf.
[c] Drop of probability = there is a negative association between variables.
[d] 42 day postpartum = at the onset of the synchronization protocol.
[e] 82 day postpartum = at pregnancy diagnosis 30 days after TAI.
[f] 112 day postpartum = at pregnancy diagnosis 60 days after TAI.
[g] Difference parturition-42 day postpartum = difference between parturition and 42 day postpartum.
[h] Differences during dry period = difference from the weaning of the previous calf to parturition.

sensitivity and specificity for pregnancy rate was BCS 3.0. The area under the curve was 60.3 (95% confidence interval [CI], 0.541–0.662; P = 0.005). At parturition (time 2), the critical category of BCS that combined the highest sensitivity and specificity for both first service conception rate 60 days after TAI and pregnancy rate was BCS 3.25. The areas under the curve were 57.1 (CI, 0.509–0.631; P = 0.04) and 63.2 (CI, 0.571–0.690; P = 0.0003) for first service conception rate 60 days after TAI and pregnancy rate, respectively.

4. Discussion

The findings, in the present study, indicated that the likelihood of first service conception and the pregnancy rate early in the BS was highest in suckled Zebu cows that had an improvement in RFAT and BCS during the dry period, and which had a BCS of 3.25 or more at parturition. A particularly notable observation was that a decline in BCS in the same cows after parturition did not impact negatively on pregnancy rate during the BS. This finding was interpreted to indicate that Zebu cows with a relatively good BCS at parturition (≥3.25 of BCS) can meet the lactation demands of the calf and lose some BCS without entering a metabolic condition, which is detrimental to the resumption of ovulation and pregnancy rate during the BS. This scenario would be partly influenced by continuing adequate nutrition of the cow postpartum.

The proportion of cows with a CL at the start of the synchronization program (42 days postpartum) was around 39%. There was no apparent effect of LW, RFAT, and BCS at parturition on the occurrence of a CL at 42 days

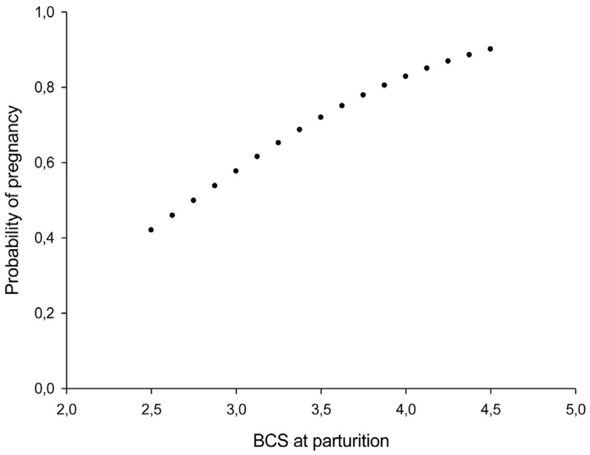

Fig. 1. Probability of pregnancy rate according to the BCS at parturition in suckled *Bos indicus* cows subjected to TAI after natural mating [probability of pregnancy = exp(−2.2959 + 0.9944 × BCS at parturition/1 + exp(−2.2959 + 0.9944 × BCS at parturition); P = 0.0007)]. BCS, body condition score; TAI, timed artificial insemination.

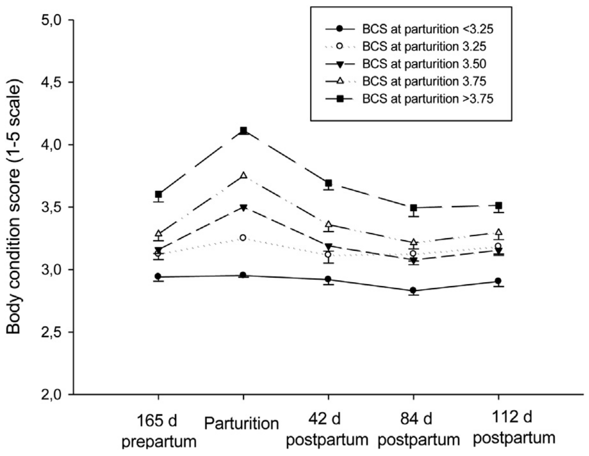

Fig. 2. Longitudinal changes in BCS according to the BCS at parturition of the suckled Zebu beef cows. BCS, body condition score.

Table 3
Differences in BCS during the dry period (i.e., from weaning of previous calf to parturition) and from parturition to the onset of the synchronization of ovulation protocol in suckled Zebu beef cows.

BCS at parturition	N	Difference in BCS during the dry period	Difference in BCS from parturition to synchronization
<3.25	69	0.01 ± 0.04^{c}	-0.03 ± 0.04^{c}
3.25	30	0.13 ± 0.04^{c}	-0.13 ± 0.06^{bc}
3.50	84	0.34 ± 0.03^{b}	-0.31 ± 0.04^{ab}
3.75	44	0.47 ± 0.05^{ab}	-0.39 ± 0.05^{a}
>3.75	39	0.51 ± 0.05^{a}	-0.42 ± 0.05^{a}

Superscript letters a,b,c: values (means ± standard error) within columns followed by a different superscript differ ($P < 0.05$).
Abbreviation: BCS, body condition score.

postpartum. Previous study described that the resumption of cyclicity in cows with a good BCS at parturition was not influenced by LW and BCS changes during the postpartum period [28]. Notwithstanding, in the present study, the probability of a CL at the start of the synchronization protocol increased when RFAT and BCS at the beginning of the synchronization treatment were greater than 0.6 cm and 3.0, respectively, revealing the importance of postpartum nutritional and metabolic condition on cyclic ovarian function.

Previous studies reported that cows with a relatively poor BCS (< 3.0 on a five point scale) present reduced conception rate [24,29,30]. In the present study, however, there was no apparent negative effect of low BCS and low RFAT on first service conception rate. This is likely explained by the incorporation of 400 IU eCG in the synchronization protocol, which would have improved the ovarian and pregnancy outcomes [20,24,31]. Therefore, the eCG treatment would particularly benefit cows in anestrus and with a low BCS and improve the pregnancy outcome in low RFAT and low BCS cows.

Rump fat thickness and BCS influenced pregnancy loss and pregnancy rate. Cows with higher RFAT and BCS at

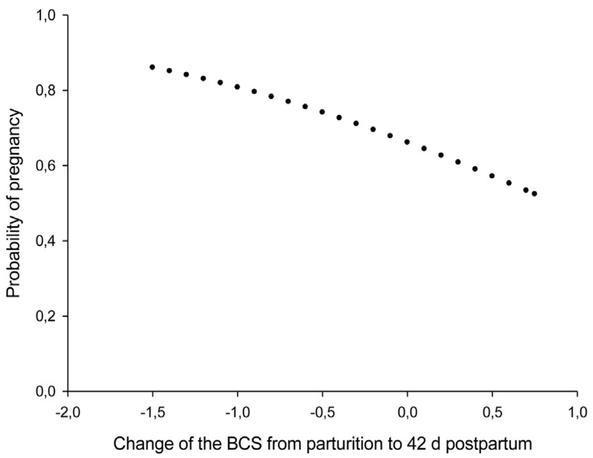

Fig. 3. Probability of pregnancy rate according to the change of the BCS from the parturition to 42 days postpartum (i.e., start of the synchronization protocol) in suckled *Bos indicus* cows subjected to TAI after natural mating [probability of pregnancy = exp(0.6703 + 0.7657 × BCS at parturition/1 + exp(0.6703 + 0.7657 × BCS at parturition); $P = 0.03$)]. BCS, body condition score; TAI, timed artificial insemination.

parturition had increased pregnancy rate, and similar results were reported by López-Gatius et al. [32] from a meta-analysis study in dairy cows. These authors found that dairy cows with a low BCS (<2.5) at parturition had a considerable (9%) reduction in pregnancy rate when compared with cows with a high BCS (>3.5). The general consensus is that a low BCS at parturition and early postpartum is related to an extended period of postpartum anestrus, delayed first ovulation, and poor reproductive outcomes [32–34]. However, in a recent study, there was no apparent effect of a BCS at calving on days to first postpartum ovulation and pregnancy rate in young (2- and 3-year-old) beef cows [35]. These different patterns among dairy and beef cows may be associated with several particularities such as their genotype, nutrition, and metabolism.

Pregnancy losses in cattle are associated with noninfectious [36–39] and infectious [40–42] causes. In the present study, the overall pregnancy loss was 5%. Similar results were reported [43] for pregnancy loss (4%) in lactating beef cows. Furthermore, it was found greater pregnancy loss in cows with a relatively low BCS at parturition and at both 30 and 60 days pregnancy diagnosis. Other studies have confirmed the relationships between BCS and pregnancy and embryonic survival in both beef and dairy cows [15,30,32,38,39,43–46]. In dairy cows, a decline of 1 U in BCS (1–5 scale) from calving to 30 days postpartum had a 2.4-fold increase in the risk of pregnancy loss [32]. Similarly, lactating dairy cows that lost 1 U in BCS from Day 28 to 56 of gestation had a 3.2-fold increase in risk of pregnancy failure in the same period [45]. Therefore, the metabolic status of the cow, as evidenced by the BCS, or the changes in BCS during the postpartum period, affects pregnancy per artificial insemination and pregnancy losses in suckled Zebu cows. The mechanism whereby nutrition influences pregnancy loss requires future investigations.

Previous studies have reported that cows that undergo a moderate loss in BCS between parturition and first postpartum service have a better pregnancy outcome than cows that have a greater loss in BCS [34,44,46–48]. The findings, in the present study, indicate that the relationships are more complex than just the absolute change in BCS postpartum and must be considered over a longer timeframe. Cows with a lower BCS (<3.0) at parturition had the lowest BCS loss (−0.03 ± 0.03) between parturition and synchronization, and also had the lowest cumulative pregnancy (56.6%). However, these were also the cows that had the lowest BCS at 165 prepartum (2.94 ± 0.04) and the lowest gain in RFAT (0.07 ± 0.02 cm) and BCS (0.01 ± 0.04) during the dry period. Further, cows with the greatest BCS at parturition had a greater loss in BCS between parturition and the onset of the synchronization (−0.42 ± 0.05) and highest pregnancy rate (84.6%). The gain in BCS during the dry period (0.51 ± 0.05) was also greater in these cows. Frood and Croxton [49] reported that dairy cows with a low BCS at parturition (1.5 on a 1–5 scale) had no BCS loss during early lactation and cows with a moderate BCS (3.0) had a greater loss of BCS to the first 60 days in milk. In other studies, cows with a relatively high BCS at parturition had a greater BCS loss and fat mobilization than cows with a lower BCS [28,50,51]. Thus, there are Zebu cows that can achieve a relatively good BCS during the dry period, and these cows can subsequently lose BCS postpartum but still return to cyclic ovarian activity relatively early. It will be important to identify the metabolic features of these cows and to establish the genetic basis for metabolic performance that supports an improved reproductive outcome.

In conclusion, Zebu cows that had the greatest increase in BCS during the dry period, and were with a relatively good BCS at parturition, were able to undergo a loss in BCS postpartum and still resume ovulation. These cows had a relatively high first service conception rate, great likelihood of pregnancy during the postpartum period, and low incidence of pregnancy loss.

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