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# Effect of Changes in Body Weight, Body Condition and Back Fat during Last Month of Pregnancy on the Reproductive Efficiency of *Bos indicus* Cows in the Tropics of Costa Rica

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## ABSTRACT

With the aim of evaluating how changes in the metabolic status in the last month of pregnancy affects reproductive efficiency, forty six *Bos indicus* multiparous cows (5.5 ± 2.4 parturitions), were used. Measurements of body weight (BW), body condition score (BCS) and dorsal back fat (BF) were taken in the last month of pregnancy, postpartum period previous to synchronization (average 50 d) and at breeding by natural mating following synchronization with a progestin (average 70 d). Average postpartum days to resumption to ovarian activity were 79.96 ± 16.5 d, and average postpartum days to conception was 88.5 ± 14 d. Days postpartum to resumption of the ovarian activity was positively correlated (0.51, $P < 0.01$) with days postpartum to conception, also, days postpartum to conception was positively correlated with prepartum back fat (14 d before parturition) (0.44, $P < 0.05$). It was observed that BF at calving which is an objective measurement had a low correlation with other productive variables such as BCS and BW (always less than 0.39). Body fat might be a more reliable indicator of the current metabolic status of the animal particularly in the last month of pregnancy when the indicators of BCS are somehow more difficult to interpret and subjective.

**Keywords:** *Bos indicus*; Cattle; Body Condition; Body Weight; Reproduction.

## 1. Introduction

The nutritional status of the cow in the last trimester of pregnancy is a determining factor in the onset of ovarian activity following calving, in turn affecting the interval from calving to conception [1,2]. The nutritional priorities of the animal are three fold: firstly to maintain adequate basal metabolism, secondly, to replenish body reserves lost during the postpartum period and lastly the resumption of ovarian activity [3].

The evaluation of the body condition score (BCS) is a simple method which allows the clinician to estimate an animal's body energy reserves and consequently the possibility of an animal becoming pregnant [4]. In earlier work, Oliver and Richardson [5] postulated that when animals lose 25% - 30% of their body weight, pregnancy was bound not to occur as a natural physiological protective mechanism. Previous work to establish optimum body weight or condition score at calving for a prompt resumption of ovarian activity has rendered conflicting results. Lents *et al.* [6] suggested that cows should be managed to calve during moderate BCS and to maintain body weight (BW) after parturition to decrease the interval to first estrus. However, prior work [7] had indicated that when beef cows are in thin to moderate body condition at calving, postpartum BW change and BCS at calving do not influence the duration of luteal activity. Moreover, Crowe [8] in a review paper on the subject concluded that the key to optimize resumption of ovulation in both beef and dairy cows is appropriate pre-calving nutrition and management so that cows calve down in BCS 2.75 - 3.0 on a scale 1 to 5 with postpartum body condition loss restricted to <0.5 BCS units. Perhaps the conflicting results are the consequence of events that happened earlier in the animal and the measurements such as

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body weight or BCS after calving do not reflect the current status of the animal.

Dorsal back fat has been advanced as a more accurate way to estimate the actual metabolic status of the animal [9]. Therefore, it would be interesting to evaluate the effect of body weight changes, BCS and fat reserves from the last trimester of pregnancy until the first 30 d post calving to be able to predict the odds for the animal to become pregnant in the next breeding season.

## 2. Material and Methods

### 2.1. Localization

The present study was undertaken in the Unit for Bovine Production "La Vega" belonging to the Instituto Tecno lógico de Costa Rica, the place is situated at 10˚25' latitude North and 84˚32' longitude West, with an elevation of 75 m above sea level. The climate of the region is classified as tropical humid with an annual pluvial precipitation of 3096 mm. Average temperature is 27˚C with a relative humidity of 85%. All animal handling and procedures performed were approved by the institutional committee for animal use for research and teaching.

### 2.2. Animals

A total of forty six *Bos indicus* multiparous cows (5.5 ± 2.4 parturitions), were used. The cows were in the last trimester of pregnancy (237 ± 22 d) when the study commenced and had calved between March and April in the previous year. All animals were kept at pasture in paddocks of mainly African star grass (*Cynodon nlemfluensis*), Pará (*Brachiaria mutica*) and Ratana (*Ischaechum indicum*).

### 2.3. Synchronization Scheme

The synchronization of the animals was accomplished using a subcutaneous ear implant releasing progestin (Norgestomet Crestar®, Mexico) which was applied at 51 ± 16 d after calving. The implant remained in place for 9 d. At withdrawal, the calves remained with dams at all times, heat detection devices (Estrus Alert®) were placed in the rump of the animal to detect when the female was mounted by the two mature bulls previously examined for breeding soundness. The bulls were placed with the herd at the moment of implant withdrawal and remained with the cows for 60 d.

### 2.4. Ultrasonography and Body Condition Score

#### 2.4.1. Phase 1, Last Month of Pregnancy

With the aim of estimating the metabolic condition in the last month of pregnancy, (when the weight of the fetus gains the most, coinciding with the height of the dry season in the tropics), measurements of dorsal back fat (BF) [9,10] and BCS were taken in the last month of pregnancy. BCS was estimated according to the scale suggested by Pullan *et al.* [11] being 1 an emaciated animal and 5 obese. BF was measured in the lumbar region between the third and fifth lumbar vertebrae, using an Aloka SSD 500 equipped with a linear 3.5 MHz probe. Body weight (BW) was obtained using an electronic scale and were weighed every two weeks until the end of the experiment at 120 d after parturition.

#### 2.4.2. Phase 2, Postpartum Period Previous to Synchronization

Starting on average at day 50th postpartum, two exams were carried out comprising BF, BCS, BW and blood samples were obtained until the bulls were introduced to the herd at approximately 70 postpartum. Blood samples were centrifuged at 4500 rpm for 10 minutes to obtain the serum which was frozen to be later analyzed for progesterone using a commercial DPC kit (Coat-a-Count, Siemens Medical Solutions Diagnostics, Los Angeles, CA, USA) in the endocrine laboratory of the Faculty of Veterinary Medicine, University of Mexico.

#### 2.4.3. Phase 3, Breeding Program and Assessment of Embryo Survival

After the bulls enter the herd (day 70 postpartum), an US examination and blood samples were taken at days 11 and 14 to ascertain the presence of a corpus luteum. Starting from day 17th, US examinations once per week were carried out to identify the possible presence of an embryo [12], blood samples were obtained concomitantly to determine progesterone concentration. Pregnancy was defined as an animal showing an embryo vesicle with a heartbeat and corroborated with progesterone value greater than 1 ng/ml. Ultrasonographic evaluations concluded at 150 d postpartum.

### 2.5. Statistical Analysis

Each cow was classified according to the differences between BF and BCS prepartum (−28 and −14 d prepartum) and the two measurements of these variables during the postpartum period (54 and 60 d postpartum) respectively, resulting in a three class group of animals: moderate losing (ML, negative difference greater than −10% difference), slight losing (SL, negative difference between −0.1% and −9.99%) and maintaining winning (MW, positive difference greater than 0%).

Consequence of these divisions, cows were classified into 9 categories regarding their BF and BCS class: BFML-BCS ML, BF ML-BCS SL, BF ML-BCS MW, BF SL-BCS ML, BF SL-BCS SL, BF SL-BCS MW, BF MW-BCS ML, BF MW-BCS SL and BF MW-BCS MW.

 

Descriptive statistics was performed with the PROC MEANS procedure of SAS to calculate mean and standard error. Additionally, a possible association was calculated between BF at calving (BFCAL), BF at the start of the breeding season (BFSBS), back fat at the end of the breeding season (BFEBS), body weight at calving (BWCAL), body weight at the start of the breeding season (BWSBS), body weight at the end of the breeding season (BWEBS), body condition score at calving (BCSCAL), body condition score at the start of the breeding season (BCSSBS), and body condition score at the end of the breeding season (BCSEBS). A Pearson correlation was calculated using the PROC CORR procedure of SAS. Days postpartum to conception was not significantly correlated with any of the variables measured, therefore, a logistic regression analysis was performed using the PROC LOGISTIC procedure in SAS from data for each animal, considering measurements of BF, BCS and BW at prepartum (−28 and −14 d), at parturition, during postpartum (54 and 60 d), and during the breeding season (81, 95, 109 and at 123 d) to determine the probability of an animal to cycle. A stepwise selection procedure was used to determine the variables that were significant to predict days postpartum to resumption of ovarian activity (which was considered as a binomial data, where 0 = anestrus, and 1 = cycling). A cycling cow was defined when at least two consecutive progesterone values were above 1 ng/ml. Finally, a polynomial regression was performed to assess the relation between the probability from the logistic regression of a cow to resume the ovarian activity and the back fat at the start of the breeding season.

## 3. Results

It was observed that before the mating period 15% (7/46) of the animals were cycling corroborated by progesterone and ultrasound findings, this proportion increased by the end of the mating period (120 d postpartum) by 59% (27/46). From this group of animals that started cycling, 70% (19/27) were diagnosed as pregnant based on progesterone samples and ultrasonography. Considering only the animals that were at risk to become pregnant, it was concluded that the pregnancy rate after the mating period was 41% (27/46). Overall, the average postpartum days to resumption to ovarian activity were 79.96 ± 16.5 d, and the average postpartum days to conception 88.5 ± 14 d.

Days postpartum to resumption of the ovarian activity was positively correlated (0.51, $P = 0.01$) with days postpartum to conception, also, days postpartum to conception was positive correlated with prepartum back fat (14 d before parturition) (0.44, $P = 0.04$). As can be seen in **Table 1**, back fat at calving was positively correlated with BF at the end of the breeding season (0.32, $P < 0.05$) and body weight at calving was positively correlated with body condition score at calving (0.37, $P < 0.05$). Additionally, there was a tendency for BCS at calving to be positively correlated with body weight at the end of the breeding season (0.29, $P < 0.10$), similarly, BWEBS was positively correlated with BCS EBS (0.29, $P < 0.05$). Finally, it was observed that BF at calving which is an objective measurement had a low correlation with other productive variables such as BCS and BW (always less than 0.39, **Table 1**).

The average measures (±SD) for BF, BW and BCS at different times (PP, CAL, SBS, EBS) within the classification of changes in condition (ML, SL, MW) is shown in **Table 2**. **Figure 1** shows the probability to predict the events using the logistic regression model if a cow had the possibility to cycle according to the dorsal back fat at the start of the breeding season. The probability increases when the animal has more dorsal back fat. This relationship was just observed with the dorsal back fat at the start of the breeding season. **Figure 2** shows the average probability

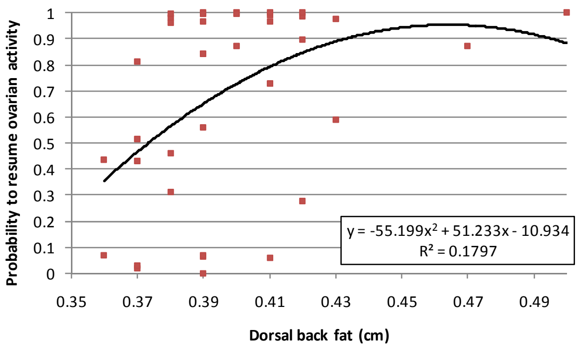


**Figure 1. Probability of an animal to cycle according to the dorsal back fat at the beginning of the breeding season.**

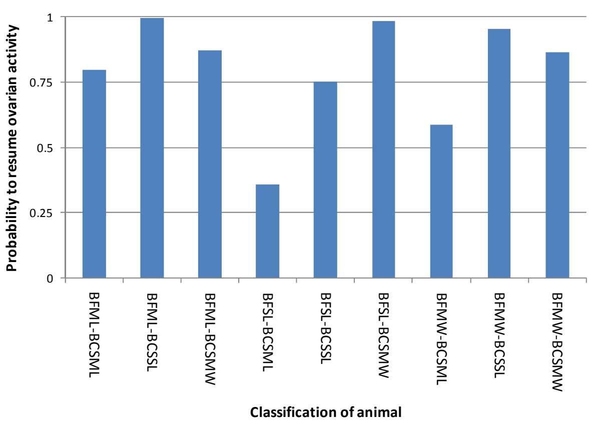


**Figure 2. Probability of an animal to cycle according to the classification based upon on the differences between BF and BCS prepartum (−28 and −14 d prepartum) and the two measurements of these variables during the postpartum period (54 and 60 d postpartum).**

 

**Table 1. Pearson correlation coefficients for productive variables measured in postpartum *Bos indicus* beef cows, (probability, n).**

| | VARIABLES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | BFCAL | BF SBS | BF EBS | BW CAL | BW SBS | BW EBS | BCS CAL | BCS SBS | BCS EBS |
| BF CAL | - | −0.06 (39) | 0.32♦ (39) | 0.06 (40) | −0.08 (38) | 0.008 (39) | −0.08 (40) | −0.04 (38) | 0.05 (39) |
| BF SBS | | - | 0.20 (45) | −0.31♦ (39) | −0.13 (44) | −0.19 (45) | −0.20 (39) | −0.09 (44) | −0.18 (45) |
| BF EBS | | | - | 0.07 (39) | 0.21 (44) | 0.27♠ (45) | −0.16 (39) | 0.36♦ (44) | 0.37♦ (45) |
| BW CAL | | | | - | 0.67♦ (38) | 0.76♦ (39) | 0.37♦ (40) | 0.26 (38) | 0.14 (39) |
| BW SBS | | | | | - | 0.82♣(44) | 0.34♦ (38) | 0.07 (44) | 0.30♦ (44) |
| BW EBS | | | | | | - | 0.29♠ (39) | 0.18 (44) | 0.29♦ (45) |
| BCS CAL | | | | | | | - | 0.06 (38) | 0.22 (39) |
| BCS SBS | | | | | | | | - | 0.29♦ (44) |
| BCS EBS | | | | | | | | | - |

ML = Moderate loss (>10%), SL = Slightly loss (<10% - 0%), MW = Maintenance or greater (>0%), BF = Back fat, BW = Body weight, BCS = Body condition score, CAL = Calving, SBS = Start of the breeding season, EBS = End of the breeding season. Values in parenthesis indicate number of observation. ♣P < 0.01, ♦P < 0.05, ♠P < 0.10.

of a given cow according to its class to resume ovarian activity. As can be seen, when the animal showed moderately BCS loss (>10%) the probability decreases, in contrast when the cow shows slightly BCS loss and maintain or gain afterwards, the probability to resume cyclicity increases.

## 4. Discussion

As expected, just a small proportion of animals were cycling at the beginning of the mating period when the bulls were introduced to the herd, this proportion increased after 12 d of male exposure. These results agreed with previous reports suggesting the bioestimulatory effect of the male on the resumption of the ovarian activity in postpartum *Bos indicus* cows [13-15]. In addition, the nutritional effect expressed in the negative energy balance has been singled out as one of the important factors restraining the restoration of ovarian activity [16]. Several studies have emphasized the effect of BCS and the presence of adipose tissue reserves on the resumption of ovarian activity. In fact, Houghton *et al.* [17] suggested that BCS at parturition affects the metabolic performance of the animal and the energy requirements during the postpartum period. In the present study, it was observed that the probability for an animal to resume ovarian activity increases with the thickness of the dorsal back fat, however, the relationship between dorsal back fat and the probability is low. This can be partially explained by the number of animals that were included in the experiment and also by the variation observed among measurements. In effect, in the extremes of the polynomial regression just a few observations were recorded. However, we believe that in spite of the reduced number of animals, the association exists and the probability for an animal to cycle is related to the metabolic status reflected in the back fat thickness (**Figure 1**).

Some studies suggested that the length of the anestrous postpartum depends greatly on the nutritional status of the animal at parturition [17,18]. Moreover , results from the current study are consistent with those reported by Houghton *et al.* [17] and Spitzer *et al.* [19] indicating that a greater BCS at parturition, might have an additive effect on estrus response and in the proportion of animals becoming pregnant. In the present study it was observed that the metabolic performance of the first 60 d, determined the reproductive outcome of the cows that resulted pregnant. Most of the studies relating changes in BCS following pregnancy to the outcome of a pregnancy in the subsequent cycle, have concluded that BCS pre calving and BCS at the start of the breeding season are the most accurate predictors of pregnancy [20]. Similar conclusions were reached in later studies [21,22]. However recent work [23] found that postpartum supplemental fat and not BCS at calving affected plasma and adipose tissue fatty acid profiles of suckling beef cows. Moreover, Chavez *et al.* [24] in agreement with the present study, found a poor relationship between BCS and the energy reserves of the animal expressed currently as body fat (BF). As the animal loses body weight, lipid reserves are mobilized, thus compromising the maintenance of pregnancy and body condition [25,26]. To what extent subjective measurement of body condition reflects the actual metabolic state of the animal needs to be properly addressed, particularly as the traditional measurements of BCS (non-bony tissue on the posterior ribs, transverse processes of the lumbar vertebrae and the pin bones) are

 

**Table 2. Average (±SD) of variables assessed according to the BF index and BCS index in postpartum *Bos indicus* beef cows.**

| CLASS OF ANIMAL | | | BACK FAT | | | | |
|---|---|---|---|---|---|---|---|
| BF | BCS | n | PP | BF CAL | BF SBS | BF EBS | % CHANGE |
| ML | ML | 4 | 0.42 ± 0.05 | 0.41 ± 0.03 | 0.37 ± 0.006 | 0.28 ± 0.03 | −11.90 |
| ML | SL | 6 | 0.41 ± 0.07 | 0.39 ± 0.01 | 0.42 ± 0.01 | 0.34 ± 0.02 | 2.44 |
| ML | MW | 3 | 0.41 ± 0.05 | 0.33 ± 0.03 | 0.39 ± 0.01 | 0.31 ± 0.02 | −4.88 |
| SL | ML | 13 | 0.41 ± 0.04 | 0.43 ± 0.01 | 0.39 ± 0.008 | 0.33 ± 0.01 | −4.88 |
| SL | SL | 9 | 0.40 ± 0.04 | 0.41 ± 0.02 | 0.38 ± 0.004 | 0.36 ± 0.01 | −5.00 |
| SL | MW | 2 | 0.46 ± 0.07 | 0.46 ± 0.06 | 0.40 ± 0.02 | 0.35 ± 0.02 | −13.04 |
| MW | ML | 4 | 0.39 ± 0.01 | 0.43 ± 0.02 | 0.40 ± 0.01 | 0.35 ± 0.02 | 2.56 |
| MW | SL | 3 | 0.39 ± 0.03 | 0.43 ± 0.01 | 0.40 ± 0.008 | 0.32 ± 0.02 | 2.56 |
| MW | MW | 2 | 0.35 ± 0.36 | 0.41 ± 0.07 | 0.41 ± 0.005 | 0.34 ± 0.06 | 17.14 |
| | | | | BODY WEIGHT | | | |
| BF | BCS | n | PP | BW CAL | BW SBS | BW EBS | |
| ML | ML | 4 | 539.9 ± 30.6 | 573.33 ± 34.64 | 462.25 ± 7.46 | 477.0 ± 10.90 | −14.38 |
| ML | SL | 6 | 530.7 ± 14.9 | 523.60 ± 11.58 | 479.50 ± 12.17 | 473.66 ± 11.45 | −9.65 |
| ML | MW | 3 | 537.8 ± 22.7 | 416.00 ± 19.37 | 432.00 ± 17.43 | 431.33 ± 21.65 | −19.67 |
| SL | ML | 13 | 499.7 ± 51.1 | 499.61 ± 11.14 | 437.23±9.24 | 442.38 ± 8.16 | −12.50 |
| SL | SL | 9 | 534.1 ± 42.7 | 556.28 ± 20.33 | 492.14 ± 13.04 | 492.75 ± 13.40 | −7.86 |
| SL | MW | 2 | 562.5 ± 78.5 | 562.0 ± 58.0 | 480.5 ± 33.5 | 495.0 ± 15.0 | −14.58 |
| MW | ML | 4 | 477.5 ± 32.1 | 499.75 ± 11.91 | 439.75 ± 16.76 | 449.5 ± 18.40 | −7.91 |
| MW | SL | 3 | 514.3 ± 19.1 | 552.66 ± 32.76 | 468.0 ± 42.52 | 450.33 ± 14.25 | −9.00 |
| MW | MW | 2 | 514.8 ± 21.6 | 524.0 ± 20.0 | 456.0 ± 3.0 | 458.0 ± 3.0 | −11.42 |
| | | | | BODY CONDITION SCORE | | | |
| BF | BCS | n | PP | BCS CAL | BCS SBS | BCS EBS | |
| ML | ML | 4 | 2.9 ± 0.1 | 2.8 ± 0.16 | 2.62 ± 0.12 | 2.65 ± 0.07 | −9.66 |
| ML | SL | 6 | 2.8 ± 0.2 | 2.7 ± 0.12 | 2.58 ± 0.08 | 2.79 ± 0.07 | −7.86 |
| ML | MW | 3 | 2.5 ± 0.0 | 2.0 ± 0.0 | 2.33 ± 0.16 | 2.66 ± 0.22 | −6.80 |
| SL | ML | 13 | 2.6 ± 0.9 | 2.53 ± 0.14 | 2.53 ± 0.03 | 2.67 ± 0.05 | −2.69 |
| SL | SL | 9 | 2.8 ± 0.1 | 2.6 ± 0.13 | 2.71 ± 0.10 | 2.71 ± 0.08 | −3.21 |
| SL | MW | 2 | 2.6 ± 0.9 | 2.75 ± 0.25 | 2.75 ± 0.25 | 2.75 ± 0.25 | 5.36 |
| MW | ML | 4 | 3.1 ± 0.4 | 2.37 ± 0.12 | 2.50 ± 0.20 | 2.56 ± 0.06 | −19.35 |
| MW | SL | 3 | 2.8 ± 0.1 | 2.83 ± 0.16 | 2.50 ± 0.0 | 2.66 ± 0.22 | −10.71 |
| MW | MW | 2 | 2.8 ± 0.0 | 2.75 ± 0.25 | 2.75 ± 0.25 | 2.75 ± 0.25 | −1.79 |

Difference between the start of breeding season (SBS) and prepartum (PP) expressed as percentage. ML = Moderate loss (>10%), SL = Slightly loss (<10% - 0%), MW = Maintenance or greater (>0%), BF = Back fat, BW = Body weight, BCS = Body condition score, CAL = Calving, SBS = Start of the breeding season, EBS = End of the breeding season.

 

quite difficult to assess in cows late in pregnancy. Nevertheless, there is a pressing need to develop a quick and reliable method to describe the current metabolic status of cows in late pregnancy. Different studies have stressed the various advantages of cows not losing weight in the critical stage prior to calving [27,28].

The present study describes the reproductive performance of the cows under grazing conditions, and without any nutritional management. Few studies have looked at non supplemented *Bos indicus* cows that had an earlier onset of ovarian activity (107 d postpartum). Our results agree with Selk *et al.* [20], who found that BCS before parturition and at the start of the breeding season were the most important variables affecting pregnancy rates. In the present experiment, the postpartum BW and BF had a stronger effect on pregnancy rate than the values observed in the prepartum BW and BF. More studies are required to critically evaluate the role of these parameters prepartum. Recently, Lents *et al.* [6] as expected, found that pregnancy rate of cows with moderate condition during the breeding season is greater than cows with thin condition at calving. How this observation relates to events late in pregnancy remains to be tested.

Body condition, parity, and the interaction of body condition and parity play an important role in reproductive performance. However, constant changes in the metabolic state of the dam make results somewhat difficult to interpret. Values obtained on a given day, probably reflect events that happened earlier and could have changed due to the energetic intake of the animal [29,30]. Finally, from the metabolic and endocrine standpoint, the nutritional status of the animal during the postpartum period is a key modulator of the resumption of the ovarian activity and ultimately the establishment of pregnancy. Vizcarra *et al.* [31] observed that changes in metabolites (glucose, insulin and NEFA) are not predictive of luteal function but can affect the breeding efficiency of postpartum cows. Based on the results obtained, it is possible to conclude that the measurement of body fat could be a more reliable indicator of the current metabolic status of the animal particularly in the last trimester of pregnancy when the indicators of BCS are somehow more difficult to interpret.

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