ABSTRACT

A new body condition score (BCS) system was developed for Murrah buffaloes. The skeletal check points were identified based on the anatomical features and carcass fat reserves. A new BCS chart with a 1-5 scale having 0.5 increments examining eight skeletal check points was developed. The ultrasonographic assessment of the precision of BCS system in 10 buffaloes for each point of the 1-5 scale indicated that BCS adequately reflected the actual fat reserves. The influence of body condition score at calving (BCS) on the reproductive and productive performance studied in 24 (4 x 6 completely randomised design) and 40 (4 x 10 completely randomized design) buffaloes, respectively, revealed that buffaloes of BCSc group 3.5-3.99 showed the best performance among the four BCSc groups with earlier (P < 0.05) resumption of ovarian activity (29.33 days), a shorter (P < 0.01) postpartum an estrus period (46.66 days), a shorter (P < 0.05) service period (58.83 days), fewer services per conception (1.50), a higher rate of first service conception (66.66%) with higher (P < 0.01) breeding efficiency (90.64 percent). The milk production traits like total milk yield up to 18 weeks of lactation (1658.67 kg), 305 day predicted lactation yield (3187.3 kg), peak milk yield (16.5 kg), milk protein and solids not fat were also higher in BCSc of 3.5-3.99 followed by the BCSc groups of 4.0-4.49, 3.0-3.49 and 2.5-2.99.

Keywords: body condition score, ultrasonography, reproduction, production, buffaloes

INTRODUCTION

The body condition score (BCS) system is a subjective scoring method of evaluating the energy reserves of dairy animals which provides a better understanding of biological relationship between body fat, milk production and reproduction that helps in adopting the optimum managemental practices to derive maximum production and maintain better health status. It is based on evaluation of the outer appearance of the animal that interacts with its body fat reserves and therefore is directly influenced by energy balance. It gives an immediate appraisal of the body state of the animal and is readily incorporated in operational decision making (Gransworthy, 1988). BCS systems have been developed earlier by many scientists like Jefferies (1961) using 0 to 5 scale in ewes, Lowman et al. (1976) using a 0 to 5 scale in beef cattle and Earle (1976) using an eight grade system in dairy cows. Edmonson et al. (1989) developed a chart for body condition scoring of Holstein dairy cows on...
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a 1 to 5 scale using 0.25 increments. Sarjan Rao et al. (2002) and Anitha et al. (2005) have utilized this chart for scoring the crossbred dairy cows in India. India has the highest buffalo population of the world and is showing an increasing trend in the population growth (FAO, 2004). It is the native tract for the best buffalo breeds of the world. In order to derive the maximum potential from native buffaloes and for their better management, there is a need to develop a body condition scoring system to evaluate their fitness. There was no scale developed specifically for buffaloes, and such studies were meager in buffaloes. Hence, the present study was taken up to develop a score system for buffaloes taking into consideration the anatomical features and amount of fat reserves at various skeletal checkpoints and to validate the precision of scores with ultrasonic measurement of subcutaneous fat so that the scale developed can be used to assess and improve the reproduction and production status of buffaloes.

MATERIALS AND METHODS

Development of the new body condition score system

The skeletal check points were identified taking into consideration the anatomical features and amount of fat reserves in 50 slaughtered buffaloes. The amount of fat reserves were measured at six skeletal check points which include points between 12th and 13th ribs, spinous and transverse processes of lumbar vertebrae, sacral crest and tuber sacrale, sacral crest and hooks, hooks and pins, tail head and pins. Based on the amount of fat reserves the scores were prioritized on a 1 to 5 scale of the new BCS proposed. The new chart for condition scoring on a 1 to 5 scale using 0.5 increments was prepared. Diagrams were added to the text to convey the gradation of body changes and reduce the dependence on written descriptions. A score of 1 indicates emaciated, 2 indicates thin, 3 indicates average, 4 indicates fat and 5 indicates obese condition (Chart 1). Eight skeletal checkpoints were examined and merits within each area were used to indicate the body condition. The eight locations observed were:

1. Tail head to pin bones.
2. Spinous processes of the lumbar vertebrae.
3. Depression between the spinous and transverse processes.
4. Transverse processes of lumbar vertebrae.
5. Point between 12th and 13th ribs.
7. Depression between sacral crest and hooks.
8. Depression between hooks and pins.

A Murrah buffalo showing the skeletal check points for BCS as presented in Figure 1. After each checkpoint was observed by vision and palpation the scores were recorded and an average BCS was assigned to a herd of 200 buffaloes.

The same buffaloes were rescored again using the same procedure without referring to the previously assigned scores to determine the accuracy. The scores assigned for the same herd of buffaloes by the faculty members of the department who had expertise in body condition scoring were also compared. The scores assigned by faculty members coincided with the scores of the researchers and so the method of score assigning by the researchers using the new score system was standardized.
Ultrasonographic assessment of the precision of new BCS system

The BCS system developed was subjected to testing for its precision in 10 buffaloes for each point (1, 2, 3, 4, 5) of the scale by ultrasonographic measurements of body fat reserves.

The BCS and ultrasonographic measurements were obtained independently for the same buffaloes on the same day. An LOGIQ α 100 ultrasound machine (GE Medical Systems) with a 5.5 MHz convex transducer was used to determine the amount of subcutaneous fat at five body locations through a coupling gel on each buffalo (Bruckmaier and Blum, 1992). Body locations were selected based on the skeletal checkpoints used for body condition scoring and ease of obtaining and reading ultrasonographic measurements.

The first location was the area between the tail head and pin bones; the second location was the lumbar area. The transducer was oriented parallel to the midline, midway between the spinous and transverse processes. The third location was the area between 12th and 13th ribs. The fourth was the area between the sacral crest and tuber coxae. The fifth area was located midway between hooks and pins above the greater trochanter of the femur.

Measurements were obtained by freezing the image on the screen of the ultrasound machine and then measuring the layer of subcutaneous fat in the centre of the screen (Domecq et al., 1995).

BCS in relation to reproductive performance

Twenty-four Murrah and graded Murrah buffaloes from the Buffalo Research Station, Venkataramannagudem, Sri Venkateswara Veterinary University, Tirupati, were selected to study the influence of BCS at calving (BCSε) on the reproductive performance. The buffaloes selected were in first to third lactation. The buffaloes selected were divided into four groups, six buffaloes each in group, in a 4 x 6 completely randomized design to study the relationship between BCSc and reproductive traits, which indicate the performance.

Postpartum resumption of ovarian activity

To study the postpartum resumption of ovarian activity, the serum progesterone (P₄) concentration was estimated as per the procedures of Hubl et al. (1982).

Blood Collection

Blood samples were collected from day 5 postpartum once every 5 days until 60 days postpartum. Approximately 6 ml of blood was collected into sterile test tubes by jugular vein puncture and allowed to clot by placing the test tubes in a slanting position. After one hour, the serum was separated and centrifuged at 3000 rpm for 5 minutes to get clear serum. The serum was stored at -20°C until utilized for the estimation of P₄ concentration.

Progesterone assay

The serum P₄ concentration was estimated by using Enzyme Linked Immuno Sorbent Assay (ELISA) technique with the help of P₄ kits (Biotron Diagnostics Inc. Hemet California, USA) and was expressed as ng/ml. The increase in serum progesterone concentration beyond one ng/ml for at least 5 days was considered as an indication of ovulation and corpus luteum formation. The day of first ovulation was presumed to be four days before the first rise in progesterone concentration of above one ng/ml. The day of first ovulation was presumed to be the day of postpartum resumption of ovarian activity.
Post-partum estrus, service period, number of services per conception, first service conception rate

Postpartum estrus was observed by the acceptance of a male by the female, which is the most prominent and reliable symptom of estrus in buffalo (Gordon, 1996). A vasectomized male was used for estrus detection on the farm.

The service period was calculated from the date of calving to date of successful service (Thomas and Sastry, 1991).

The data regarding number of services per conception were obtained from the records of the farm.

The first service conception rate was calculated by the percentage of experimental buffaloes conceiving out of the total buffaloes at first insemination (Rajagopal, 2008). The total numbers of services for successful conception also were recorded.

Breeding Efficiency (BE)

The breeding efficiency (BE) of experimental buffalo herd in relation to BCSc was calculated by using the formula:

\[
BE \text{ of buffalo} = \frac{\left[ n(365) + 1040 \right]}{AC + C_i} \times 100
\]

Where
- \( n \) is the number of calving intervals
- \( AC \) is the age at first calving
- \( C_i \) is the calving interval in days
(Jagdish Prasad and Neeraj, 2007).

The data regarding the calving intervals and age at first calving were obtained from the records of the farm.

BCS in relation to productive performance

The influence of body condition on milk production traits was studied in a herd of 40 buffaloes from calving up to 18 weeks postpartum in a 4 x 10 CRD (four groups divided based on BCSc).

Milk yield (kg)

The production data including the daily milk yield (kg) up to 18 weeks of lactation was measured every day both morning and evening after separating the milk for pail feeding the calves.

The peak milk yield (kg) pertaining to the test herd was obtained from the computed data of the farm.

The 305-day predicted lactation yields were calculated by using the ratio estimates of partial lactations of Murrah buffaloes (Thomas and Sastry, 1991). The lactation yield up to 18 weeks was multiplied by the corresponding ratio estimate of 1.9216 to obtain estimate of lactation yield.

Milk components

The milk components, including fat, protein and solids not fat (SNF), were studied in relation to BCS. Representative milk samples from individual buffaloes in the test herd were collected twice in sterile sample bottles during the study period (6-8 weeks after calving and again at 16-18 weeks after calving). The milk samples were analysed for fat, protein and SNF. The fat percent of the milk samples was determined in duplicate (IS: 1224, Part-I, 1977). The milk protein was estimated in duplicate as detailed in procedure (IS: 1479, Part II, 1961). The milk SNF was determined in duplicate (IS: 1224-1958).

Statistical Analysis

Analysis of variance was used to study the variation in carcass fat thickness at various skeletal check points, the variation in ultrasonographic fat
reserves within BCS and among different BCS groups, the relationship of BCSc with the parity and postpartum estrus, parity and service period, parity and number of services per conception, first service conception rate, resumption of ovarian activity, breeding efficiency, total milk yield up to 18 weeks after calving, predicted lactation yield, peak milk yield, persistency index, milk fat, protein and SNF and for comparison of scores assigned with carcass fat reserves. Correlation coefficients were used to study the relationship among BCS, carcass, fat and ultrasonographic fat reserves (Snedecor and Cochran, 1994).

RESULTS

Development of the new BCS system

The anatomical features studied in slaughtered buffaloes showed that the narrow and pointed ends of the spinous and transverse processes of lumbar vertebrae make it possible to assess the fat reserves easily by vision and palpation on live animal. The convexity of the dorsal sacral crest and the sharp bony prominences of the hooks and pin bones help in the examination of fat cover in the pelvic area. The carcass fat reserves measured at six skeletal check points showed that the fat thickness (mm) at tail head to pin bones (6.28 ± 0.37) was significantly (P < 0.01) higher than the fat at other skeletal check points, followed by the fat thickness at the lumbar area (4.43 ± 0.28), between the 12th and 13th ribs (4.19 ± 0.27), sacral crest to tuber sacrale and sacral crest to hooks (3.56 ± 0.23), hooks to pins (3.22 ± 0.19). Based on the amount of fat reserves the scores were assigned on a 1 to 5 scale. The mean values of carcass fat thickness for the scores 1 to 5 at individual skeletal check points and the mean of all the six check points are presented in Table 1. Significant (P < 0.01) differences were observed in the carcass fat thickness among the five scores at all the individual check points as well as the mean of the six check points indicating that the scale was internally consistent.

The BCS chart with a 1 to 5 scale using 0.5 increments, examining eight skeletal check points was developed (Chart 1), and BCSs were assigned to a herd of 200 buffaloes using the chart.

Ultrasonic assessment of the precision of the BCS system

The ultrasonographic fat measurements at five BCS skeletal check points showed that the fat thickness was highest at the tail (P < 0.01), followed by the lumbar area, ribs, sacral crest to hooks and hook to pins. Figure 2, 3, 4, 5 and 6 show the ultrasonographic fat measurements in Murrah buffaloes of BCSSs 1, 2, 3, 4 and 5, respectively. The ultrasonographic measurements of mean body fat thickness for buffaloes of different body condition scores are presented in Table 1. Significant (P < 0.01) differences were observed in the fat thickness for buffaloes of various BCS groups. As the BCS increased, the amount of fat reserves also increased, indicating that BCSs were adequately reflected in the amount of actual fat reserves. BCS was significantly (P < 0.01) correlated with the carcass fat reserves (0.86) as well as ultrasonographic fat reserves (0.85).

BCS in relation to reproductive performance

Parity and the interaction of parity with BCS did not shown any significant influence on the reproductive performance whereas BCS had a significant effect on the reproductive performance in the test herd. The reproductive performances of buffaloes of various BCSc groups in the test herd
are presented in Table 2. The buffaloes of BCS group 3.5-3.99 had earlier (P < 0.05) resumption of ovarian activity, a shorter postpartum an estrus period (P < 0.01), a shorter service period (P < 0.05), fewer services per conception, higher first service conception rate, and higher breeding efficiency (P < 0.01) of 29.33 days, 46.66 days, 58.83 days, 1.5, 66.66 percent, and 90.64 percent, respectively, followed by buffaloes of BCS group 4.0-4.49 with 39.33 days, 55.16 days, 77.16 days, 1.83, 50 percent, and 87.48 percent, respectively, followed by buffaloes of BCS group 4.0-4.49 with 39.33 days, 55.16 days, 77.16 days, 1.83, 50 percent, and 87.48 percent, respectively, followed by buffaloes of BCS group 3.0-3.49 with 42 days, 65.66 days, 85.66 days 2.0, 33.33 percent and 80.58, respectively, followed by buffaloes of BCS group 2.5-2.99 with 47.25 days, 77.16 days, 125.16 days, 2.66, 16.66 percent and 70.49 percent, respectively. It was observed that the reproductive performance improved as the BCS increased up to 3.99, but beyond that a decline was noticed.

**BCS in relation to productive performance**

The relationship between BCS and milk yield in the test herd is presented in Table 3. Buffaloes of BCS group 3.5-3.99 had higher (P < 0.01) milk yields up to 18 weeks of lactation (kg), 305 day predicted lactation yield (kg), and peak milk yield (kg) of 165.87, 3187.31 and 16.5, respectively, followed by buffaloes of BCS group 4.0-4.49 with 1359.92, 2613.23 and 13.75 respectively, followed by buffaloes of BCS group 2.5-2.99 with 1030.93, 1981.05 and 9.50, respectively. As the BCS increased beyond 3.99, the milk yield showed a decline. Table 4 shows the relationship between BCS and milk components. Buffaloes of BCS group 4.0-4.49 had higher (P < 0.01) milk fat percent followed by BCS group of 3.5-3.99, 3.0-3.49 and 2.5-2.99 at 6-8 weeks after calving whereas buffaloes of BCS group 3.5-3.99 had higher (P < 0.01) milk protein and SNF percent followed by BCS groups of 4.0-4.49, 3.0-3.49 and 2.5-2.99 at 6-8 weeks and at 16-18 weeks after calving.

**DISCUSSION**

The concept of body condition scoring of dairy animals has gained widespread acceptance as a managemental aid in dairy production. In the present research work, a new BCS system was developed for Murrah buffaloes. The skeletal check points were identified by selecting the anatomical features which made it possible to assess the fat reserves easily and by measuring the amount of fat reserves in slaughtered animals. The scores were assigned on a 1 to 5 scale based on the amount of carcass fat reserves. The mean±SE (mm) values of carcass fat thickness for the scores 1 to 5 ranged from 1.67 ± 0.07 to 7.82±0.21 at the point between 12th and 13th ribs whereas the values recorded by Apple et al. (1999) by assigning scores to beef cows on a 9 point scale ranged from 0.5±1.5 to 27.3±1.5 at the 12th/13th rib interface. The difference in these fat thickness measurements with those of the present study might be attributed to the species difference.

The new BCS chart with a 1 to 5 scale having 0.5 increments examining eight skeletal check points was developed to score Murrah buffaloes. For beef cattle, a 9-point scale is commonly used (Wagner et al., 1988). Concerning dairy cows, 8 and 10 point scales are used in Australia and New Zealand (Roche et al., 2004). The prevailing scoring systems in the United States and Ireland use a 5-point scale. The BCS is determined by vision and palpation of the skeletal check points in
the present study which was in tune with Wildman et al. (1982) and Ferguson et al. (1994) whereas Edmoson et al. (1989) evaluated the body locations only visually. BCS was assigned using the chart developed and the new BCS system was found to be precise and consistent. Thus, the present study suggested that anatomical studies, amount of fat reserves and the assessment of scores helped in the development of a valid BCS system.

An ultrasonographic machine with a 5.5 MHz convex transducer was used to determine the amount of subcutaneous fat whereas Domecq et al. (1995) used a 5 MHz linear array transducer. The ultrasonographic fat thickness measurements were significantly (P<0.01) higher at the check point between tail head to pin bones, and this was in accordance to the findings of Gentry et al. (2004) who observed that tail head area accounted for the majority of the variation in BCS in mares. As the BCS increased, the amount of fat reserves increased significantly (P<0.01) indicating that BCS adequately reflected the amount of actual fat reserves. Significant (P<0.01) correlation was observed between BCS and ultrasonographic fat reserves (0.85) and this was in accordance to the findings of Lubis and Fletcher (1985), who reported significant correlation (0.87) between subjectively determined BCS and ultrasonically determined back fat thickness in swamp buffalo cows.

The results of the present study highlighted the importance of body condition at calving in achieving good reproductive performance. Studies on the interaction of BCS with parity showed no significant effect on reproductive performance. However, Roche et al. (2007) reported that interaction of calving BCS with parity was consistent and suggested that cows in first and second parity may have good reproductive performance from greater BCS. Parity had no significant effect on reproduction in the present study whereas Buckley et al. (2003) reported that parity was associated with likelihood of pregnancy at first service.

The resumption of ovarian activity was observed at mean values of 47.25±2.39, 42.0±2.91, 29.33±3.33 and 39.33±4.21 days for the BCS groups of 2.5-2.99, 3.0-3.49, 3.5-3.99 and 4.0-4.49, respectively, whereas Nosier and Hussein (1988) report that postpartum ovarian activity resumed in the fourth week after calving in Egyptian buffaloes was earlier than the values of the present study. However, there was a great diversity in the postpartum interval to first ovulation in dairy cows and was reported as 17 days (Schams et al., 1978), 18 days (Stevenson and Britt, 1979), 19 days (Ducker and Morant, 1984), 21 days (Carruthers and Hafs, 1980; Fonseca et al., 1983) and 36 days (Butler et al., 1981). The findings on the influence of BCS on the resumption of ovarian activity were in agreement with the report of Langley and Sherington (1983) that cows of higher BCS had a shorter interval from calving to first ovulation.

The results showed that body condition at calving was the critical factor related to reestablishment of ovarian function. Buffaloes of BCS range 3.5-3.99 showed early resumption of ovarian activity, which is an indicator of good reproduction performance, whereas buffaloes of BCS range 2.5-2.99 took a longer period for resumption of ovarian activity, showing poor reproductive performance, which was in tune with the findings of Beam and Butler (1997) and Reksen et al. (2002), who reported the delayed resumption of luteal function in thinner cows. Similarly, Markusfeld et al. (1997) reported that thinner cows at calving were more likely to have inactive ovaries. Ramirez-Iglesia et al. (1992) also reported that body condition, reflecting the nutritional status of the cows at calving, favoured the onset of sexual
activity.

For every one unit increase in BCS, a decrease of 20.5 days in postpartum estrus period, 37.41 days in service period, 0.66 in the number of services per conception and an increase of 33.33 percent in the conception rate at first service was observed. The reproductive performance improved as the BCS increased to 3.99 but beyond that a decline was noticed. These findings were in agreement with the reports of Langley and Sherington (1983) who observed that cows with higher BCS at calving had a shorter interval to first detected oestrus. Hajurka et al. (1999) also reported that as BCS increased from 1 to 3.5, the number of days to first signs of oestrus decreased. Yaylak (2003) reported that as BCS increased (< more or > 3.50), service period became shorter. Lopez Gatius (2003) also reported that cows with a BCS of higher than 3.5 at calving showed significant reduction in the number of days open compared with cows of BCS less than 3.5 at calving and that pregnancy at first A.I. showed a significant drop in cows delivering in poor condition, which findings were in accordance with the present study.

Studies on the influence of BCS on productive performance showed that for every one unit increase in BCS, an increase of 395.27 kg, 795.55 kg and 4.57 kg was observed in the 18 weeks lactation yield, 305 day predicted lactation yield, and peak milk yield, respectively. These findings were in accord with the reports of Mohammed et al. (1988) that cows with BCS of 2.5 produced less milk than those with 3 to 3.5. Flamenbaum et al. (1995) also reported that milk production for 150 days of lactation was greater for cows at higher BCS (3.80±0.08) than for cows at low BCS (2.65±0.07). Similarly, Pedron et al. (1993) observed that BCS was related (P<0.05) to peak production, and one unit of BCS was associated with 422 kg 305 day milk production in Holstein cows, the value being lower than the predicted values of the present study, whereas Ruegg and Milton (1995) reported that BCS had no effect on 305 day milk yields in Holstein cows. The majority of investigations undertaken in grazing systems has reported a positive association between calving BCS and milk production (Stockdale, 2005; Roche et al., 2005) which was in accordance with the present study.

For every one unit increase in BCS, an increase of milk fat percent of 1.8 and 2.0 and milk protein / SNF percent of 0.55 and 0.54 was observed at 6-8 weeks after calving and 16-18 weeks after calving, respectively. Holter et al. (1990) observed that cows considered as underconditioned at calving had reduced milk fat concentration, which was in accordance with the present findings. Roche et al. (2007) reported that fat content increased with increasing BCS (0.1 and 0.02 percent fat up to 60 and 270 days in milk, respectively, per BCS unit at calving) which was less than the values observed in the present study, and that BCS at calving did not significantly affect milk protein content, which was in contrast to the present findings.

The results of the study revealed that the reproductive performance and milk production increased with BCS up to a score of 3.99, but beyond this there was a decline. The present study suggested that a BCS of 3.5-3.99 was ideal for better reproductive and productive performance of Murrah buffaloes, and hence the feeding management should be monitored such that the buffaloes maintain a BCS of 3.5-3.99 at the time of calving.
Table 1. The mean carcass and ultrasonographic fat thickness (mm) for the five scores of body condition.

<table>
<thead>
<tr>
<th>BCS</th>
<th>Carcass Between 12th and 13th ribs</th>
<th>Lumbar area</th>
<th>Carcass Between sacral crest and tuber sacrale</th>
<th>Carcass Between sacral crest and hooks</th>
<th>Carcass Between hooks and pins</th>
<th>Carcass Between Tail head and pins</th>
<th>Mean of all check points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carcass Ultrasonograph</td>
<td>Carcass Ultrasonograph</td>
<td>Carcass Ultrasonograph</td>
<td>Carcass Ultrasonograph</td>
<td>Carcass Ultrasonograph</td>
<td>Carcass Ultrasonograph</td>
<td>Carcass Ultrasonograph</td>
</tr>
<tr>
<td>1</td>
<td>1.67 1.6</td>
<td>2.21 1.8</td>
<td>1.73 ---</td>
<td>1.73 1.3</td>
<td>1.64 1.2</td>
<td>2.70 2.7</td>
<td>1.95 1.72</td>
</tr>
<tr>
<td>2</td>
<td>2.68 3.2</td>
<td>3.08 3.3</td>
<td>2.37 ---</td>
<td>2.37 2.8</td>
<td>2.50 2.6</td>
<td>4.23 4.6</td>
<td>2.97 3.3</td>
</tr>
<tr>
<td>3</td>
<td>4.16 4.3</td>
<td>4.27 4.6</td>
<td>3.48 ---</td>
<td>3.48 3.8</td>
<td>3.33 4.0</td>
<td>6.50 6.4</td>
<td>4.35 4.62</td>
</tr>
<tr>
<td>4</td>
<td>6.06 6.2</td>
<td>6.24 6.6</td>
<td>5.20 ---</td>
<td>5.20 5.6</td>
<td>4.45 5.0</td>
<td>8.69 8.5</td>
<td>6.15 6.38</td>
</tr>
<tr>
<td>5</td>
<td>7.82 8.0</td>
<td>8.22 8.0</td>
<td>6.68 ---</td>
<td>6.68 6.8</td>
<td>5.34 5.9</td>
<td>11.02 12.5</td>
<td>7.83 8.06</td>
</tr>
</tbody>
</table>

Table 2. Reproductive performance of buffaloes of various BCSc groups in the test herd.

<table>
<thead>
<tr>
<th>Reproduction Parameters</th>
<th>BCSc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.5-2.99</td>
</tr>
<tr>
<td>Post-partum resumption of ovarian activity</td>
<td>47.25 ± 2.39</td>
</tr>
<tr>
<td>Post-partum estrus (days)</td>
<td>77.16 ± 5.33</td>
</tr>
<tr>
<td>Service period (days)</td>
<td>125.16 ± 17.42</td>
</tr>
<tr>
<td>No. of services per conception</td>
<td>2.66 ± 0.61</td>
</tr>
<tr>
<td>1st service conception rate (%)</td>
<td>16.66</td>
</tr>
<tr>
<td>Breeding efficiency</td>
<td>70.49 ± 2.35</td>
</tr>
</tbody>
</table>
Table 3. Relationship between BCSc and milk yield in the test herd.

<table>
<thead>
<tr>
<th>BCSc</th>
<th>Milk yield upto 18 weeks of lactation (kg)</th>
<th>‘F’ Value</th>
<th>Predicted lactation yield (kg)</th>
<th>‘F’ Value</th>
<th>Peak milk yield (kg)</th>
<th>‘F’ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5-2.99</td>
<td>1030.93**b</td>
<td>150.33d</td>
<td>1981.05d</td>
<td>150.33d</td>
<td>9.50d</td>
<td></td>
</tr>
<tr>
<td>3.0-3.49</td>
<td>1197.12c</td>
<td>150.33**</td>
<td>2300.39c</td>
<td>11.60c</td>
<td>16.50b</td>
<td>78.73**</td>
</tr>
<tr>
<td>3.5-3.99</td>
<td>1658.67a</td>
<td>1658.67a</td>
<td>3187.31a</td>
<td>16.50b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0-4.49</td>
<td>1359.92b</td>
<td>1359.92b</td>
<td>2613.23b</td>
<td>13.75b</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a, b, c, d: values with different superscripts vary significantly (P < 0.01).

Table 4. Relationship between BCSc and milk components in the test herd.

<table>
<thead>
<tr>
<th>BCSc</th>
<th>At 6-8 weeks after calving</th>
<th>At 16-18 weeks after calving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fat %</td>
<td>Protein %</td>
</tr>
<tr>
<td>2.5-2.99</td>
<td>5.82d</td>
<td>3.12d</td>
</tr>
<tr>
<td>3.0-3.49</td>
<td>6.80c</td>
<td>3.47c</td>
</tr>
<tr>
<td>3.5-3.99</td>
<td>7.76b</td>
<td>3.96a</td>
</tr>
<tr>
<td>4.0-4.49</td>
<td>8.46a</td>
<td>3.74b</td>
</tr>
</tbody>
</table>

a, b, c, d: values with different superscripts vary significantly (P < 0.01).
Figure 1. Murrah buffalo showing the skeletal check points for BCS.
Figure 2. Ultrasonographic fat measurements in a Murrah buffalo of BCS 1. (A) Fat thickness at the area between tail head and pins was 3 mm, (B) Fat thickness at the lumbar area was 2 mm, (C) Fat thickness at the area between 12th and 13th ribs was 2 mm, (D) Fat thickness at the area between sacral crest and tuber coxae was 2 mm, (E) Fat thickness at the area between hooks and pins was 1 mm.
Figure 3. Ultrasonographic fat measurements in a Murrah buffalo of BCS 2. (A) Fat thickness at the area between tail head and pins was 5 mm, (B) Fat thickness at the lumbar area was 4 mm, (C) Fat thickness at the area between 12th and 13th ribs was 3 mm, (D) Fat thickness at the area between sacral crest and tuber coxae was 3 mm, (E) Fat thickness at the area between hooks and pins was 2 mm.
Figure 4. Ultrasonographic fat measurements in a Murrah buffalo of BCS 3. (A) Fat thickness at the area between tail head and pins was 6 mm, (B) Fat thickness at the lumbar area was 5 mm, (C) Fat thickness at the area between 12th and 13th ribs was 4 mm, (D) Fat thickness at the area between sacral crest and tuber coxae was 4 mm, (E) Fat thickness at the area between hooks and pins was 3 mm.
Figure 5. Ultrasonographic fat measurements in a Murrah buffalo of BCS 4. (A) Fat thickness at the area between tail head and pins was 8 mm, (B) Fat thickness at the lumbar area was 6 mm, (C) Fat thickness at the area between 12th and 13th ribs was 6 mm, (D) Fat thickness at the area between sacral crest and tuber coxae was 5 mm, (E) Fat thickness at the area between hooks and pins was 4 mm.
Figure 6. Ultrasonographic fat measurements in a Murrah buffalo of BCS 5. (A) Fat thickness at the area between tail head and pins was 11 mm, (B) Fat thickness at the lumbar area was 8 mm, (C) Fat thickness at the area between 12th and 13th ribs was 8 mm, (D) Fat thickness at the area between sacral crest and tuber coxae was 7 mm, (E) Fat thickness at the area between hooks and pins was 6 mm.
Chart 1. Body condition scoring chart for Murrah and graded Murrah buffaloes on a 1 to 5 scale having 0.5 increments.
ACKNOWLEDGEMENT

The authors thank the Director of Research, Sri Venkateswara Veterinary University, Tirupati, for providing the facilities to carry out the research work.

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