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Research Article

STUDY ON THE RELATIONSHIP OF BCSc AND LACTATION CURVE CHARACTERISTICS IN MURRAH AND GRADED MURRAH BUFFALOES UNDER FIELD CONDITIONS

***Ashalatha P., Sarjan Rao K, Jagadeeswara Rao S, Ravindra Reddy Y., Moorthy PRS and Ramana JV**
Department of Livestock Production and Management, NTR College of Veterinary Science, Sri Venkateswara Veterinary University, Gannavaram-521102
**Author for Correspondence*

ABSTRACT
The lactation curve characteristics studied in relation to BCSc in 40 buffaloes in a 4 x 10 CRD, showed that the milk production increased from calving until two months of lactation, reaching peak production and then gradually showed a decline for all the BCSc groups of the test herd. The total milk yield upto 18 weeks of lactation was higher for the BCSc group of 3.5 - 3.99. For every one unit increase in BCSc, an increase of 432.01 kg kg in the 18 weeks lactation yield was observed. But as the BCSc exceeded 3.99 a decrease in milk yield was noticed. The predicted lactation yield was higher for the BCSc group of 3.5-3.99. For every one unit increase in BCSc an increase of 882.43 kg was observed in the predicted lactation yield. But as the BCSc exceeded 3.99 the predicted yield showed a decline. The peak milk yield was higher for the BCSc group 3.5-3.99. For every one unit increase in BCSc, an increase of 3.64 kg of peak yield was noticed. Further, the peak yield and persistency index showed a decrease as BCSc exceeded 3.99. For every one unit increase in BCSc an increase of milk fat per cent of 1.88 and 1.91 was observed at 6-8 weeks and 16-18 weeks after calving, respectively. For every one unit increase in BCSc an increase of milk protein / SNF of 0.30 and 0.57 / 0.76 and 0.61 was observed at 6-8 weeks and 16-18 weeks after calving respectively. As the BCS increased from 6-8 weeks after calving to 16-18 weeks after calving the milk components i.e., fat, protein and SNF showed an increasing trend.

Keywords: *BCSc, Murrah Buffalos, Lactation Curve Characteristics*

INTRODUCTION
India ranks first in the buffalo population of the world and is showing an increasing trend in the population growth (FAO, 2010). 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 validate the developed body condition scoring systems to evaluate their fitness. Earlier studies were conducted only in small herds and mostly organized controlled livestock feeding centres and farms. Hence, the present study is taken up to validate the score system developed by Anitha *et al.*, (2010) in field conditions using large herds of buffaloes both by taking into consideration the anatomical features and amount of fat reserves at various skeletal checkpoints in relation to the production, reproduction and health status of buffaloes. Keeping this in view, the present research work was carried out to study the relationship of BCSc with lactation curve characteristics in murrah buffaloes.

MATERIALS AND METHODS
The new chart for condition scoring in a 1 to 5 scale using 0.5 increments, functioning as a 9 point scale was prepared by Anitha *et al.*, 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 emanciated, 2 indicate thin, 3 indicate average, 4 indicate fat and 5 indicates obese condition. 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.
6. Sacral crest.
7. Depression between sacral crest and hooks and
8. Depression between hooks and pins.

The buffaloes were scored at monthly interval from calving (BCSc) to 4 months to study the postpartum changes in BCS.

The production data including the daily milk yield (kg) upto 18 weeks of lactation was measured everyday 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 upto 18 weeks was multiplied by the corresponding ratio estimate of 1.9216 to obtain estimate of lactation yield.

The milk components include 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 per cent of the milk samples were 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 were determined in duplicate (IS: 1224-1958).

RESULTS AND DISCUSSION

Results

Tabulation of BCSc, milk yield particulars, persistency index and milk components (lactation curve characteristics) of the test herd was presented in Table 1. The mean BCSc of the test herd was 3.37 ± 0.09. The mean milk yield per day of the test herd was 8.60 ± 0.28 during the first month of lactation, 10.04 ± 0.29 during the second month, 9.12 ± 0.32 during the third month and 9.02 ± 0.37 during the fourth month of lactation. The total milk yield upto 18 weeks from calving ranged from 866 kg to 1735.6 kg with a mean value of 1119.28 ± 21.81. The predicted lactation yield for 305 days of the test herd ranged from 1664.10 kg to 3335.12 kg with a mean yield of 2333.99 ± 41.92. The peak milk yield ranged from 8 to 18 kg with a mean peak yield of 11.69± 0.30kg. The mean persistency index of the test herd was 1.45 ± 0.04.

The milk fat per cent at 6-8 weeks after calving ranged from 5.4 to 9.1 with a mean value of 7.04 ± 0.06. The milk fat per cent at 16-18 weeks after calving ranged from 6.1 to 10.4 with a mean value of 7.64 ± 0.11. The milk protein per cent at 6-8 weeks after calving ranged from 2.89 to 4.08 with a mean value of 3.39 ± 0.02. The milk protein per cent at 16-18 weeks after calving ranged from 3.2 to 4.3 with a mean value of 3.55 ± 0.02. The milk SNF per cent at 6-8 weeks after calving ranged from 8.49 to 9.7 with a mean value of 9.17 ± 0.03. The milk SNF per cent at 16-18 weeks after calving ranged from 8.8 to 9.9 with a mean value of 9.43 ± 0.02.

The monthly postpartum BCS and milk yield per day in the test herd was presented in Table 2. The mean BCS values during the first, second, third and fourth months of lactation were 3.27, 2.84, 3.04 and 3.15 respectively with overall mean postpartum BCS of 3.07. The mean milk yield per day (kg) during the first, second, third and fourth months of lactation were 8.60 ± 0.28, 10.04 ± 0.29, 9.02 ± 0.32 and 9.12 ± 0.37, respectively with an overall mean milk yield of 10.26 ± 0.24 kg per day during the study period. The correlation between BCS and milk yield in the test herd showed that BCS was significantly ($P < 0.05$) negatively correlated with the milk yield during the study period. As the BCS decreased from first to second month of lactation the milk yield / day showed an increase and as the BCS gradually increased trend from second to fourth month of the milk yield showed decreasing trend indicating inverse relationship between BCS and milk yield during the study period of 4 months of lactation.

The relationship between BCSc and milk yield in test herd was presented in Table 3. The mean of the total milk yield upto 18 weeks of lactation for the BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99 and 4.0

– 4.49 was 1030.93, 1197.12, 1658.67 and 1359.92 kg respectively. Buffaloes of BCSc group 3.5 – 3.99 had significantly ($P < 0.01$) higher milk yield than the remaining three BCSc groups. Buffaloes of BCSc group 4.0 – 4.49 had significantly ($P < 0.01$) higher milk yield than the BCSc groups of 3.0 – 3.49 and 2.5 – 2.99. Buffaloes of BCSc 3.0 – 3.49 had significantly ($P < 0.01$) higher milk yield upto 18 weeks of lactation than BCSc group of 2.5 – 2.99. The mean of the predicted lactation yield (kg) for the BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99 and 4.0 – 4.49 was 1981.05, 2300.39, 3187.31 and 2613.23 respectively. There was a significant ($p < 0.01$) difference in the predicted lactation yield among all the four BCSc groups. Buffaloes of BCSc group 3.5 – 3.99 had the highest predicted lactation yield, followed by BCSc groups 4.0 – 4.49, 3.0 – 3.49 and 2.5 – 2.99.

The relationship between BCSc and peak milk yield in the test herd was presented in Table 4. The mean peak milk yield (kg) for the BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99 and 4.0 – 4.49 was 9.50, 11.60, 16.50 and 13.75, respectively. There was a significant ($P < 0.01$) difference in the peak milk yield among all the four BCSc groups. Buffaloes of BCSc group 3.5 – 3.99 had higher peak yield, followed by BCSc groups 4.0 – 4.49, 3.0 – 3.49 and 2.5 – 2.99. The relationship between BCSc and persistency of milk production was presented in Table 42. The persistency index for the BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99 and 4.0 – 4.99 were 1.65, 1.69, 1.77 and 1.68, respectively. Though, there was no significant difference in the persistency index among the BCSc groups, buffaloes of BCSc group 3.5 – 3.99 had comparatively higher persistency index.

The relationship between BCSc and milk fat percent in the test herd was presented in Table 5. The fat per cent at 6-8 weeks after calving for BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99 and 4.0 – 4.49 was 5.82, 6.80, 7.76 and 8.46, respectively. There was a significant ($P < 0.01$) difference in the fat per cent among all the four BCSc groups. Buffaloes of BCSc group 4.0 – 4.49 had high milk fat per cent, followed by BCSc groups of 3.5 – 3.99, 3.0 – 3.49 and 2.5 – 2.99. The milk fat per cent values at 16-18 weeks after calving for BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99 and 4.0 – 4.49 were 6.44, 7.54, 8.62 and 9.37 respectively. There was a significant ($P < 0.010$ difference in the fat per cent among all the four BCSc groups. Buffaloes of BCSc group 4.0 – 4.49 had higher milk fat per cent than BCSc groups of 3.5 – 3.99, 3.0 – 3.49 and 2.5 – 2.99.

The relationship between BCSc and milk protein per cent in the test herd was presented in Table 6. The protein per cent for the BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99, 4.0 -4.49 at 6-8 weeks after calving and at 16-18 weeks after calving were 3.12, 3.47, 3.96, 3.74 and 3.39, 3.74, 4.24 and 3.97, respectively. There was a significant ($P < 0.01$) difference in the milk protein per cent among all the four BCSc groups. Buffaloes of BCSc group 3.5 – 3.99 had higher milk protein, followed by BCSc groups of 4.0 – 4.49, 3.0 – 3.49 and 2.5 – 2.99 at 6-8 weeks after calving as well as at 16-18 weeks after calving.

The relationship between BCSc and milk SNF per cent in the test herd was presented in Table 7. The SNF per cent for the BCSc groups 2.5 – 2.99, 3.0 – 3.49, 3.5 – 3.99, 4.0 – 4.49 at 6-8 weeks after calving and at 16-18 weeks after calving were 8.73, 9.07, 9.56, 9.34 and 8.99, 9.34, 9.84, 9.57, respectively. There was a significant ($P < 0.01$) difference in the milk SNF per cent among all the four BCSc groups. Buffaloes of BCSc group 3.5 – 3.99 had higher SNF per cent, followed by BCSc groups of 4.0 – 4.99, 3.0 – 3.49 and 2.5 – 2.99, at 6-8 weeks as well as at 16-18 weeks after calving.

The lactation curve characteristics of BCSc group 2.5 – 2.99 were depicted in Fig. 1. The mean milk yield (kg) values during the first, second, third and fourth months of lactation were 8.60 ± 0.28, 10.04 ± 0.29, 9.12 ± 0.32 and 9.02 ± 0.37 respectively. The peak yield was 9.5 kg. The milk yield increased during the first two months of lactation, reached peak yield during the second month and thereafter showed a declining trend whereas the milk components fat, protein and SNF showed an increasing trend from second to fourth months of lactation. The lactation curve characteristics of BCSc group. 3.0 – 3.49 were depicted in Fig. 2. The mean milk yield (kg) values during the first, second, third and fourth months of lactation were 8.93, 10.35, 9.82 and 8.99 respectively. The peak milk yield was 11.69± 0.30kg. The milk yield increased during the first two months of lactation, reached peak yield during the second months and thereafter showed a declining trend, whereas the milk components, fat, protein and SNF showed an increasing trend from second to fourth months of lactation.

The lactation curve characteristics of BCSc group 3.5 – 3.99 were depicted in Fig. 3. The peak milk yield was 16.5 kg. The milk yield increased during the first two months of lactation, reached peak yield during the second month, the milk yield was sustained during the third month of lactation and then showed a declining trend during the fourth month of lactation. The milk fat, protein and SNF showed an increasing trend from second to fourth months of lactation.

The lactation curve characteristics of BCSc group 4.0 – 4.49 were depicted in Fig. 4. The mean milk yield (kg) yield during the first, second, third and fourth months of lactation were 10.33, 11.62, 11.15 and 10.40, respectively. The peak milk yield was 13.75 kg. The lactation curve showed an increasing trend during the first two months of lactation, reached peak during second month and thereafter showed a declining trend, whereas the milk, fat, protein and SNF showed an increasing trend from second to fourth months of lactation. An inverse relationship was noticed between milk yield and milk fat per cent in all the BCSc groups which was in agreement with the general consensus

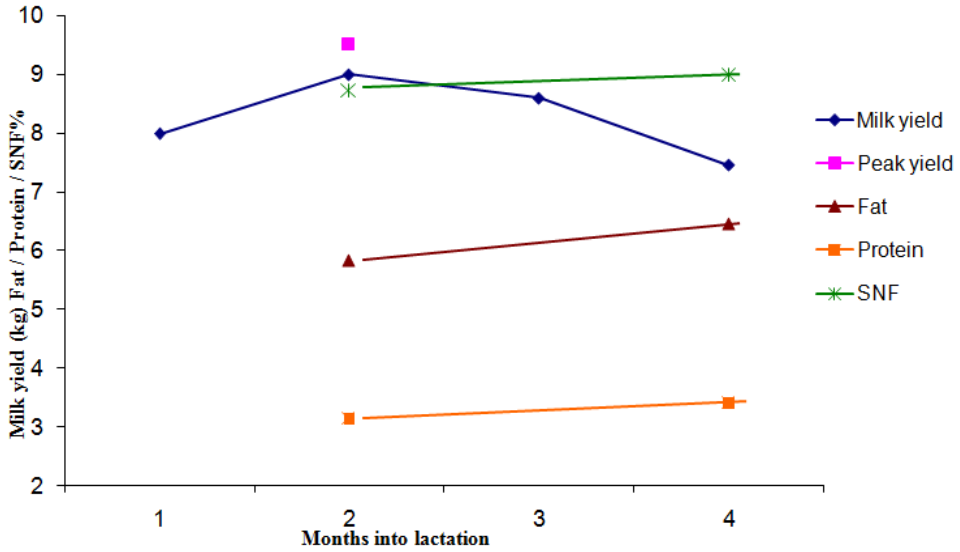

Figure 1: Lactation curve characteristics of BCSc group of 2.5 - 2.99 in the test herd

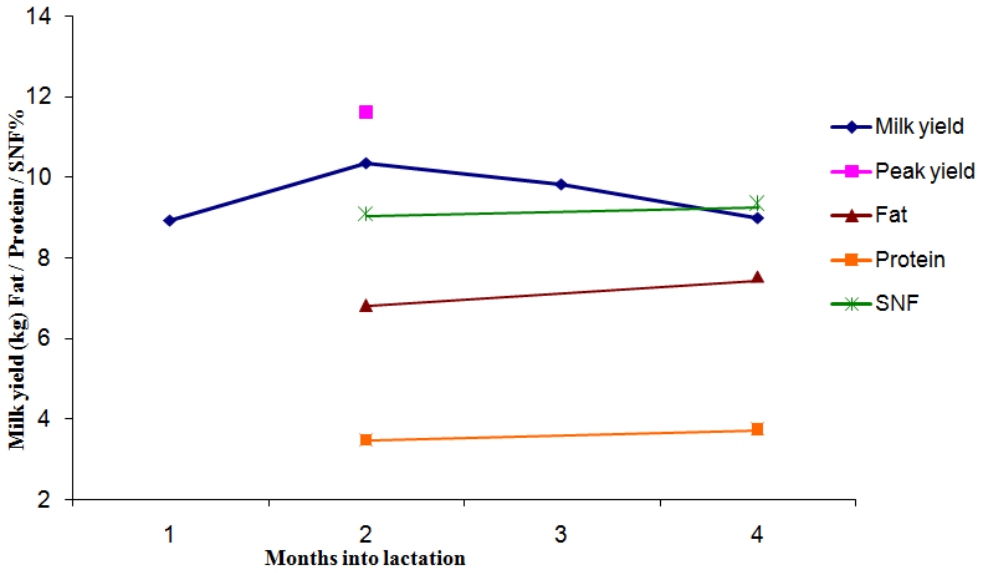

Figure 2: Lactation curve characteristics of BCSc group of 3.0 - 3.49 in the test herd

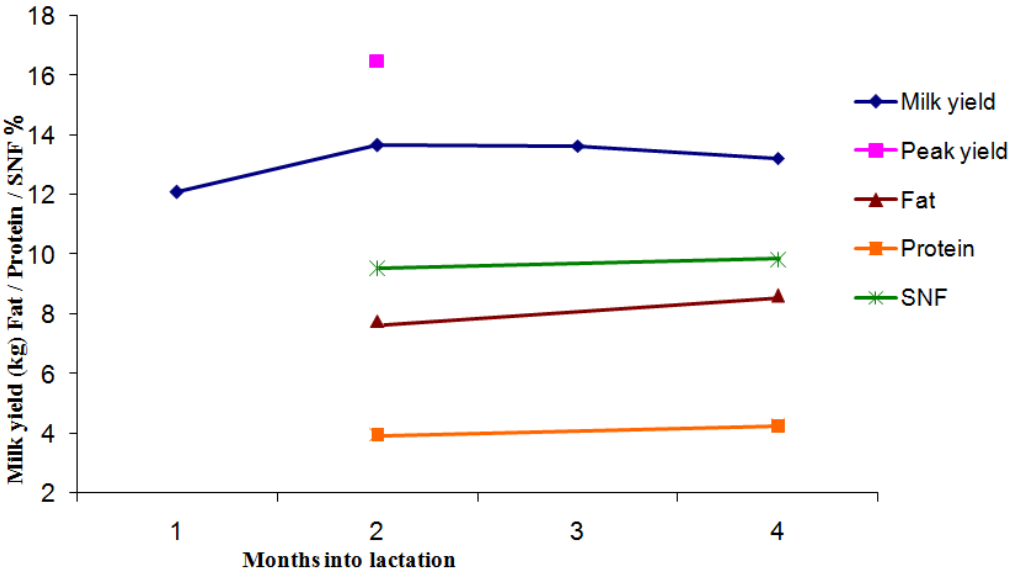

Figure 3: Lactation curve characteristics of BCSc group of 3.5 - 3.99 in the test herd

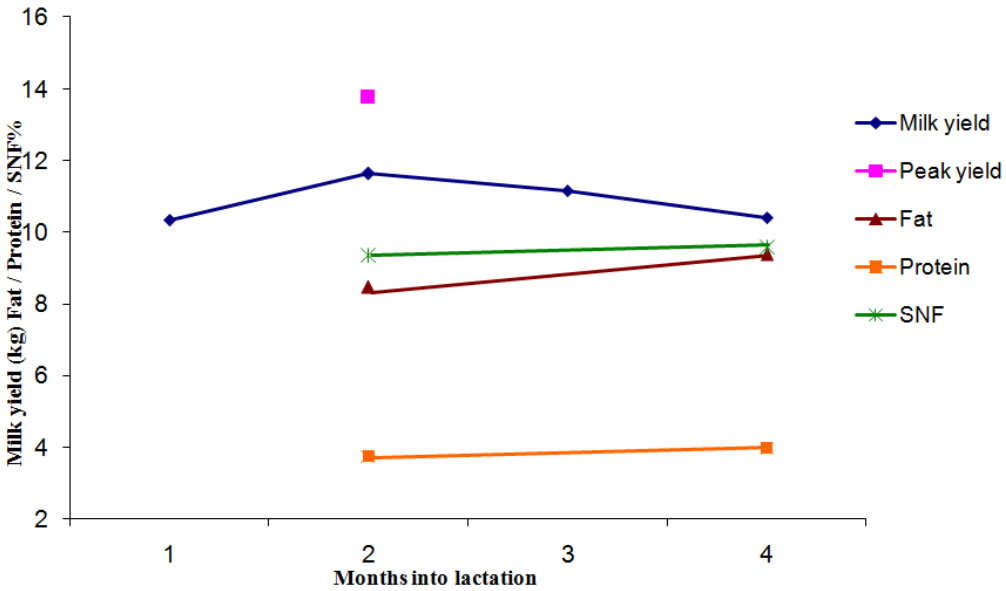

Figure 4: Lactation curve characteristics of BCSc group of 4.0 - 4.49 in the test herd

Discussion

The lactation curve characteristics studied in relation to BCSc showed that the milk production increased from calving until two months of lactation, reaching peak production and then gradually showed a decline for all the BCSc groups of the test herd. The total milk yield upto 18 weeks of lactation was higher for the BCSc group of 3.5-3.99. But as the BCSc exceeded 3.99 a decrease in milk yield was noticed. The predicted lactation yield was higher for the BCSc group of 3.5-3.99. But as the BCSc exceeded 3.99 the predicted yield showed a decline. The peak milk yield was higher for the BCSc group 3.5-3.99. Further, the peak yield and persistency index showed a decrease as BCSc exceeded 3.99. For every one unit increase in BCSc an increase of milk fat was observed at 6-8 weeks after calving and 16-18 weeks after calving. For every one unit increase in BCSc an increase of milk protein / SNF was observed at 6-8 weeks after calving and 16-18 weeks after calving. As the BCS increased from 6-8 weeks after calving to 16-18 weeks after calving the milk components i.e., fat, protein and SNF showed an increasing trend.

Table 1: Lactation curve characteristics related to BCSc in the test herd

S. No	BCSc	Mean milk yield (kg) from calving				Total milk yield upto 18 weeks from calving (kg) (305 days)	Predicted lactation yield (kg)	Peak yield (kg)	Persistency Index	Milk components Fat %		Protein %		SNF%	
		0-30 days	31-60 days	61-90 days	91-120 days					6-8 weeks after calving	16-18 weeks after calving	6-8 weeks after calving	16-18 weeks after calving	6-8 weeks after calving	16-18 weeks after calving
1.	2.87	9.96	9.86	7.46	3.95	961.00	1846.65	10	1.09	5.8	6.3	3.3	3.5	8.9	9.1
2.	2.56	6.93	7.73	7.0	6.0	866.00	1664.10	8	1.56	5.6	6.2	3.4	3.5	9.0	9.1
3.	2.75	7.38	8.43	8.16	7.7	996.70	1915.25	8.5	1.73	5.7	6.1	3.06	3.2	8.66	8.8
4.	2.69	7.56	8.76	9.02	7.26	1021.76	1963.41	9	1.73	5.9	6.5	3.23	3.4	8.83	9.0
5.	2.94	8.08	8.77	8.86	7.8	1052.50	2022.48	9.5	1.68	6.0	6.7	2.89	3.3	8.49	8.9
6.	2.81	6.76	9.28	8.86	8.03	1036.49	1991.73	10.5	1.88	6.1	6.8	2.9	3.2	8.5	8.8
7.	2.62	8.9	9.93	9.13	8.4	1141.40	2193.31	10	1.62	5.4	6.4	3.1	3.4	8.7	9.0
8.	2.74	7.31	9.33	9.8	9.06	1074.50	2064.88	11	1.96	5.8	6.5	3.2	3.4	8.8	9.0
9.	2.84	8.73	9.1	9.0	8.03	1094.19	2102.6	9.5	1.62	5.9	6.4	3.3	3.5	8.9	9.1
10.	2.58	8.2	8.73	8.6	8.3	1064.80	2046.11	9	1.69	6.0	6.5	3.0	3.5	8.6	9.1
11.	3.44	8.05	9.13	8.73	8.26	1075.09	2065.91	11	1.70	6.6	7.2	3.5	3.75	9.1	9.35
12.	3.06	8.30	9.63	9.2	8.56	1122.59	2157.18	10	1.72	6.8	7.6	3.57	3.8	9.17	9.4
13.	3.25	8.73	9.93	9.4	8.8	1158.8	2226.75	10.5	1.69	6.7	7.6	3.4	3.8	9.0	9.4
14.	3.19	8.3	10.43	9.33	7.3	1104.80	2122.98	12	1.61	6.9	7.5	3.42	3.7	9.02	9.3
15.	3.37	9.6	10.2	10.0	9.36	1233.19	2369.71	10.5	1.66	6.8	7.6	3.59	3.67	9.19	9.27
16.	3.31	9.13	10.4	10.03	9.13	1215.79	2336.28	11	1.7	7.0	7.8	3.6	3.8	9.2	9.4
17.	3.15	8.73	10.93	11.26	10.16	1293.99	2486.55	12.5	1.89	7.1	8.0	3.4	3.7	9.0	9.3
18.	3.29	9.3	11.1	10.4	10.06	1288.39	2475.78	13	1.74	7.0	7.6	3.3	3.65	8.9	9.25
19.	3.32	9.13	10.6	9.8	9.06	1213.39	2331.66	11.5	1.67	6.6	7.4	3.6	3.8	9.2	9.4
20.	3.41	10.03	11.06	10.03	9.2	1265.2	2431.20	14	1.59	6.5	7.1	3.4	3.75	9.0	9.35
21.	3.75	11.06	13.13	13.0	12.7	1573.2	3023.06	15	1.82	7.8	8.6	4.0	4.3	9.6	9.9
22.	3.69	11.6	13.36	13.03	13.0	1608.0	3089.93	16	1.78	7.6	8.9	4.08	4.2	9.68	9.8
23.	3.94	11.9	13.31	13.3	12.33	1601.49	3077.44	15.5	1.73	7.5	8.4	4.1	4.26	9.7	9.86

S. No	BCS c	Mean milk yield (kg) from calving				Total milk yield upto 18 weeks from calving (kg) (305 days)	Predicted lactation yield (kg)	Peak yield (kg)	Persistency Index	Milk components					
										Fat %		Protein %		SNF%	
		0-30 days	31-60 days	61-90 days	91-120 days					6-8 weeks after calving	16-18 weeks after calving	6-8 weeks after calving	16-18 weeks after calving	6-8 weeks after calving	16-18 weeks after calving
24.	3.62	12.8	13.7	13.3	13.06	1665.39	3200.23	18	1.68	7.8	8.5	3.95	4.21	9.55	9.81
25.	3.56	11.1	12.97	14.96	13.6	1660.9	3191.58	16	1.99	7.9	8.8	3.9	4.26	9.5	9.86
26.	3.75	12.7	13.7	13.58	13.26	1677.09	3222.71	17	1.72	8.0	8.9	4.0	4.23	9.6	9.83
27.	3.68	12.5	13.13	13.0	12.8	1621.8	3116.45	15	1.69	7.9	8.5	3.85	4.19	9.45	9.79
28.	3.72	11.65	14.43	14.26	14	1714.5	3294.58	17	1.88	7.8	8.6	3.9	4.2	9.5	9.8
29.	3.86	12.9	14.23	14.03	13.9	1735.6	3335.12	17.5	1.75	7.6	8.3	3.97	4.3	9.57	9.9
30.	3.91	12.57	14.73	14.0	13.6	1728.8	3322.06	18	1.75	7.7	8.7	3.88	4.3	9.48	9.9
31.	4.19	9.18	11.18	10.29	9.6	1265.4	2431.59	13	1.72	9.1	10.4	3.8	4.0	9.4	9.6
32.	4.25	8.73	11.26	11.9	10.4	1280.4	2460.41	13.5	1.82	9.0	10	3.75	3.9	9.35	9.5
33.	4.44	10.6	11.73	10.46	10.2	1352.2	2598.38	14	1.60	8.1	9.3	3.7	3.9	9.3	9.5
34.	4.12	11.38	10.45	10.2	9.53	1304.19	2506.15	12	1.50	8.3	9.8	3.85	3.95	9.45	9.55
35.	4.19	10.6	11.73	10.93	10.06	1360.39	2614.14	14	1.63	8.6	9.1	3.65	4.0	9.25	9.6
36.	4.31	10.95	11.6	11.66	10.16	1392.49	2675.82	14	1.64	8.8	9.5	36.6	4.0	9.2	9.6
37.	4.23	10.68	12.06	12.23	11.7	1470.7	2826.09	14.5	1.79	8.4	8.9	3.8	4.0	9.4	9.6
38.	4.34	10.13	11.66	11.96	10.46	1389.79	2670.63	13	1.77	7.9	8.6	3.85	3.95	9.45	9.55
39.	4.41	10.3	12.06	10.38	11.45	1394.7	2680.05	14.5	1.70	8.1	9.0	3.72	4.0	9.32	9.6
40.	4.28	10.7	12.46	11.5	10.43	1389.0	2669.10	15	1.66	8.3	9.1	3.74	4.0	9.34	9.6
Mean E	**3.37 ± 0.09**	**8.60 ± 0.28**	**10.04 ± 0.29**	**9.12 ± 0.32**	**9.02 ± 0.37**	**1119.28 ± 21.81**	**2333.99 ± 41.92**	**11.69± 0.30**	**1.45 ± 0.04**	**7.04 ± 0.06**	**7.64 ± 0.11**	**3.39 ± 0.02**	**3.55 ± 0.02**	**9.17 ± 0.03**	**9.43 ± 0.02**

Table 2: Tabulation of postpartum BCS and milk yield in the test herd

Month of lactation	Mean BCS ± SE	Mean milk yield / day (kg) ± SE
1	3.27 ± 0.08	8.60 ± 0.28
2	2.84 ± 0.09	10.04 ± 0.29
3	3.04 ± 0.09	9.02 ± 0.32
4	3.15 ± 0.09	9.12 ± 0.37

Table 2a: Correlation between BCS and milk yield in the test herd

	Mean BCS	Mean milk yield / day
Mean BCS	---	-
Mean milk yield / day	-0.96**	----

** Significant (P < 0.05)*

Table 3: Relationship between BCSc and milk yield in the test herd

BCSc	Milk yield upto 18 weeks of lactation (kg)	'F' Value	Predicted lactation yield (kg)	'F' Value
2.5 – 2.99	810.43^{d}	144.30**	1881.05^{d}	132.88**
3.0 – 3.49	996.12^{c}		1904.49^{c}	
3.5 – 3.99	1418.65^{a}		2737.11^{a}	
4.0 – 4.49	1251.92^{b}		2813.29^{b}	

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

Table 4: Relationship between BCSc and milk fat percent in the test herd

BCSc	At 6-8 weeks after calving		At 16-18 weeks of calving	
	Fat %	'F' Value	Fat %	'F' Value
2.5 – 2.99	5.66^{d}	164.39**	6.14^{d}	79.61**
3.0 – 3.49	6.54^{c}		7.24^{c}	
3.5 – 3.99	7.70^{b}		8.32^{b}	
4.0 – 4.49	8.26a		8.87^{a}	

a, b, c, d: values with different superscripts vary significantly

Table 5: Relationship between BCSc and milk protein per cent in the test herd

BCSc	At 6-8 weeks after calving		At 16-18 weeks of calving	
	Protein %	'F' Value	Protein %	'F' Value
2.5 – 2.99	3.11^{d}	88.24**	3.19^{d}	182.10**
3.0 – 3.49	3.42^{c}		3.34^{c}	
3.5 – 3.99	3.69^{b}		4.04^{b}	
4.0 – 4.49	3.44a		3.62^{a}	

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

Table 6: Relationship between BCSc and peak milk yield in the test herd

BCSc	Peak milk yield (kg)	'F' Value
2.5 – 2.99	9.10^{d}	78.73**
3.0 – 3.49	10.66^{c}	
3.5 – 3.99	14.30^{a}	
4.0 – 4.49	12.70^{b}	

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

Table 7: Relationship between BCSc and persistency of milk production in the test herd

BCSc	Persistency	'F' Value
2.5 – 2.99	1.37	1.41
3.0 – 3.49	1.43	
3.5 – 3.99	1.54	
4.0 – 4.49	1.24	

Table 8: Relationship between BCSc and milk SNF per cent in the test herd

BCSc	At 6-8 weeks after calving		At 16-18 weeks of calving	
	SNF %	'F' Value	SNF %	'F' Value
2.5 – 2.99	8.63^{d}	87.44**	9.04^{d}	212.34**
3.0 – 3.49	9.02^{c}		9.54^{c}	
3.5 – 3.99	9.16^{b}		9.99^{a}	
4.0 – 4.49	9.48a		9.67^{b}	

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

The results of the study revealed that the milk production, peak milk yield, persistency, milk protein and SNF increased with BCSc upto a score of 3.99 but beyond this there was a decline. Further it was suggested that the ideal BCS at calving was 3.5-3.99 to achieve better production, peak yield and persistency.

Discussion

Significant change was observed in the monthly postpartum changes in the test herd from calving to four months postpartum. BCS decreased significantly from first to second month of lactation and then increased gradually showing a significant increase from second to third and third to fourth months of lactation. The loss in BCS from calving to second month of lactation might be due to loss in body fat reserves which can be attributed to the effect of milk secretion and to a great extent to the peak milk yield. The recoupment in BCS from third month might be attributed to the lowered milk production as the lactation advanced. Based on these results, it can be predicted that the buffaloes might have regained the normal BCS which they had at BCSc by the end of lactation. Similar trends were reflected in the weekly postpartum changes observed in the present study. These findings were in accordance with the trends observed by Gallo *et al.*, (1996), Sarjan *et al.*, (2002) in cows and Anitha *et al.*, (2010) in buffaloes during early lactation.

The importance of BCS has been reported for decades (Grainger and McGowan, 1982; Wildman *et al.*, 1982; Waltner *et al.*, 1993) but reported responses have been variable (Broster and Broster, 1998; Stockdale, 2001). Much of the published data relating BCS to milk production have been taken from studies using small number of cows, in which only 2 or 3 levels of BCS were investigated. Stockdale (2001) referred to this lack of available information on the effect of BCS on milk yield for pasture-based dairy cows. Despite some inconsistencies in the reported literature, the similarity in the response to either calving BCS or BCS change across various studies is remarkable, especially considering the large differences in systems (intensive grazing Vs. confinement), diets and mean milk production per animal.

Significant ($P < 0.05$) negative correlation was observed between the postpartum BCS and milk yield during the study period. As the BCS decreased from first to second month of lactation the mean milk yield / day showed an increase and as the BCS gradually increased from second to fourth month, the mean milk yield / day showed a decreasing trend. This inverse relationship between postpartum BCS changes and milk yield was also reported earlier by Wildman *et al.*, (1982), Anitha *et al.*, (2007) in crossbred cows and Anitha *et al.*, (2010) in Murrah and Graded Murrah buffaloes.

The lactation curve characteristics were studied in relation to BCSc. The mean milk yield / day (kg) in the test herd was 8.60 during the first month of lactation, which has increased to 10.04 during the second month reaching peak production and then gradually decreased to 9.12 and 9.02 during the third and fourth months of lactation which was in agreement with the ideal lactation curve trends of milk production.

The total milk yield upto 18 weeks of lactation was significantly ($P < 0.01$) higher for the BCSc group of 3.5 – 3.99 compared to other BCSc groups. Buffaloes of the BCSc group 2.5 – 2.99 showed the least milk yield. For every one unit increase in BCSc an increase of 608.22 and 255.8 kg milk yield was observed for the BCSc ranges of 2.5 – 2.99 to 3.5 – 3.99 and 3.0 – 3.49 to 4.0 – 4.49 respectively with a mean 18 weeks milk yield of increase of 432.01 kg for every one unit increase in BCSc. It is possible that the greater milk yield from increased calving BCS is a result of increased mammary cell proliferation and that this results in an increase in dry matter intake after the initial suppression. This is the accepted reason for the positive carryover effect of increased milking frequency in early lactation on milk yield (Hale *et al.*, 2003) and for the increased dry matter intake following bovine somatotropen administration, which follows rather than precedes the increase in milk yield (Bauman, 1999).

Another possible reason for a positive association between calving BCS and milk production might be a reduced partitioning of nutrients to BCS gain in animals in greater calving BCS. Mitchel and Keesey (1977) reported an innate desire of mammals to maintain a physiological steady state with respect to BCS. If fatter than the ideal, neurological stimuli reduce dry matter intake, and if thinner, animals will increase dry matter intake and partition more nutrients to BCS gain. This theory is consistent with a reduced partitioning of nutrients to BCS gain in fatter animal and a consequently greater milk yield assuming dry matter intake is not suppressed.

Further, it was observed that the total milk yield upto 18 weeks of lactation increased upto BCSc of 3.99 but beyond that it was observed that as the BCSc exceeded the milk yield showed a declined trend. These findings were in tune with that of reports of Mohammed *et al.,* (1988) who observed that cows with a score of 2.5 at calving produced less milk than those with scores of 3 to 3.5 at calving. Similarly, Waltner *et al.,* (1993) observed increase in milk yield with increase in BCSc and reported a 322 kg increase in milk yield to 90 days in milk by increasing calving BCS from 2.0 to 3.0. Flemenbaum *et al.,* (1995) also reported that milk production for 150 days of lactation was more for cows at higher body condition at calving (3.80 ± 0.08) than for cows at low body condition at calving (2.65 ± 0.07).The milk production values in the present study were marginally higher than the values reported by Anitha *et al.,* (2010), who reported marginally lower milk production for every unit of BCS increment, might be attributed by the milking practices being adopted by the farmers in the field conditions aiming at obtaining maximum milk production and also comparatively lower quantity of milk being left out for the calf suckling at the farmers households.

The predicted lactation milk yield was significantly higher for the BCSc group of 3.5-3.99 compared to other BCSc groups. For every one unit increase in BCSc an increase of 856.06 and 908.8 kg of predicted lactation yield was observed for the BCSc ranges of 2.5-2.99 to 3.5-3.99 and 3.0-3.49 to 4.0-4.49 respectively with a mean increase of 882.43 kg for every one unit increase in BCSc. Further, it was observed that as the BCSc exceeded beyond 4.0 the predicted lactation yield showed a decline trend. Anitha *et al.,* (2010) reported marginally lower predicted lactation milk yield than the present study. This might be due to the inclusion of the milk included for calf suckling in the records of the organized farms, where as little attention is being paid the farmers towards the calf suckling, hence higher levels of milk production and predicted yields have been noticed.

Pedron *et al.,* (1993) also observed that one unit of BCSc was associated with 422 kg of 305 day milk production in Holstein Friesian cows, the value being lower than the predicted values of the present study, whereas Ruegg and Milton (1995) reported that BCSc had no effect on 305 day milk yields in Holstein cows. The majority of research 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 to the present trends.

Roche *et al.,* (2007) reported that optimum calving BCS for milk yield was approximately 6.5 BCS units (in a 1 to 10 scale) with the marginal response in milk yield to greater calving BCS negative beyond this which was in tune with the present trends. However, they have observed very little increase in milk production beyond a BCS of 5.0 to 5.5 (270 day milk yield increased by 209 and 144 kg for a calving BCS increase of 3.0 to 4.0 and 4.0 to 5.0, respectively, but only by 45 kg from a BCS of 5.5 to 6.5)

Significant (P<0.01) relationship was observed between BCSc and peak milk yield. The peak milk yield (kg) was significantly higher for the BCSc group of 3.5-3.99 (14.30 kg), followed by the BCSc groups of 4.0-4.49 (12.70 kg), 3.0-3.49 (10.66 kg) and 2.5-2.99 (9.10 kg). For every one unit increase in BCSc an increase in peak yield of 5.20 and 2.04 kg was observed for the BCSc ranges of 2.5-2.99 to 3.5 - 3.99 and 3.0-3.49 to 4.0-4.49 respectively with a mean increase in peak milk yield of 3.64 kg for every one unit increase in BCSc. But as the BCSc increased beyond 4.0 the peak yield was reduced. Although marginally higher milk production values have been recorded in the present study in comparison to Anitha *et al.,* (2010), the peak yields per unit of BCS are marginally lower. Similarly, Pedron *et al.,* (1993) also observed that BCSc was related (P<0.05) to peak production whereas Ruegg and Milton (1995) and Anitha *et al.,* (2007) reported that BCSc had no significant effect on peak milk production.

The persistency index increased by 0.06 and 0.11 for the BCSc ranges of 2.5-2.99 to 3.0-3.49 and 3.0-3.49 to 3.5-3.99 but decreased by 0.30 for the BCSc range of 3.5-3.99 to 4.0-4.49 which showed that the persistency index increased as the BCSc increased upto 3.99 but beyond that as the BCSc exceeded, the persistency index decreased. Similar trends were observed by Wildman *et al.,* (1982), Sarjan *et al.,* (2002) and Anitha *et al.,* (2010), who observed the low persistency in cows with excess of BCSc.

The milk fat percentage increased linearly (P<0.01) with increasing BCSc at both the measured time points of 6-8 wks after calving and 16-18 weeks after calving. For every one unit increase in BCSc an increase in milk fat per cent of 2.04 and 1.72 was observed for the BCSc ranges of 2.5-2.99 to 3.5-3.99 and 3.0-3.49 to 4.0-4.49 respectively with a mean increase in fat per cent of 1.88 at 6-8 weeks after calving. For every one unit increase in BCSc an increase of 2.18 and 1.63 in fat per cent was observed for the BCSc ranges of 2.5-2.99 to 3.5-3.99 and 3.0-3.49 to 4.0-4.49 respectively with mean increase in fat per cent of 1.91 for every one unit increase in BCSc at 16-18 weeks after calving. These results suggested that the buffaloes should be maintained at an ideal body condition at calving in order to augment fat per cent because the pricing policy was mainly based on the fat per cent in milk. Holter *et al.,* (1990) observed that cows considered as under conditioned at parturition had reduced milk fat concentration which was in accordance to the present trends. Grainger and McGowan (1982) also reported an increase in milk fat production (7.5 ± 3.5 kg) for each BCS unit increase between 3 and 6 at calving in a 1 to 8 scale, which was higher than the values observed in the present study whereas Roche *et al.,* (2007) reported that fat content increased with increasing BCS (0.1 and 0.02 per cent fat upto 60 and 270 days in milk, respectively, per BCS unit at calving) which was less than the values observed in the present study. These results are in concurrence with the study reports of Anitha *et al.,* (2010) in organized herd of buffaloes.

The increase in fat per cent was observed at 16-18 weeks after calving in comparison to the fat per cent observed at peak milk yield period of 6-9 weeks after calving. This trend was supported by the normal relationship between milk yield and fat per cent. As the milk yield decreased from 6-8 weeks to 16-18 weeks after calving, the gain in BCS was noticed. As the BCS increased the increasing trend in fat per cent was observed. The increase in fat per cent with the increase in BCS was also observed by Gransworthy and Jones (1987). On contrary, Prasad and Tomer (1998) observed that BCS was negatively correlated with the fat yields.

The milk protein per cent in the test herd was well within the normal range of protein percentages in milk relative to the species and breed. The protein per cent increased linearly (P<0.01) with increasing BCSc at both the measured time points of 6-8 weeks after calving and 16-18 weeks after calving. For every one unit increase in BCSc an increase in protein per cent of 0.58 and 0.02 was observed for the BCSc ranges of 2.5-2.99 to 3.5-3.99 and 3.0-3.49 to 4.0-4.49 respectively with a mean increase in protein per cent of 0.30 at 6-8 weeks after calving.

For every one unit increase in BCSc an increase in protein per cent of 0.85 and 0.28 was observed for the BCSc range of 2.5-2.99 to 3.5-3.99 and 3.0-3.49 to 4.0-4.49 respectively with a mean increase in protein per cent of 0.57 at 16-18 weeks after calving. In contrast, Roche *et al.,* (2007) reported that BCS at calving had not significantly affected milk protein content averaged across the first 60 or 270 days of lactation.

As the BCS increased from 6-8 weeks to 16-18 weeks after calving the increasing trend in the protein per cent was observed. Lomovsek *et al.,* (1993) also reported that poor body condition at 4 to 8 weeks postpartum was associated with lower protein in milk. Similarly Roche *et al.,* (2007) observed that protein per cent increased linearly with increasing BCS which was in tune to the present trends whereas, Prasad and Tomer (1998) observed a negative relationship between BCS and protein. Similar trend was also observed by Anitha *et al.,* (2010) in the buffalo herds of organized farms.

The milk SNF per cent increased linearly with increasing BCSc at both the measured time points of 6-8 weeks after calving and 16-18 weeks after calving. For every one unit increase in BCSc an increase in SNF per cent of 0.53 and 0.46 was observed for the BCSc ranges of 2.5-2.99 to 3.5-3.99 and 3.0-3.49 to 4.0-4.49 respectively with a mean increase in SNF per cent of 0.76 at 6-8 weeks after calving. For every one unit increase in BCSc an increase in protein of 0.95 and 0.13 was observed for the BCSc ranges of 2.5-2.99 to 3.5-3.99 and 3.0-3.49 to 4.0-4.49 respectively with a mean increase in SNF per cent of 0.61 at 16-18 weeks after calving. As the BCS increased from 6-8 weeks to 16-18 weeks after calving the increasing trend in the SNF per cent was noticed whereas Prasad and Tomer (1998) reported that body condition was negatively correlated with the SNF yields. Marginally higher SNF increment was noticed per unit increase in BCS when compared to the study reports of Anitha *et al.*, (2010).

The influence of body condition on production traits was studied in 40 buffaloes in a 4 x 10 CRD from calving to 18 weeks postpartum.

The monthly postpartum changes in BCS studied in the test herd showed that BCS decreased from calving to two months of lactation and then gradually increased. The loss in BCS during the first two months was attributed to the loss in body fat reserves due to peak milk yields and the recoupment in BCS from the third month was attributed to the lowered milk production as the lactation advanced. Inverse relationship was observed between the monthly postpartum BCS and milk yield during the study period.

The lactation curve characteristics were studied in relation to BCSc. The mean milk yield / day (kg) in the test herd was 8.60 ± 0.28 during the first month of lactation, which has increased to 10.04 ± 0.29 during the second month reaching peak production and then gradually decreased to 9.12 ± 0.32 and 9.02 ± 0.37 during the third and fourth months of lactation.

The total milk yield upto 18 weeks of lactation was higher for the BCSc group of 3.5-3.99. For every one unit increase in BCSc, an increase of 432.01 kg in the 18 weeks lactation yield was observed. But as the BCSc exceeded 3.99, a decrease in milk yield was noticed. The predicted lactation yield was higher for the BCSc group of 3.5-3.99. For every one unit increase in BCSc an increase of 882.43 kg was observed in the predicted lactation yield. But as the BCSc exceeded 3.99 the predicted yield showed a decline. The peak milk yield was higher for the BCSc group 3.5-3.99. For every one unit increase in BCSc, an increase of 4.57 kg of peak yield was noticed. Further, the peak yield and persistency index showed a decrease as BCSc exceeded 3.99.

For every one unit increase in BCSc an increase of milk fat per cent of 1.88 and 1.91 was observed at 6-8 weeks after calving and 16-18 weeks after calving respectively. For every one unit increase in BCSc an increase of milk protein / SNF of 0.55 and 0.54 was observed at 6-8 weeks after calving and 16-18 weeks after calving respectively. As the BCS increased from 6-8 weeks after calving to 16-18 weeks after calving the milk components i.e., fat, protein and SNF showed an increasing trend.

The results of the study revealed that the milk production, peak milk yield, persistency, milk protein and SNF increased with BCSc upto a score of 3.99 but beyond this there was a decline. Further it was suggested that the ideal BCS at calving was 3.5-3.99 to achieve better production, peak yield and persistency.

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