Effect of Level of Feeding on the Performance of Crossbred Cows during Pre- and Post-partum Periods

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ABSTRACT : The study was undertaken to see the effect of elevated feeding during pre-partum or pre- as well as post-partum period on the productive and reproductive performance of crossbred cows. The experiment lasted for 60 d pre-partum to 120 d post-partum. Eighteen dry pregnant crossbred cows divided into three equal groups were fed either as per NRC feeding standard (C) or 20% above NRC during 60 d pre-partum (T_1) or fed 20% above NRC during both 60 d pre-partum to 120 d post-partum (T_2) period. During pre-partum period body weight gain was significantly ($p \leq 0.05$) higher in T_1 and T_2 groups than that of control group. The animals fed at higher plane of nutrition (T_1 and T_2) took significantly lesser time for complete relaxation of pelvic muscles, act of calving and for expulsion of placenta than that of control group. Moreover, such cows delivered 2 to 3 kg heavier calves as compared to normal fed dams. During post-partum period, the average daily milk yield was significantly higher in T_2 group than that in T_1 and control groups. The peak yield was significantly higher in T_2 group, it took longer time to reach peak production but it was more persistent in this group as compared to T_1 and control groups. Average milk fat, solids-not-fat (SNF) and total solids were significantly higher in T_1 and T_2 groups as compared to control group. Body weight losses incurred during early lactation were not even compensated by end of 4th month of lactation in C and T_1 groups whereas the animals in T_2 group gained 2.0 kg. The 1st post-partum estrus and conception rate were better in high fed groups (T_1 and T_2) than that of control group. The returns over feed cost of milk production were higher in T_2 group followed by T_1 and control groups indicating the advantage of elevated feeding during pre- and post-partum periods. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 12 : 1749-1754)***

Key Words : Elevated Feeding, Pre-partum, Post-partum, Milk Production, Reproduction, Cows

INTRODUCTION

In developing countries, more than 70% of the expenditure, in dairy farming is on the feeding of animals. Most of the farmers are, not aware of the benefits of quality feeding and that of balanced diet. Even, a few, progressive farmers also, think about the feeding strategy once the cow has given the birth to a calf, which is similar to the saying "Start digging a well once you are thirsty". Rather, there should be a well-planned feeding and management schedule, for the transition period (last phase of gestation and ensuing lactation). Improper feeding (under- or over-) during this phase could lead to low birth weight of newborn calf, post-partum estrus and obviously low productive performance of cows (Sasser et al., 1988; Qureshi, 1995). However, comprehensive reports on nutrition-production-reproduction inter-relationship are not available. This study was, therefore, planned to see, how the plane of nutrition during pre-partum period or during complete transition (pre- as well as post-partum) period, affects the productive and reproductive performance of dairy cows. The goal of this feeding program is to provide the correct amount and balance of nutrients to cows at the proper time to achieve optimum production, reproductive efficiency and profitability.

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MATERIALS AND METHODS

Feeding and management

Eighteen dry pregnant crossbred cows and heifers were selected from the dairy herd of the university on the basis of parity, body weight, previous lactation yield and expected date of calving (Table 1). The experiment lasted 60 d pre-partum to 120 d post-partum duration. The animals divided into three equal groups were offered feed either as per NRC (1989) feeding standard (C) or 20% above NRC only during 60 d pre-partum period (T_1) or 20% above NRC during 60 d pre-partum to 120 d post-partum period (T_2). During pre-partum phase, the animals were offered concentrate mixture (Table 2) once-a-day at 9:00 h followed by seasonal green fodder mixed with wheat straw (50:50) at 11:00 h. The roughage to concentrate ratio was 70:30 during the pre-partum period. During post-partum phase, the concentrate was offered at the time of milking in the milking parlour.

The animals were fed individually. Water was available to the animals around the clock. The animals were weighed for 3 consecutive days at each fortnight. The animals were kept in semi-loose housing system. Two weeks prior to expected date of calving, the animals were shifted to individual maternity pens, so as to provide utmost care

Table 1. Distribution of experimental animals

Animals No.	Body weight (kg)	Parity	305 days previous lactation yield (litres)
Control group (C):			
HRS-607	420.00	2	2,095
HRS-492	441.33	3	3,105
1F-501	450.00	2	2,931
2F-442	500.33	5	2,211
HHS-682	333.33	-	-
3F-663	410.00	-	-
Mean	425.78±20.56	2.00±0.71	2,585.5±219.39
T_1 group:			
HHS-568	520.00	2	3,304
HS-519	410.67	3	2,195
1F-465	428.00	5	2,712
HS-582	460.67	2	2,229
HRS-675	362.00	-	-
3F-654	371.00	-	-
Mean	425.39±21.98	2.00±0.71	2,610.0±224.92
T2 group:			
2F-585	442.00	3	2,378
HRS-617	420.00	2	2,860
1F-603	380.67	2	2,867
2F-466	481.00	4	2,217
HHS-648	384.00	-	-
3F-681	434.67	-	-
Mean	423.67±14.13	1.80±0.50	2,580.5±144.34

during advanced pregnancy. Immediately after parturition, the animals were closely watched for incidence of any metabolic disorders like parturient paresis, ketosis and other diseases like mastitis, which were treated accordingly by the Animal Health Specialist.

Reproduction parameters

The signs of oestrus were detected by bull parading. This practice was followed regularly daily in morning and late in the evening. The animals in heat were also detected from different signs such as bellowing, mounting over other animals, less interest in feed and vaginal discharge.

Calving observations : The calving observations were recorded for the following traits:

i) Loosening of pelvic muscles : The time of relaxation of sacrosciatic ligaments and sinking of croup (a part of hind quarters lying immediately behind the loin) muscles before parturition.

ii) Start of labour : The animals were watched for initiation of labour and time was recorded when parturition symptoms like nervousness, restlessness, loss of appetite and change in posture (sitting, standing and walking in semi-circles), frequent micturition, occasional glances at the flank and stamping the ground with limbs etc. tended to appear.

iii) Time taken for act of calving : It comprised of complete dilation of the os-uteri to the delivery of the foetus. It started from the appearance of water bag at vulva till the complete expulsion of calf. The cleaned and dried calf before feeding colostrum was weighed within an hour after its birth.

iv) Time taken for expulsion of placenta : The time interval between expulsions of calf to the expulsion of placenta.

v) Post-partum reproductive efficiency : It was measured from post-partum oestrus interval, number of inseminations per conception, and conception rate etc. Animals detected in estrus in morning were inseminated in the evening on the same day and those detected in heat in the evening were served next day in the morning.

Milking and composition of milk

The cows were milked in milking parlour 2 to 3 times-a-day by using milking machines and milk yield of each crossbred cow was recorded daily during first 4 months of their lactation. Milk samples of each animal were analysed, at fortnightly interval, for fat, solids-not-fat, protein and lactose by automatic milk analyser (Milkoscan 133B).

Digestibility of nutrients

It was assessed by indicator method, using chromic oxide green as an external marker at the rate of 0.2% of daily dry matter intake, for 10 d as adaptation period followed by 7 d collection period. Grab samples of faeces were collected directly from rectum twice daily i.e. at 8:00 and 16:00 h and dried in forced air oven at 80°C.

Analytical methods

The finely ground samples of feed, feed residue and faeces were analysed for proximate principles (AOAC, 1984). Cellulose (Crampton and Maynard, 1938), other cell

Table 2. Chemical composition of feedstuffs (% DM basis)

Constituents	Concentrate mixture	Wheat straw	Green fodder				
			Egyptian clover	Oats	Corn	Pearl milet	Sorghum
Organic matter	87.70±1.70	91.89±1.69	87.80±1.41	88.55±1.22	89.50±0.99	88.67±1.02	91.80±2.06
Crude protein	19.37±0.57	2.96±0.25	18.85±0.56	11.24±0.79	11.50±0.67	12.50±0.51	12.60±0.32
Cellulose	7.58±0.75	44.38±0.24	20.02±0.41	23.48±0.78	30.20±1.00	30.00±0.62	29.40±0.52
Ether extract	3.89±0.10	1.65±0.07	1.70±0.09	1.69±0.14	2.75±0.12	1.49±0.08	1.02±0.06
Total ash	12.30±0.21	8.11±0.19	12.20±0.19	11.45±0.33	10.50±0.24	11.33±0.12	8.20±0.11

* Wheat 36, rice kani 2, extracted mustard cake 15, mustard seed 2, rice bran 6, extracted rice bran 32, molasses 3.5, urea 0.5, mineral mixture 2.0 and common salt 1 part each by weight.

Table 3. Effects of level of feeding on DM intake and live weight changes during pre- and peri-partum periods

	C	T_1	T_2	Pooled SE
DMI (kg/day)	11.30[a]	13.46[b]	13.67[b]	0.26
Concentrate mixture	3.33[a]	3.97[b]	3.99[b]	0.03
Green fodder	3.73[a]	4.42[b]	4.48[b]	0.02
Wheat straw	4.76[a]	5.07[b]	5.10[b]	0.06
Live weight (kg)				
Two months before calving	425.83	425.39	423.72	18.89
One day before calving	486.33[a]	517.67[b]	510.67[b]	17.11
Gain per day	0.98[a]	1.46[b]	1.45[b]	0.05
One day after calving	438.00	464.00	459.00	17.72
Loss during calving	48.33[a]	53.67[b]	51.67[b]	3.65

Different superscripts in a row differ significantly (≤0.05).

Table 4. Effect of level of feeding on time taken for different calving observations

	C	T_1	T_2	Pooled SE
Loosening of pelvic muscles (days)	4.00	3.33	3.50	0.41
Act of calving (min)	45.83[b]	37.00[a]	36.83[a]	2.50
Expulsion of placenta (h)	6.90	5.68	5.80	0.40
Weight of placenta (kg)	4.61[b]	2.86[a]	3.37[a]	0.36
Birth weight of calf (kg)	31.00	33.50	33.80	1.61

Different superscripts in a row differ significantly (≤0.05).

wall constituents (Robertson and VanSoest, 1981) and chromic oxide (Hill and Anderson, 1958). The data was analysed by using completely randomised design (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

The chemical composition of different feedstuffs, offered to the animals, revealed that amongst the forages, the Egyptian clover, being leguminous, had the highest CP and lowest cellulose content (Table 2). Wheat straw had the lowest CP and highest cellulose content amongst the feedstuffs selected.

The animals, in the experimental groups, consumed significantly ($p<0.05$) higher quantity of concentrate mixture, green fodder and wheat straw, both during pre- and peri-partum periods, as compared to those in the control group resulting in significantly ($p<0.05$) higher total daily DM intake (Table 3). The concentrate mixture, green fodder and wheat straw contributed 29.4, 32.9 and 37.7% of DM, respectively.

The live weight of all the animals, at 60 d pre-partum, was comparable, thereafter; it increased linearly in all the groups. The average body weights one day before calving were significantly higher ($p<0.05$) in experimental than those in control group (Table 3), which could be due to improved nutritional status of animals in T_1 and T_2 groups. More live weight gain in animals, fed at higher plane of nutrition, during 55 to 60 days pre-partum period have also reported by Kale and Tomar (1991) and Prasad and Tomar (1995a). Qureshi et al. (2002) showed that ME intake, above requirements during pre-partum period resulted in higher body condition score in dairy buffaloes. The peri-pertum losses were significantly ($p<0.05$) higher in animals of T_1 and T_2 groups (13.1 and 14.9%) as compared to those in control group, which could be due to birth of heavier calves in experimental groups (8.5% more weight).

Table 5. Effect of level of feeding on milk production

	C	T_1	T_2	Pooled SE
DMI (kg/day)	18.91[a]	19.34[a]	25.23[b]	1.61
Concentrate mixture	8.20[a]	8.79[a]	12.07[b]	0.20
Green fodder	6.45[a]	6.49[a]	8.34[b]	0.51
Wheat straw	4.26	4.29	4.82	0.27
Milk yield (kg/d)	15.14[a]	16.40[b]	18.40[c]	0.42
Mean peak yield (kg)	21.70[a]	22.40[a]	24.44[b]	1.10
Time taken to attain peak yield (days)	41.30	48.39	50.66	16.90
Increase in milk production over control (%)	-	7.30	17.72	-

Different superscripts in a row differ significantly (≤0.05).

The animals, kept on higher plane of nutrition during the pre-partum period (T_1 and T_2), took less time for, complete relaxation of pelvic muscles (17.0 and 12.5%), calving (19.5%), and expulsion of placenta (16.5%) and had significantly ($p<0.05$) lesser weight of placenta (38 and 27%) than the animals in control group (Table 4). Similar observations about calving have also been reported (Yadava et al., 1976; Little and Harrison, 1981; Prasad and Tomar, 1995b).

During post-partum period the daily DM intake was significantly higher ($p<0.05$) in T_2 group as compared to that in C and T_1 groups (Table 5). The comparable DM intake in C and T_1 group, during post-partum period, was because these animals were offered diet at same feeding level i.e. 100% NRC. The roughage to concentrate ratio (70:30) followed during pre-partum period was narrowed to 55:45 in order to meet the increased nutrient requirements during post-partum period for milk production. The ratio of green fodder to wheat straw was also changed from 50:50 to 62:38. The DM consumption increased linearly up to 3rd fortnight and thereafter, it declined gradually. Garnsworthy and Topps (1982) also reported linear increase in voluntary DM intake after parturition so as to meet the increasing demands of nutrients for milk production up to 45 to 50 d.

The average daily milk yield, throughout the experimental period, was significantly higher ($p<0.05$) in animals fed 20% above NRC standard during pre- and post-partum period as compared to those fed as per NRC standards or fed 20% above NRC standards, only during pre-partum period (Table 5) indicating, that higher plane of nutrition both during pre- and post-partum period, could

Table 6. Effect of level of feeding on composition of milk (%)

	C	T_1	T_2	Pooled SE
Protein	3.45	3.51	3.57	0.04
Lactose	4.69	4.54	4.49	0.05
Fat	3.72[a]	4.21[b]	4.28[b]	0.10
SNF	8.08[a]	8.24[b]	8.38[b]	0.10
Total solids	11.81[a]	12.45[b]	12.67[b]	0.09

Table 7. Effect of level of feeding on reproductive performance of crossbred cows

	C	T_1	T_2	Pooled SE
First postpartum oestrus (days)	53.50[b]	46.20[a]	42.00[a]	1.92
Number of inseminations per conception	1.33	1.50	1.60	0.25
Number of cows conceived	3	4	5	-
Conception rate	50.00[a]	66.67[b]	83.33[c]	-
Service period (days)	78.00[a]	88.00[b]	94.00[b]	8.43

Different superscripts in a row differ significantly (≤0.05).

improve milk production potential of crossbred cows. The cows in T_1 and T_2 groups produced 7.3 and 17.75% more milk than those of their counterparts in control group. Significantly higher digestibility of nutrients in animals fed at higher plane of nutrition than those fed as per standard NRC seems to play this role. The digestibility of OM, CP, NDF and cellulose was 67.27 and 75.65%; 68.00 and 75.80%; 64.78 and 70.21% and 69.60 and 75.20%, respectively in control and experimental groups. Chicco et al. (1982) and Gargantini et al. (1984) reported a significant increase in milk production due to higher pre- and post-partum feeding levels. However, Lodge et al. (1975) failed to establish the significant effects of higher pre-partum feeding on milk production. Khan et al. (2002) reported that *ad. libitum* feeding of crossbred cows during last trimester of pregnancy resulted in deposition of fat, gain in weight during pre-calving period and produced less milk during post-calving period. The animals in T_2 group took longer period to reach peak production but the peak was more persistent in than C and T_1 groups. The peak yield was significantly higher in animals in T_2 group than those in C and T_1 groups. Johnson (1979) also reported higher peak yield in animals fed at higher level than those fed at low level of nutrition.

The higher level of feeding during pre-partum period alone or both during pre- and post-partum period had improved the quality of milk significantly (Table 6). The improvement was 11 to 13% in fat, 2 to 3.6% in SNF and 5 to 7% in total solids with the improvement in nutritional status of the animals. Similar trend was observed in case of protein content (1.7 to 3.4%) also, but the differences were statistically non-significant. Treacher et al. (1986) and Holter et al. (1990) also observed similar trend in animals

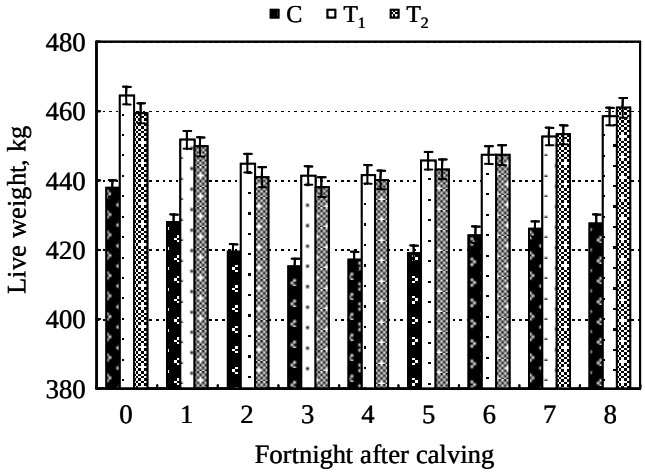

Figure 1. Body weight changes during post-partum period.

fed at higher plane of nutrition than those at lower plane of nutrition. The lactose secretion in milk has been reported to be independent of nutritional status of the animal (Kunz et al., 1985), but quantum of milk in the udder affect its concentration that is why the low yielding cows (control) had higher concentration of lactose as compared to high yielding animals in T_1 and T_2 groups, respectively. Treacher et al. (1986) also observed low lactose level in fat cows (4.66%) as compared to thin cows (4.77%).

Post-partum body weight changes revealed that the average live weights of experimental animals one day after calving were 438, 464 and 459 kg in C, T_1 and T_2 groups, respectively which declined sharply in all groups to 415, 441 and 438 kg in respective groups by 3rd fortnight indicating that the stress of pregnancy followed by initiation of milk secretion lead to body weight losses during early lactation. As the stress reduced, animals started gaining weight and the animal fed at higher plane of nutrition gained more weight as compared to those fed as per NRC during 4th to 8th fortnight (Figure 1). The overall gain/loss in body weight of animals fed as per NRC standard, 20% above NRC only during pre-partum period and 20% above NRC both during pre- and post-partum periods was -9.28, -4.24 and 2.00 kg, respectively. Similar trends in body weight losses of dairy cows have been reported by Khatkar et al. (1992).

The first post-partum oestrus was observed much earlier ($p<0.05$) in animals fed at higher plane of nutrition during pre-partum (T_1) or during pre- as well as post-partum periods (T_2) than the animals fed as per NRC standard (Table 7). It could be due to body weight loss, which might have affected the initiation of ovarian activity after calving. Yadava et al. (1974) also observed earlier exhibition of 1st post-partum oestrus in high fed animals (48 d) as compared to low fed animals (51 d). The elevated feeding level during

Table 8. Economics of milk production in crossbred cows

Particulars	C	T_1	T_2
Milk production			
Milk yield/cow during 120 days (kg)	1,810.8	1,968.0	2,208.0
Extra milk produced over control (kg)	-	151.2	391.2
Fat (%)	3.72	4.21	4.28
SNF (%)	8.08	8.24	8.38
Feed Consumption (kg)			
Concentrate mixture*	1,314.4	1,413.6	1,844.8
Green fodder*	4,916.4	5,372.8	6,221.4
Wheat straw*	820.8	877.8	976.2
Feed cost of milk production			
Sale price of milk (Rs**./kg)	6.60	7.03	7.15
Feed cost of milk production (Rs./kg)	4.38	4.36	4.84
Returns over feed cost/kg of milk production (Rs.)	2.22	2.66	2.31
Returns per cow over control group during 1st 120 days of lactation (Rs.)	-	708.33	1,103.2

* Cost of concentrate mixture, green fodder and wheat straw was Rs. 369, 45 and 110/q, respectively. ** Rupees.

pre- as well as post-partum period (T_2) resulted in significantly higher conception rate (83.3%) as compared to animals offered higher plane of nutrition only during pre-partum (T_1) period (66.7%) which in turn was significantly higher than animals in control group (50%). McClure (1965) reported that loss in body weight during early lactation resulted in low blood glucose concentration, which is positively correlated with conception rate. However, the service period was extended significantly ($p<0.05$) in T_1 and T_2 as compared to cows in control group. Treacher et al. (1986) also observed longer service period in fat cows (98 d) as compared to thin cows (89 d).

The cows in T_1 and T_2 groups produced 151 and 391 kg extra milk over their counterparts in control group (Table 8). The sale price of milk in Rupees (Rs.) was calculated on the basis of milk fat and SNF content. Although the feed cost per kg of milk production was comparatively more in T_2 group (Rs. 4.84) followed by control group (Rs. 4.38) and T_1 group (Rs. 4.36). However, the return over feed cost per kg of milk production was found to be maximum in T_1 (Rs. 2.66) followed by T_2 (Rs. 2.31) and control group (Rs. 2.22). So, the returns per cow were also more in T_1 and T_2 groups. Flaherty (1993) also observed similar results. The results, conclusively revealed that feeding of dry pregnant animals at higher plane of nutrition should start, not only during 60d pre-partum but the same plane should be continued 120d post-partum , so as to improve productive and reproductive performance of high yielding cows and to make dairy farming more economical as indicated by cost/benefit ratio.

REFERENCES

AOAC. 1984. Official Methods of Analysis. 14th edn. Association of Official and Agricultural Chemists, Arlington, Virginia, USA.

Chicco, C. F., E. Shultz, V. Bodisco and A. Shultz. 1982. Effects of pre- and post-partum feeding levels on body weight changes and milk production of Holstein and Brown-swiss cows tropical conditions. Nutr. Abstr. Review 53:3137.

Crampton, E. W. and L. A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. J. Nutr. 16:383-95.

Flaherty, M. 1993. A nutrition boost right before calving. Dairy Herd Mgmt. 30:36-39.

Gargantini, O. F., A. C. G. Castro and J. A. Carcia. 1984. Study of three periods of pre-partum feeding in relation to the performance of dairy cows. Dairy Sci. Abstr. 47:4565.

Garnsworthy, P. C. and J. H. Topps. 1982. The effect of body condition of dairy cows at calving on their food intake and performance when given complete diets. Anim. Prod. 35:113-19.

Hill, F. N. and D. L. Anderson. 1958. Comparison of metabolizable energy and productive energy determination with growing chicks. J. Nutr. 64:587-603.

Holter, J. B., M. J. Slotnick, H. H. Hayes, C. K. Bozak, W. E. Urban and McGilliard. 1990. Effect of pre-partum dietary energy on condition score, post-partum energy, nitrogen partition and lactation production responses. J. Dairy Sci. 73:3502-11.

Johnson, C. L. 1979. Effect of level and frequency of concentrate feeding on the performance of dairy cows of different yield potentials. J. Agric. Sci. Camb. 92:743-51.

Kale, M. M. and O. S. Tomer. 1991. Effect of pre-partum feeding on the post-partum performance of crossbred cows. Indian J. Anim. Prod. Mgmt. 7:1-7.

Khan, M. A. A., M. N. Islam, M. A. S. Khan and M. A. Akbar. 2002. Effect of restricted and *ad. libitum* feeding during late pregnancy on the performance of crossbred cows and their calves. Asian Aust. J. Anim. Sci. 15:1267-72.

Khatkar, M. S., A. K. Jain and O. S. Parmar. 1992. Body weight changes after calving and their relationship with production and service period in crossbred cows. SARAS J. Livestock and Poult. Prod. 8:30-35.

Kunz, P. L., J. W. Blum, I. C. Hart, H. Bichet and J. Landis. 1985. Effect of different energy intakes before and after calving on food intake, performance and blood hormones and metabolites in dairy cows. Anim. Prod. 40:219-31.

Little, W. and R. D. Harrison. 1981. Effect of different rates of live weight gain during rearing on the performance of Friesian heifers in their first lactation. Anim. Prod. 32:362.

Lodge, G. A., L. J. Fisher and J. R. Lassard. 1975. Influence of pre-partum feed intake on performance of cows fed *ad. libitum* during lactation. J. Dairy Sci. 58:697-702.

McClure, T. J. 1965. A nutritional cause of low non-return rates in dairy herds. Aust. Vet. J. 41:119-22.

National Research Council. 1989. Nutrient Requirements of Dairy Cattle. 6th edn. National Academy Press, Washington, DC., USA.

Prasad, S. and O. S. Tomar. 1995a. Effect of pre-partum level of

conditioning on body condition score and related physical parameters in crossbred cows. Indian J. Anim. Prod. Mgmt. 11:135-38.

Prasad, S. and O. S. Tomar. 1995b. Effect of pre-partum level of conditioning of certain calving and related parameters in crossbred cows. Indian J. Anim. Prod. Mgmt. 11:139-42.

Qureshi, M. S. 1995. Conventional buffalo farming system in North-West Frontier Province of Pakistan. Buffalo Bulletin 34:38-41.

Qureshi, M. S., G. Habib, H. A. Samad, M. M. Siddiqui, N. Ahmad and M. Syed. 2002. Reproduction-nutrition relationship in dairy buffaloes. 1. Effect of intake of protein, energy and blood metabolite levels. Asian-Aust. J. Anim. Sci. 15:330-39.

Robertson, J. A. and P. J. VanSoest. 1981. The detergent system of analysis and its application to human food. In: The Analysis of Dietary Fibre in Food, (Ed. W. P. T. James and O. Theander. Marcel Decker) Inc., New York. 123-58.

Sasser, R. G., R. J. Williams, R. C. Bull, C. A. Ruder and D. G. Falh. 1988. Post-partum reproductive performance crude; protein restricted beef cows: Return to estrus and conception. J. Anim. Sci. 60:3033.

Snedecor, G. W. and W. G. Cochran. 1968. Statistical Methods. Oxford and IBH Publishing Company, Mumbai.

Treacher, R. J., I. M. Reid and S. J. Roberts. 1986. Effect of body condition at calving on the health and performance of dairy cows. Anim. Prod. 43:1-6.

Yadava, R. K., L. O. Gilmore and H. R. Conard. 1974. The effect of body condition at calving on milk production in dairy cow. Indian J. Dairy Sci. 27:197-99.

Yadava, R. K., H. R. Conrad and L. O. Gilmore. 1976. Effect of body condition at calving on reproductive performance in dairy cows. Indian J. Dairy Sci. 29:139-40.