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RESEARCH ARTICLE

Effects of Compensatory Growth Pattern on Growth Rate, Reproduction and Lactation Performance in Stall Fed Buffalo *(Bubalus bubalis)* Heifers

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ABSTRACT

Two groups each of 10 Nili-Ravi buffalo heifers of 6-8 months age and 98.55±5 kg body weights (BW) were used to study the effects of compensatory growth pattern on growth, reproduction and lactation performance. After adjustment period of 4 weeks, two groups were fed either as per National Research Council (NRC) recommendations or stair-step feeding (SSF). For NRC heifers adopted Holstein Friesian nutrients requirements for growth rate of 0.6 kg/day considering BW of 100, 200 and 300 kg at the beginning of phase I (from 8 to 13 months), phase II (from 14 to 19 months) and phase III (from 20 to 25 months), respectively. The SSF was designed in three phase programme each having 6 months duration started on energy restricted diet (80% ME of NRC) for 4 months and ended with compensatory energy diet (120% ME of NRC) for 2 months. It was found that daily DM consumption for the entire feeding period was statistically ($P>0.05$) similar in both groups however; heifers on SSF gained 6.8% higher BW than NRC group. Feed conversion ratio was better ($P<0.05$) in SSF heifers compared to those fed as per NRC (8.78 vs 9.36). Age and weight at puberty, services per conception and gestation period were not influenced ($P>0.05$) by dietary treatments. Stair-step feeding has saved significant ($P<0.05$) cost of feeding (1850 rupees/animal) as compared to as per NRC requirements. Average milk yield (5.72 vs 5.10 litres/day) in SSF was significantly ($P<0.05$) higher than as per NRC group. Results can be concluded that SSF is a cost effective approach for rearing of buffalo heifers without any adverse effects on the growth rate, time to puberty, services per conception, conception rate and gestation period as compared to heifers fed as per NRC recommendations from weaning to breeding age. However, average milk yield of first calved heifers reared on SSF was 12.16% higher than those fed as per NRC recommendations.

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INTRODUCTION

Buffalo *(Bubalus bubalis)* is the major dairy animal and Pakistan is placed at second position in the world after India for buffalo production contributing approximately 67% of total milk production in the country. Buffalo is rightly called as black gold of Pakistan and is playing a leading role in providing milk, meat and draught power. Due to high milk fat (5-7%) content, buffalo milk is preferred in Pakistan. Buffaloes of Nili-Ravi breed are best milk producer amongst other breeds of buffaloes in the world but per head milk yield is still much less as compared to the milk production of the established dairy cattle breeds of the developed world. In Pakistan, slow growth rate and lower production of animals is due to inadequate feed resources and traditional feeding resulted delayed age at puberty. Average age at puberty of Pakistani buffaloes is 37 months (Bashir, 2006) higher than exotic or crossbred cattle (18 months). The reduction in age at puberty means not only saving the feeding cost but also one additional reproductive cycle. Furthermore, few studies indicated that Pakistani buffaloes have potential to attain puberty at 18 to 24 months of age (Jabbar, 2004; Anjum *et al.*, 2012).

Heifer production is considered to be the most expensive part of dairy farm operation because it needs

more inputs for a longer period with no immediate returns (Heinrichs, 1993). For efficient dairy farming, a complete package of heifer rearing is needed to exploit the performance potential at minimum expense. Feed cost represents 84% (Razzaque *et al*., 2010) of the total input costs for heifer's production. The SSF is to reduce energy levels for a limited period and then compensate this effect by supplying the energy in excess to exploit the effect of compensatory growth (Kim *et al*., 1998). This feeding scheme is based on a combination of both restriction and realimentation of energy that is designed to induce compensatory growth for developing dairy (Ford and Park, 2001; Park *et al*. 1989) and beef (Park *et al*., 1998), heifers. Researchers have attempted to develop heifer feeding and rearing programs with a particular emphasis on the effects of high feeding intensity on pubertal heifers (Ford and Park, 2001). However, numerous studies have observed that over fattening of the pre pubertal heifer by feeding high energy diets resulted in impaired mammary parenchymal development. Therefore, the present study was conducted to evaluate the effects of compensatory growth pattern on feed intake, growth rate, reproductive and productive performance in stall fed buffalo heifers.

MATERIALS AND METHODS

Animals and their management

Twenty Nili-Ravi buffalo heifers 6-8 months age and average BW 98.55±5 kg at the beginning of experiment were provided feed as per NRC (2001) requirements for one-month as adjustment period preceding the trial. Before the start of experiment, subcutaneous Promectine® injection @ 2 ml/animal was given to control parasites. The heifers were housed in individual tie stall in well ventilated, concrete floor and asbestos sheet roof shed and offered feed once daily in mangers. Fresh water was provided 4-5 times a day. In the morning all heifers were let loose in open paddock for three hours throughout the experimental period except during severe weather. Daily sweeping and cleaning of floors and bathing the heifers with fresh ground water was practiced to provide good hygienic environment.

Dietary treatments

Heifers were divided into two equal groups and randomly assigned two dietary treatments i.e., as per NRC requirements or stair-step feeding (SSF). The SSF was designed in three phase programme each having 6 months duration i.e., phase I (8 to 13 month), II (14 to 19 month) and III (20 to 25 month). In each phase SSF heifers started on restricted energy diet (80% ME of NRC) for 4 months and ended by compensatory energy diet (120% ME of NRC) for the period of 2 months. However, NRC heifers were fed of Holstein Friesian heifers requirements of growth rate of 0.6 kg/day considering BW of 100, 200 and 300 kg at the beginning of phase I (from 8 to 13 months), phase II (from 14 to 19 months) and phase III (from 20 to 25 months), respectively (Table 1). Heifers of both groups were offered @ 2 kg/animal/day of available green fodders to meet the requirement of vitamin A. Total digestible nutrients (TDN) were calculated by Wardeh (1981) equation based on proximate composition (AOAC, 1990).

$$TDN\ (\%) = 40.32 + 0.5398CP + 0.448NFE + 1.422\ EE - 0.7007\ CF$$

Digestible energy (DE) and metabolizable energy (ME) was calculated by using NRC (2001) equation as under:

$$DE\ (Mcal/kg) = 0.04409 \times TDN\ (\%)$$
$$ME\ (Mcal/kg) = 1.01 \times DE\ (Mcal/kg) - 0.45$$

Parameters studied

Heifers were weighed fortnightly to monitor the growth rate after restriction of feed and water intake for 16 hours. Feed conversion ratio (FCR) was calculated as kilograms of feed intake per kilogram of live weight gain. Data on feed consumption during phase I, II, and III were used to calculate the saving of feed cost of SSF heifers over the NRC heifers (Perrin *et al*. 1979). The heifers showed estrus signs were bred by natural mating and those not returning to estrus were examined for pregnancy through rectal palpation at 70-90 days post breeding. Numbers of services per conception were also recorded. The heifers that have calved and were reared on SSF versus as per NRC requirement after calving were used for recording of lactation performance. Individual feeding and milking, twice a day was practiced. Feed eaten and milk produced in morning and evening was recorded. During gestation and lactation periods seasonal available green fodders were offered daily @ 40 kg/buffalo along with concentrate supplementation @ 1kg/2.5 litres of milk. Concentrate feed consisted of 90% dry matter, 17.50% crude protein and 22.00% crude fibre and 68 % total digestible nutrients.

Statistical analysis

Data collected were analyzed with a linear model using student's paired t-test described by Steel *et al*. (1997). Data are given as means plus or minus the standard error of the mean.

RESULTS AND DISCUSSION

Dry matter intake (DMI) and growth performance in heifers fed SSR versus as per NRC requirement from 8 to 25 months age are presented in Table 2. The DMI did not differ ($P>0.05$) between heifers fed SSF versus NRC diets throughout the study period. However, overall less dietary energy was used numerically by SSF heifers to attain more BW than by the heifers fed as per NRC requirements. These results are in line with the findings of Clanton *et al*. (1983) who reported that beef heifers raised on SSF (compensatory growth) needed less feed to reach an equal body weight than by heifers fed for constant growth rate. Our findings coincided with the results of Grings *et al*. (1999) who found no change in DMI in beef heifers raised on stair-step versus control diets. Similarly, other studies (Choi *et al*., 1997; Yambayamba and Price, 1997; Ford and Park, 2001; Jin *et al*., 2004) demonstrated that the cattle heifers raised on SSF had improved weight gain efficiency by consuming less feed (energy content) compared to their counterparts fed for continuous growth rate.

Over the entire developmental period, 6.8% greater weight gain was found in heifers raised on SSF growth pattern than those fed as per NRC requirements, may be

Table 1: Ingredients and chemical composition of experimental diets

Ingredients (%)	Phase I (8-13 months)				Phase II (14-19 months)				Phase III (20-25 months)			
	Restricted for 4 months		Compensatory for 2 months		Restricted for 4 months		Compensatory for 2 months		Restricted for 4 months		Compensatory for 2 months	
	SSF	NRC	SSF	NRC	SSF	NRC	SSF	NRC	SSF	NRC	SSF	NRC
Maize oil cake	-	17.00	20.00	17.00	-	7.00	16.00	7.00	-	7.00	19.00	7.00
Cottonseed meal	-	12.00	15.00	12.00	-	10.00	15.00	10.00	-	3.00	10.00	3.00
Cottonseed cake	32.00	-	-	-	28.00	5.00	-	5.00	26.00	16.00	1.00	16.00
Sunflower meal	13.00	1.00	-	1.00	19.00	4.50	1.00	4.50	19.00	5.00	1.00	5.00
Canola meal	2.00	6.00	3.00	6.00	4.00	4.00	1.00	4.00	1.50	3.00	1.00	3.00
Rice polish	-	5.00	7.00	5.00	-	3.00	8.00	3.00	-	2.00	9.00	2.00
Wheat bran	1.00	7.00	5.00	7.00	-	9.00	1.00	9.00	1.00	8.00	3.00	8.00
Corn gluten feed	12.75	5.00	2.00	5.00	0.50	5.00	1.00	5.00	1.00	4.00	3.50	4.00
Corn grains	-	12.00	15.00	12.00	-	10.00	22.00	10.00	-	11.00	17.00	11.00
Vegetable oil	0.25	1.00	6.00	1.00	-	1.00	3.50	1.00	-	0.50	3.00	0.50
Wheat straw	30.00	25.00	18.00	25.00	42.00	35.00	25.00	35.00	44.00	33.00	25.00	33.00
Cane molasses	6.00	6.00	6.00	6.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00
Urea	0.50	0.50	0.50	0.50	-	-	-	-	-	-	-	-
C. ingredients[§]	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Total	100	100	100	100	100	100	100	100	100	100	100	100
Chemical Composition												
CP (%)	15.84	16.16	16.11	16.16	13.70	13.41	13.65	13.41	12.76	12.31	12.89	12.36
ME (Mcal/kg)	2.03	2.55	3.01	2.55	1.89	2.35	2.80	2.35	1.84	2.30	2.76	2.30

[§]Constant ingredients: Di-calcium phosphate 1.00%, limestone powder 0.50%, sodium chloride 0.50% and mineral premix 0.50%
[+]Buffalo heifers fed SSF with restricted energy diet for 4 mo followed by compensatory energy for 2 mo during each phase (I, II and III). Restricted energy diets (80% ME of NRC) contained ME 2.03, 1.89 and 1.84 Mcal/kg; compensatory energy (120% ME of NRC) diet's ME was 3.01, 2.80 and 2.76 Mcal/kg and NRC diet's (100% ME of NRC) ME was 2.55, 2.35 and 2.30 Mcal/kg while crude protein was 16, 13 and 12% during phase I, II and III, respectively; Where SSF= Stair-step feeding, NRC= National Research Council, TMR= Total mixed ration, CP= Crude protein, ME= Metabolizable energy, DM=Dry matter.

Table 2: Feed intake (kg), feed conversion ratio (FCR kg feed: kg gain) and weight gain (kg/head /day) (Mean ± SE) of Nili-Ravi buffalo heifers fed SSF versus NRC diets

Parameters	[1]Feeding Regimen		P value
	SSF	NRC	
Phase I (8 to 13 mo)			
Daily DM intake	3.65±0.09	3.65±0.10	0.49
Daily weight gain	0.61±0.03	0.60±0.03	0.32
FCR	6.03±0.23	6.25±0.23	0.20
Phase II (14 to 19 mo)			
Daily DM intake	5.53±0.08	5.52±0.34	029
Daily weight gain	0.63±0.04	0.58±0.03	0.36
FCR	9.10±0.60	9.32±0.38	0.30
Phase III (20 to 25 mo)			
Daily DM intake	7.40±0.05	7.37±0.05	0.36
Daily weight gain	0.59±0.02	0.57±0.02	0.28
FCR	12.73±0.43	13.03±0.46	0.32
Overall (8 to 25 mo)			
Initial body weight	98.53±5.00	98.62±5.15	0.45
Final body weight	440.00±15.30	419.88±21.99	0.15
Total weight gain	341.47±12.80	320.88±18.58	0.22
Daily weight gain	0.63±0.03	0.59±0.02	0.11
Total DM intake	2984.74	2978.30	0.13
Daily DM intake	5.53±0.23	5.52±0.40	0.12
FCR	8.78±0.05	9.36±0.03	0.03

Where SE= standard error of means, SSF= Stair-step feeding, NRC= National Research Council, DM= Dry matter intake, FCR= Feed conversion ratio and mo= Month; [1]Buffalo heifers fed SSF with restricted ME diet for 4 mo followed by compensatory ME for 2 mo during each phase (I, II and III). Restricted diets (80% ME of NRC) contained ME 2.03, 1.89 and 1.84 Mcal/kg; compensatory (120% ME of NRC) diet's ME was 3.01, 2.80 and 2.76 Mcal/kg and NRC diet's (100% ME of NRC) ME was 2.55, 2.35 and 2.30 Mcal/kg while crude protein was 16, 13 and 12% during phase I, II and III, respectively.

due to sound effects of compensatory growth. Ford and Park (2001) reported that the heifers fed energy restricted diet exhibited higher subsequent growth rate when moved on high energy diet than did heifers fed control regimen. Our results also coincided with the findings of Choi *et al*. (1997) and Jin *et al*. (2004), who reported that dairy heifers raised on SSF according to 3, 2, 4, 2, 5 and 2 months alternatively with 20% below or 25% above ME of NRC requirements, had higher weight gain than those fed as per NRC requirement.

The FCR was significantly (P<0.05) better in heifers fed SSF compared to those fed as per NRC requirements over the entire experimental period. These findings are in agreement with that of Ford and Park (2001) who reported that heifers raised on stair-step growth pattern, gained significantly more weight (0.95 vs 0.80 kg/day) and consumed less feed (8.8 vs 11.3 kg/day), resulting in 52.48% improved FCR (9.26 vs 14.12) compared to conventionally fed control heifers. The FCR was poorer in buffalo heifers fed on SSF low energy diets during all phases compared to heifers fed as per NRC requirements, respectively. But FCR was significantly improved when these heifers moved on high energy diet during three phases compared to those fed control diet. It is speculated that on energy restricted periods most of the energy was used for the maintenance requirements and probably very less amount of energy was spared for weight gain, thereby resulting in poor FCR of the SSF heifers. Similarly findings were reported by Choi *et al*. (1997), Yambaya-mba and Price (1997), Ford and Park (2001), Jin *et al*. (2004).

Stair-step feeding has saved significant (P<0.05) cost of feeding (1850 Pakistani Rupees/animal) as compared to as per NRC requirements from weaning to breeding age (Table 3). Earlier researchers (Park *et al*., 1989; Choi *et al*., 1997; Ford and Park, 2001 and Jin *et al*., 2004) have used alternating growth patterns (compensatory growth) for dairy heifers' development from weaning to breeding

Table 3: Economic analysis of buffalo heifers fed SSF versus NRC diets

Dry mater intake (kg/animal) and its cost (Rs.)	Feeding Regimen[1]		
	SSF	NRC	P value
During postweaning phase[A]			
Step 1 on low energy for 4 months	406.80±12.12	404.40±12.28	0.46
Feed cost (Rs).	5125.47±157.72	6528.66±198.17	0.00
Step 2 on high energy for 2 months	250.58±5.16	253.06±6.66	0.39
Feed cost (Rs).	5026.69±103.55	4084.36±106.36	0.00
Total cost, Rs.	10152.16±249.67	10613.02±291.77	0.14
During prepubertal phase[B]			
Step 1 on low energy for 4 months	625.91±9.98	627.77±10.95	0.49
Feed cost (Rs).	7604.85±121.30	9385.21±163.75	0.00
Step 2 on high energy for 2 months	368.39±3.47	366.97±4.26	0.31
Feed cost (Rs).	6660.50±62.68	5486.25±68.18	0.00
Total cost (Rs.)	14265.35±187.96	14871.46±191.24	0.03
During pubertal phase[C]			
Step 1 on low energy for 4 months	849.88±6.26	845.93±7.13	0.28
Feed cost (Rs).	9782.12±72.05	12139.15±102.37	0.00
Step 2 on high energy for 2 months	483.50±3.10	479.89±2.61	0.21
Feed cost (Rs).	8461.25±54.25	6886.49±37.39	0.00
Total cost (Rs.)	18243.37±123.30	19025.65±138.74	0.00
Grand total (A+B+C) cost, (Rs.)	42660.88±350.90	44509.96±367.24	0.02
Saving over control (Rs.)	1849.05	-	-

±SE = Standard error of means; [A]Cost per kg of NRC diet was Rs. 16.14, stair-step low ME diet Rs. 12.60 and stair-step high ME diet Rs. 20.06; [B]Cost per kg of NRC diet was Rs. 14.95, stair-step low ME diet Rs. 12.15 and stair-step high ME diet Rs. 18.08; [C]Cost per kg of NRC diet was Rs. 14.35, stair-step low ME diet Rs. 11.51 and stair-step high ME diet Rs. 17.50; [1]NRC = National Research Council diet's contained (100% ME of NRC) for 6 months, SSF = stair-step feeding with low ME diet (80% ME of NRC) fed for 4 months during step 1 followed by high ME diet (120% ME of NRC) for 2 months in step 2, during each phase (postweaning 7 to 13 month age; prepubertal 14 to 19 month age; and pubertal 20 to 25 month age). Low ME diets contained ME 2.03, 1.89 and 1.84 Mcal/kg; high ME diet's ME was 3.01, 2.80 and 2.76 Mcal/kg and NRC diet's ME was 2.55, 2.35 and 2.30 Mcal/kg while crude protein was 16, 13 and 12% during postweaning, prepubertal and pubertal phases, respectively.

Table 4: Reproductive performance of experimental buffalo heifers

Parameters	Feeding Regimen[1]		
	SSF (n=10)	NRC (n=10)	P value
Heifers attaining puberty by 26 months age (%)	80	80	-
Age at first estrus (days)	658±25.2	665±22.5	0.410
First conception (days)	736±15	732±12	0.078
Services per conception (Nos.)	1.22±0.2	1.46±0.3	0.150
Gestation period (days)	305±8	309±9	0.145

[1]NRC = National Research Council diet's contained (100% ME of NRC) for 6 months, SSF = stair-step feeding with low ME diet (80% ME of NRC) fed for 4 months during step 1 followed by high ME diet (120% ME of NRC) for 2 months in step 2, during each phase (postweaning 7 to 13 month age; prepubertal 14 to 19 month age; and pubertal 20 to 25 month age). Low ME diets contained ME 2.03, 1.89 and 1.84 Mcal/kg; high ME diet's ME was 3.01, 2.80 and 2.76 Mcal/kg and NRC diet's ME was 2.55, 2.35 and 2.30 Mcal/kg while crude protein was 16, 13 and 12% during postweaning, prepubertal and pubertal phases, respectively.

Table 5: Milk yield and composition of experimental buffalo heifers

Parameters	SSF (n=8)	NRC (n=7)	P value
Average DM intake (kg/day)	12.90±1.50	12.85± 1.20	0.072
Average milk yield (liter/day)	5.72±0.11	5.10±0.16	0.001
Feed efficiency (kg feed/kg of milk)	2.25	2.52	-
Chemical composition			
Milk protein (%)	4.78±0.07	4.76±0.04	0.142
Milk fat (%)	6.21±0.15	6.24±0.12	0.090
Milk fat yield (kg/day)	0.355	0.318	-
Total ash (%)	0.82±0.07	0.83±0.05	0.081

DM =Dry matter, NRC= National Research Council, SSF = stair-step feeding.

age that has not only affected the feeding cost (Freetly *et al*., 2001) but also improved the lactation performance (Park *et al.*, 1989). Managing heifers to attain puberty with decreased feed inputs and then taking advantage of compensatory gains may have economic advantages. Feed cost, among the input cost of rearing heifers is considered being the most important cost factor having direct influence on growth rate of heifers. When the heifers attained faster growth rate, then relatively proportion of consumed feed used for maintenance decreased, which showed that an accelerated growth was effective in feed cost savings (Razzaque *et al*., 2009). Age and weight at puberty, conception, services per conception and gestation period were not influenced (P>0.05) by dietary treatments (Table 4). These results agreed with the findings of Choi *et al*. (1997) and Jin *et al*. (2004).

The buffalo heifers reared on SSF vs NRC were used for recording of lactational performance (Table 5). In buffaloes average milk yield was 12.16% higher (P<0.05) in the ones reared on stair-step feeding (n=8) than those fed on control (n=8) diet (5.72 vs. 5.10 liter/head/day). There was no difference in milk composition of both groups of buffaloes. Heifers raised on SSF compared to NRC standard feeding practices had similar end weights while consuming less feed, resulting in improved growth efficiency, better mammary gland development and enhanced lactation potential (Ford and Park, 2001). Park *et al.*, (1989) observed better growth efficiency and increase milk yield from first calved heifers raised on SSF than for conventionally fed animals.

Results can be concluded that SSF is a cost effective approach for rearing of buffalo heifers without any adverse effects on the growth rate, time to puberty, services per conception, conception rate and gestation

period as compared to heifers fed as per NRC recommendations from weaning to breeding age. Average milk yield of first calved heifers reared on SSF was 12.65% higher than those fed as per NRC recommendations.

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