EFFECTS OF LONG DAY PHOTOPERIOD ON MILK YIELD AND CIRCULATING CONCENTRATIONS OF INSULIN-LIKE GROWTH FACTOR-1 AND PROLACTIN IN JAFFRABADI BUFFALO

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ABSTRACT

An experiment was conducted to study the effect of long day photoperiod and showering on milk production and associative endocrine changes in lactating Jaffrabadi buffaloes between November, 2013 and May, 2014 at Cattle Breeding Farm, Junagadh Agricultural University, Junagadh (India) on twenty-four recently calved Jaffrabadi buffaloes for a total duration of 182 days. The treatment groups were T_1 (control-Natural day photoperiod-NDPP), T_2 (NDPP + showering twice a day), T_3 (long day photoperiod of 18 h-LDPP) and T_4 (LDPP + showering twice a day). The buffaloes were fed as per ICAR (2010) feeding standards to meet the nutritional demands of lactation. Supplemental lighting of 20 footcandle at eye level of buffaloes in T_3 and T_4 was provided by fluorescent lamps, controlled by automatic timer. Plasma was assayed for Insulin like Growth Factor-1(IGF-1) and Prolactin (PRL) hormones by using ELISA kit. Buffaloes in T_4 produced 27.68% (1.55 lit) more milk than control group of buffaloes, followed by T_3 group of buffaloes producing 24.0% (1.35 lit) and T_2 group of animals producing 8.93% (0.5 lit) more milk per day. Buffaloes exposed to LDPP showed greater concentrations of IGF-1 and prolactin than buffaloes exposed to NDPP. Exposure to LDPP and showering twice a day increased milk yield and circulating concentrations of IGF-1 and PRL in Jaffrabadi buffaloes indicating that IGF-1 and PRL are galactopoietic in dairy buffaloes and revealed physiological basis for possible endocrine mechanism for the galactopoietic response of both the hormones. LDPP along with showering twice a day produce synergetic effect on milk yield in Jaffrabadi buffaloes. These practices are simple to implement, easy to manage, profitable, cost effective and does not require any technological insertion and thus provide another management tool for dairy buffalo producers to enhance productivity and profitability.

Keywords: *Bubalus bubalis*, buffalo, Jaffrabadi buffalo, milk yield, Insulin like growth Factor-1, prolactin, photoperiod, showering

INTRODUCTION

First reported by Peters *et al.* (1978), the galactopoietic response of cows to a long daily (24 h) photoperiod (16 to 18 h of light to 6 to 8 h of darkness) has subsequently been confirmed by a number of investigators (Stanisiewski, *et al*., 1985; Bilodeau *et al*., 1989; Evans and Hacker, 1989). However, the physiologic explanation for this phenomenon was unknown. Insulin like growth factor-1 (IGF-I) is associated with increased milk yield in cows following treatment with exogenous

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somatotropin (ST) (Dahl *et al.* 1991; Bauman and Vernon, 1993). Long day photoperiods stimulate IGF-I secretion in a number of species, including cattle, and these increases can be independent of ST (Suttie *et al.*, 1991; Spicer *et al.*, 1994). Close arterial infusion of IGF-I in the mammary gland stimulates milk yield in goats, suggesting that the galactopoietic action of IGF-I is direct (Prosser *et al.*, 1990). Dahl *et al.* (1997) reported that a long daily photoperiod increases circulating concentrations of IGF-I and milk yield in lactating cows. The light stimulus inhibits the secretion of melatonin by the pineal gland such that melatonin is high at night and low during the day (Stanisiewski *et al.*, 1988). In lactating dairy cows, exposure to a long-day photoperiod of 16 h of light and 8 h of dark (16L : 8D) is associated consistently with an increase in prolactin (PRL) concentration and milk production (Dahl and Petitclerc, 2003).The effect of photoperiod on circulating concentration of IGF-1 and prolactin is of particular interest, because both the hormones influence on the function of mammary glands of animals.

Sharma and Gangwar (1981) revealed that the showers and the evaporative cooling were responsible for increasing the galactopoietic responses in Murrah buffaloes. Verma *et al.* (1988) studied the effect of showering and observed significant increase in FCM yield in lactating buffaloes. Ahmad and Tariq (2010) opined that showering of buffaloes twice a day, wallowing and cooled drinking water can increase conception rate from 21 to 30% and there is a definite increase in milk yield of about 20 to 25%. Ambulkar *et al.* (2011) concluded that the high pressure fogger system (HPFF) was beneficial in terms of the body comfort of the animals and the milk yield in Murrah buffaloes.

Hence, considering the importance of photoperiod and thermal cooling in enhancing milk production and paucity of such studies in Jaffrabadi buffaloes, the present investigation was undertaken to investigate the production and endocrine responses to long day photoperiod and thermal cooling in Jaffrabadi buffaloes.

MATERIALS AND METHODS

The experiment was conducted between November 2013 and May 2014 at Cattle Breeding Farm, Junagadh Agricultural University, Junagadh (India). Twenty-four recently calved Jaffrabadi buffaloes after attaining their peak yield in their 1 to 5 lactations were balanced for uniformity according to average daily milk yield and body weight. The buffaloes were maintained under standard feeding conditions as per ICAR (2010) feeding standards to meet the nutritional demands. The buffaloes were housed in a barn under stall fed conditions. Buffaloes were randomly assigned to one of to four treatments, each group consisting of 6 lactating buffaloes in a completely randomized design. This study consisted of 13 fortnights (182 days) measurement periods. The treatment groups were T_1 (control-Natural day photoperiod-NDPP), T_2 (NDPP + showering twice a day), T_3 (long day photoperiod of 18 h-LDPP) and T_4 (LDPP + showering twice a day). Supplemental lighting of 20 footcandle at eye level of buffaloes was provided by fluorescent lamps, controlled by automatic timer. Lights were turn on at 17:30 h and off at 24 h for group T_3 and T_4. showering was offered twice in a day at 10:30 h and at 16 : 00 h. (each for 15 minutes) for T_2 and T_4 groups. Buffaloes were milked daily at 4:30 h and at 16:30 h by hand milking. Blood samples were collected in 10 ml tubes (BD Vacutainer, K2E 18.0 mg) containing EDTA anticoagulant by puncture of a jugular vein of buffaloes at 30, 60, 120 and 180 day of the experiment. Plasma was harvested after centrifugation for 10 minutes at 3000 rpm and frozen at -20^{o}C until concentrations of Insulin like Growth Factor-1 (IGF-1) and Prolactin (PRL) were determined by using ELISA kit (MyBioSource, California, USA).

Statistical analysis

Data generated during the experiment were analyzed as per Completely Randomized Design (CRD) (Snedecor and Cochran, 1994) and results are presented as average ± standard error of mean.

RESULTS AND DISCUSSION

Milk yield

Mean daily milk yield during entire experimental period was 5.60±0.55, 6.10±0.63, 6.95±0.62 and 7.15±0.44 litres in T_1, T_2, T_3 and T_4 respectively (Table 1). Differences in milk production during different periods was non-significant. In all the treatments mean daily milk yield increased linearly from P1 to P3 in T_1 and T_2 and thereafter declined gradually. However, in T_3 and T_4 peak milk yield was recorded in P4 and thereafter declined in linear fashion. Though differences were non-significant, buffaloes in T_4 produced 27.68% (1.55 lit) more milk than control group of buffaloes, followed by T_3 group of buffaloes producing 24.0% (1.35 lit) and T_3 group of animals producing 8.93% (0.50 lit) more milk per day than control group.

Total whole milk produced during entire experimental period of 182 days was 1098.30±108.56, 1195.02±124.35, 1362.55±121.47 and 1402.32±86.27 liters in T_1, T_2, T_3 and T_4 respectively.

Increase in milk yield due to extended photoperiod was observed by number of researchers (Peters *et al*., 1978; Stanisiewski, *et al*., 1985; Bilodeau *et al*., 1989; Evans and Hacker, 1989; Dahl *et al*., 2000; Vanbaale *et al*., 2005; Gavan and Motorga, 2009) in exotic cows.

Insulin-like growth factor-1(IGF-1)

Concentration of IGF-1 did not increase significantly in plasma at 30, 60, 120 and 180 days of the experiment. IGF-1 concentration ranged from 7.37±2.44 ng/ml in T_2 at 30 day to 43.46±22.69 ng/ml at 60 day in T_4. Extension of photoperiod under T_3 and T_4 from 12 h to 18 h /day increased plasma concentration of IGF1. Though levels decreased simultaneously afterward but remained higher than control and T_2 group of buffaloes. Increase in IGF-1 level was associated with increased milk production in T_3 and T_4 compared to other groups (Table 2).

An interesting observation in present experiment is that photoperiod combined with showering effect appeared to have associative positive (additive) effect on IGF-1 concentration than photoperiod alone, as is evident from similar concentration of IGF-1 at both 120 and 180 day collection. It is likely that buffaloes responded to showering and photoperiod better than cows. Present study conformed galactopoietic effect of IGF-1 due to extended photoperiod.

The observation that buffaloes exposed to the long photoperiod had increased milk yield relative to buffaloes exposed to the natural photoperiod confirmed previous reports that long days are galactopoietic in cows (Peters *et al*., 1978; Stanisiewski, *et al*., 1985; Bilodeau *et al*., 1989; Evans and Hacker, 1989). Our finding that an increase in circulating concentrations of IGF-I accompanies the milk yield response was in agreement with that of Dahl *et al.* (1997).

The effect of a long photoperiod on IGF-I in Jaffrabadi buffaloes must also be considered in the context of the biological outcome, that is, increased milk yield. Bauman and Vernon (1993) have suggested that the galactopoietic effects of ST in ruminants are mediated by the concomitant increases in circulating concentrations of IGF-I. Indeed, there is evidence that IGF-I has a direct galactopoietic action at the mammary gland (Prosser *et al*., 1990), even in the absence of elevated concentrations of ST. The results of the present study support the concept that net increase in circulating concentration of IGF-1 is galactopoietics.

Prolactin

Concentration of Prolactin hormone increased significantly in plasma at 30, 120 and 180 days of the experiment. Prolactin concentration ranged from 17.26±1.51 ng/ml in T_1 at 30 day to 36.41±1.75 ng/ml at 30 day in T_4. Prolactin concentration increased linearly in plasma in T_1 to T_4 at 30 days. Significantly ($P<0.05$) higher concentration of prolactin was recorded in buffaloes subjected to photoperiod treatment (T_3) and photoperiod and showering (T_4) in comparision to T_1 and T_2 (Table 3). In T_1, concentration of Prolactin increased up to 60 days and declined thereafter at 120 and 180 days. T_2 group of buffaloes followed the same pattern. Highest concentration of Prolactin was observed in T_3 and T_4 at 30 days and declined thereafter. Prolactin concentration did not differ significantly among treatments at 60 day sampling. However, at 120 day sampling, differences among prolactin concentration were significant ($P<0.05$) and followed the trend similar to that of 30 day sampling. At 180 day sampling, the differences were also significant ($P<0.05$) in prolactin concentration. T_3 and T_4 were at par in terms of prolactin concentration. T_1 and T_2 were at par at 180-day sampling, however, T_2 group of buffaloes were at par with all the experimental buffaloes. Extension of photoperiod under T_3 and T_4 from 12 h to 18 h /day increased plasma concentration of Prolactin. Though levels decreased simultaneously afterward but remained higher than control and T_2 group of buffaloes. Increase in Prolactin level was associated with increased milk production in T_3 and T_4 compared to other groups and revealed a physiological basis for possible endocrine mechanism for the galactopoietic response of Prolactin hormone. Prolactin emerged as the initial candidate responsible for the galactopoietic effects of photoperiod. Indeed, long day photoperid increase circulating concentrations of PRL in a number of species, including cattle (Tucker *et al*., 1984). Short days, and melatonin replacement to mimic short days, decrease circulating PRL (Buchanan *et al*., 1993). Because of the galactopoietic role of PRL in a number of species, it would appear to be a logical mediator of the photoperiodic effect on lactation in Jaffrabadi buffalo.

Showering

From point of view of dark skinned. Buffaloes due to their dark skin and very less number of sweat glands/square inch (Marai and Haeeb, 2010) require a mechanism to dissipate body heat, showering was main option available. During the experimental periods maximum daily temperature recorded was 40.1°C in May, 2014. Showering in combination to LDPP (T_4) seems to have synergetic effect on milk production. Increased milk yield was noticed by providing thermal cooling in buffaloes by number of workers

Table 1. Average daily milk yield (l) of experimental Jaffrabadi buffaloes during different periods.

Treatment	P0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	Overall
T_1	6.68 ± 0.51	6.90 ± 0.78	7.11 ± 0.84	7.13 ± 0.74	7.11 ± 0.70	6.82 ± 0.68	6.91 ± 0.85	6.40 ± 0.77	6.29 ± 0.69	5.65 ± 0.62	5.13 ± 0.48	4.70 ± 0.52	4.25 ± 0.61	4.04 ± 0.63	5.60 ± 0.55
T_2	6.68 ± 0.43	7.34 ± 0.28	7.58 ± 0.54	7.69 ± 0.61	7.61 ± 0.63	7.22 ± 0.72	7.10 ± 0.86	6.36 ± 0.76	6.75 ± 0.93	6.22 ± 0.88	5.88 ± 0.83	5.78 ± 0.87	5.09 ± 0.80	4.73 ± 0.79	6.10 ± 0.63
T_3	6.70 ± 0.36	7.72 ± 0.37	8.53 ± 0.63	8.81 ± 0.75	9.16 ± 0.87	8.62 ± 0.81	8.29 ± 0.80	7.83 ± 0.74	7.48 ± 0.85	6.76 ± 0.71	6.61 ± 0.80	6.33 ± 0.88	5.80 ± 0.82	5.38 ± 0.78	6.95 ± 0.62
T_4	6.63 ± 0.48	7.80 ± 0.39	8.88 ± 0.40	9.10 ± 0.47	9.49 ± 0.36	8.91 ± 0.52	8.54 ± 0.52	7.97 ± 0.41	7.92 ± 0.74	7.20 ± 0.63	6.80 ± 0.64	6.37 ± 0.61	5.82 ± 0.63	5.39 ± 0.52	7.15 ± 0.44
S.Em.±	0.45	0.49	0.63	0.65	0.67	0.69	0.77	0.69	0.81	0.72	0.70	0.74	0.72	0.69	0.57
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	16.5	16.21	19.11	19.05	19.61	21.28	24.49	23.61	27.79	27.21	28.22	31.19	33.76	34.54	21.54

Table 2. Average Insulin like growth factor-1 (IGF-1) (ng/ml) levels in Jaffrabadi buffaloes during different phases of experiment.

Treatment	30 Day	60 Day	120 Day	180 Day
T_1	9.48±3.34	15.78±5.93	16.27±10.22	17.63±4. 20
T_2	7.37±2.44	17.95±6.14	18.44±11.29	17.37±4.37
T_3	23.18±11.87	29.38±13.07	27.53±11.82	23.30±10.17
T_4	39.58±21.57	43.46±22.69	37.17±16.86	37.37±17.87
S.Em.±	12.42	13.62	14.18	10.71
C.D. at 5%	NS	NS	NS	NS
C.V. %	23.29	28.65	32.52	42.56

Table 3. Average bovine Prolactin (ng/ml) levels in Jaffrabadi buffaloes during different phases of experiment.

Treatment	30 Day	60 Day	120 Day	180 Day
T_1	$17.26±1.51^b$	28.55±1.80	$23.51±0.22^b$	$18.17±1.82^b$
T_2	$18.40±1.53^b$	27.10±2.21	$25.81±1.55^b$	$22.19±1.75^b$
T_3	$35.62±1.43^a$	33.52±2.29	$30.63±1.36^a$	$28.36±1.72^a$
T_4	$36.41±1.75^a$	31.81±1.93	$30.35±1.35^a$	$26.28±2.81^a$
S.Em.±	1.56	2.07	1.24	2.08
C.D. at 5%	4.68	NS	3.7	6.23
C.V. %	12.96	15.28	10.04	19.58

Means in a column with different superscripts differ significantly ($P<0.05$).

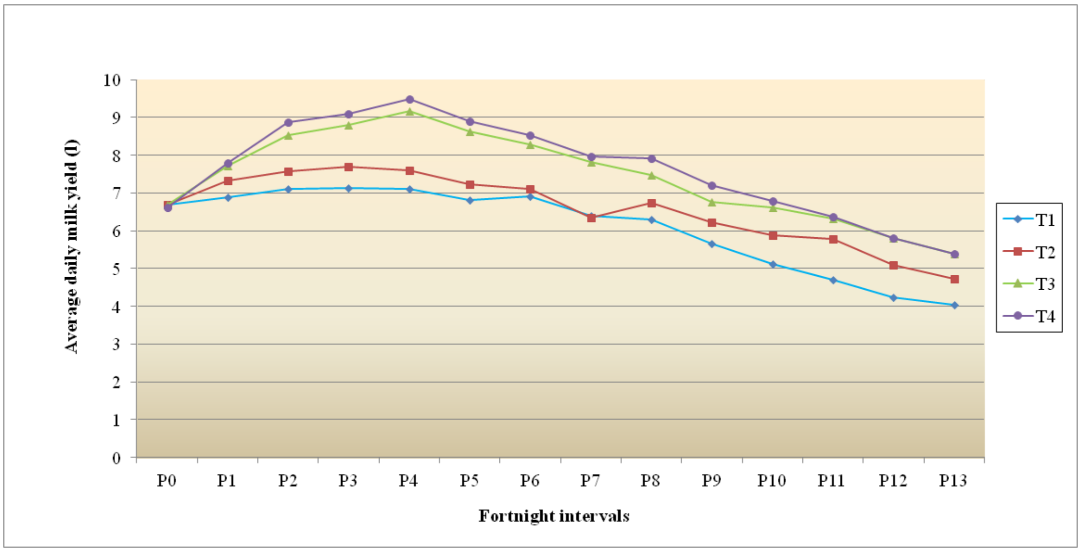

Figure 1. Average daily milk yield (lit) of Jaffrabadi buffaloes during different phages of experiment.

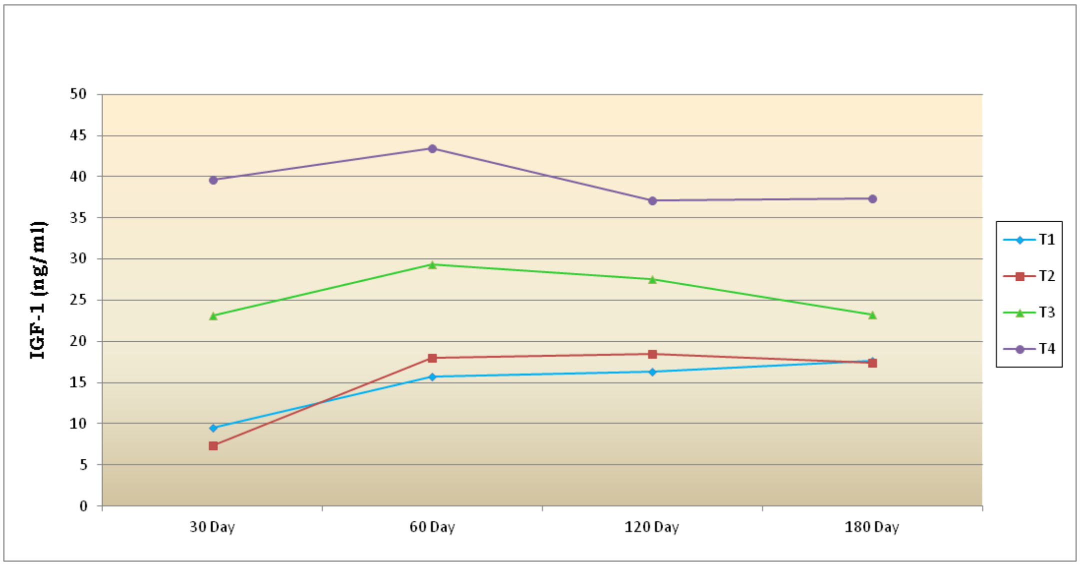

Figure 2. Average IGF-1 (ng/ml) levels in experimental Jaffrabadi buffaloes during different phages of experiment.

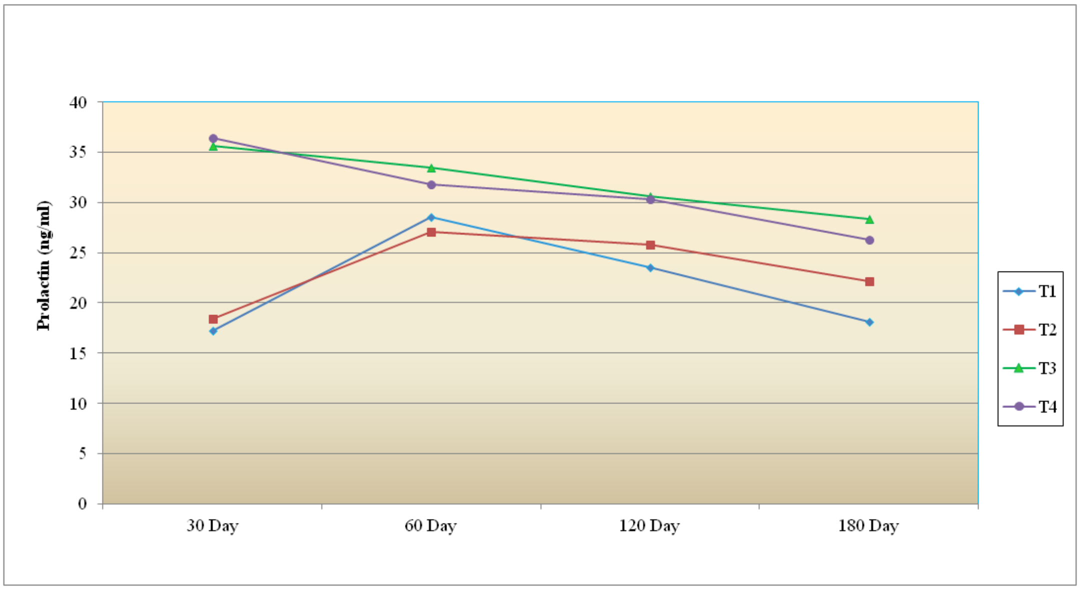

Figure 3. Average Prolactin (ng/ml) levels in experimental Jaffrabadi buffaloes during different intervals.

(Sharma and Gangwar, 1981; Verma *et al.*, 1988; Ahmad and Tariq, 2010; Ambulkar *et al.*, 2011). Exposure to long day photoperiod (LDPP) during lactation increased milk yield and circulating IGF-I and prolactin (PRL) concentrations in Jaffrabadi buffaloes provide good body of evidence indicating that IGF-I and prolactin (PRL) are galactopoietic in dairy buffaloes and revealed physiological basis for possible endocrine mechanism for the galactopoietic response of both the hormones. Long day photoperiod and showering twice a day are effective managerial practices that can be used to improve milk production of lactating Jaffrabadi buffaloes. These practices are simple to implement, easy to manage, profitable, cost effective and does not require any technological insertion in dairy buffalo management.

Collectively, the efficiency of milk production in Jaffrabadi buffaloes can be enhanced through photoperiod manipulation and showering twice a day, and thus provide another management tool for dairy producers to enhance productivity and profitability.

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