



Effect of climatic changes on reproductive performance of Murrah buffaloes in Punjab: A retrospective analysis

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ABSTRACT

The present study was conducted to assess the effect of climatic changes on reproductive performance of Murrah buffaloes in Punjab. Retrospective analysis of farm records of 15 years and climatic data on oestrus expression and conception interval revealed that even though buffalo calved and showed postpartum oestrus throughout the year, their seasonal pattern in postpartum oestrus incidence could be due to seasonal changes in climatic factors. Relative humidity, rainfall and vapour pressure had positive influence and air temperature and number of sunshine hours had negative influence on postpartum ovarian activity. Season of calving influenced the intervals from calving to oestrus and conception. Monsoon calving buffalo had shorter while summer and winter calving buffalo had longer intervals from calving to oestrus and conception. Parity order had negative correlations and lactation yield had positive correlations with intervals from calving to oestrus and conception. The interval from calving to oestrus was shorter than the interval from calving to conception across the season of calving, parity order and lactation yield. Therefore, it appears that climatic factors, parity order and lactation yield together with individual animal variations may have influenced the conception. However, this study suggests that further studies are required to elaborate the impact of these factors on postpartum reproductive physiology of buffalo in relation to their hormonal and metabolic environment, ovarian activity, expression of oestrus and conception during the early postpartum period.

Key words: Buffalo, Climate, Conception, Oestrus, Reproduction

The buffalo has gained popularity among rural farmers due to their contribution in milk, meat, manure, draught power and fuel. However, it is a difficult breeder with high incidence of subestrus and anoestrus especially during early postpartum period, resulting in low reproductive efficiency. The deleterious effects of summer stress on fertility have been well documented in this species (Ribeiro *et al.* 2003, El-Wishy 2007). However, limited studies have been attempted to identify and prioritize farm-level condition of buffaloes based on reproductive performance (Rane *et al.* 2003). Moreover, in an evolutionary perspective, buffaloes prefer temperate climate (Zicarelli 1997) and the effect of change of climate on their reproductive performance have not been critically investigated. Therefore, the present study

was planned with the objective to analyse the effect of climate on postpartum fertility parameters retrospectively in buffalo over a period of 15 years under Indian subtropical conditions.

MATERIALS AND METHODS

Herd and reproductive management: Data for analysis of postpartum fertility parameters was collected from the records of breeding, calving and lactation of Murrah buffalo maintained at the Government Buffalo Breeding farm, Mattewara over a period of 15 years from 1994 to 2008. The dairy farm is located in the subtropical northwestern India between 28°28' and 30°30' N latitude and 74°31' and 77°02' E longitude. During this period, the average monthly air temperatures and relative humidity ranged from 14.9 to 36.7°C and 40.7 to 50.5% in spring (March to May), 30.8 to 42.0°C and 67.7 to 73.8% in summer (June to August), 15.6 to 28.9°C and 46.6 to 52.5% in autumn (September to November), and 1.7 to 10.4°C and 33.8 to 41.4% in winter (December to February), respectively. The mean annual milk yield was 1895 kg per buffalo for the herd. All the buffaloes were maintained in free-stall facilities. During last trimester of pregnancy, the animals were kept separated from rest of

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the herd. Two days after calving, buffaloes were shifted to a separate shed where they were milked manually. Milking was done twice a day, morning (4.00 AM) and evening (3.00 PM) in the presence of calves. Lactating buffaloes were provided with 40 kg of green fodder, 10 kg of dry fodder and 4.5 kg of concentrates per day per head. Ad-libitum drinking water was supplied. Shower bath was given during summer season, in addition. The postpartum reproductive diseases, if any, were treated until recovery, pregnancy or culling.

Data collection: The total number of calving occurred during this period were 899 out of which, 848 calving were normal. Only normal calvings were incorporated in this study. Seasonal calving and oestrus pattern and intervals from calving to first observed oestrus and conception were studied. In addition, effect of season and month of calving, parity and lactation yield on calving to first observed oestrus interval and calving to conception interval were studied. To reduce the complexity of data analysis, considering the management system to be similar over the study period, the effect of year or period on the postpartum fertility was not considered.

Statistical analysis: Statistical analyses were performed on subpopulation of all the buffaloes with complete information about their age, parity and reproductive status, etc. using SPSS (statistical package for social sciences). Analysis of variance, mean comparisons (Tukey's method) and correlation analyses were performed according to the procedures described by Zar (2008). Chi-squared tests were used to determine if there was an overall effect of each variable on the outcome of interest. If this effect of variable(s) was significant ($P < 0.05$), multiple comparisons were carried out. The total number of calvings as well as the buffalo showing first postpartum oestrus spanning over 15 consecutive years was pooled for each month. Monthly and season-wise percentage of calvings and postpartum oestrus incidence were calculated. Mean monthly values of climatic factors for the same period were also calculated. In order to

study the short-term and long-term effects of climatic factors on postpartum reproductive performance, two correlation analyses were done separately. Least square means and standard errors for calving to oestrus and conception interval across month and season of calving, parity order and lactation yield were calculated.

RESULTS AND DISCUSSION

Data during the period (1994 – 2008) was analysed retrospectively. 899 calvings including 51 stillbirths occurred during this time. Of the total, 848 calving were normal and taken for the analysis. The monthly variation of calving and postpartum oestrus incidence and climatic factors are shown in Table 1.

Calving and postpartum oestrus pattern: The results indicated that calving occurred throughout the year. While maximum calvings occurred in the month of August, minimum were recorded in January. Similarly, season-wise percentage of calving was 12.5, 16.6, 52.7 and 18.2 during winter, pre-monsoon, monsoon and post-monsoon season, respectively, with maximum being during monsoon. Clearly, seasonality exhibited a pronounced impact on calving parameter in buffalo. Seasonal pattern in oestrus expression and conception is often followed by seasonal pattern in calving (Buglio *et al.* 2000).

A similar trend was observed in oestrus expression by postpartum buffalo. The maximum percentage of buffalo exhibited postpartum oestrus in the month of September followed by October and minimum in April and May. The percentage of buffalo that showed postpartum oestrus was 20.7, 5.4, 42.2 and 31.8 during winter, pre-monsoon, monsoon and post-monsoon season, respectively. Similar observations have been recorded in previous studies which were done at different time periods and locations on different breeds managed under different management systems (Kamboj and Chawla 2006).

Table 1. Monthly percentage of calving and percentage of postpartum buffalo coming to oestrus and monthly averages for climatic factors

Month	Calving (%)	Oestrus (%)	Max. Temp. (°C)	RH (%)	VP(mm Hg)	SSH (hrs/day)	RF (mm)
January	3.18	5.47	17.40	79.2	8.09	5.51	31.21
February	4.13	3.92	21.62	74.2	9.42	7.45	34.07
March	4.25	3.45	27.91	65.7	11.70	9.17	17.18
April	5.42	0.95	36.18	43.3	10.43	9.84	19.80
May	6.96	0.95	38.81	43.6	14.43	9.40	30.66
June	10.97	3.80	36.93	59.4	19.88	8.04	92.78
July	13.56	8.92	34.23	76.3	24.50	6.59	187.80
August	15.45	9.87	33.82	79.2	24.49	7.56	179.45
September	12.74	19.50	33.26	75.5	21.46	8.00	88.26
October	13.09	19.38	32.21	64.7	14.01	7.94	8.18
November	5.07	12.37	27.13	64.5	9.72	6.96	2.16
December	5.19	11.41	20.69	74.2	8.38	6.24	8.22

Max. Temp., maximum air temperature; RH, relative humidity; VP, vapour pressure; SSH, number of sunshine hours; RF, rainfall.

Environmental temperature and postpartum oestrus: The average maximum air temperature was recorded in May with average minimum in January. During the period from April to October, the average maximum air temperature ranged from 32.2°C to 38.8°C which was comparatively high than during rest of the period (28.0°C). The current study showed a negative correlation ($r = -0.06$) between monthly postpartum oestrus incidence and mean maximum air temperature. This indicated that high air temperature caused immediate suppressive effect either on ovarian activity or on oestrus expression and/or both. During April and May, when the maximum air temperature was highest, the percentage of buffalo expressing oestrus was lowest. In the months of September and October, when the maximum air temperature was still above 30.0°C, percentage of buffalo displaying oestrus was highest. From January through March, though maximum air temperature was low, the percentage of buffalo coming to oestrus was still low. Despite the effect of environmental temperature, buffalo commenced their calving season in July and continued till October. About 1–2 months after the commencement of calving season, the breeding season started and continued till December. Due to this pattern in calving and breeding, the majority of postpartum buffalo might be in pregnant stage after July. This could be the possible reason that during the period from January to March, the percentage of buffalo that came to oestrus was low even though maximum air temperature was low. Buffalo are eminently tolerable against high environmental temperature (Acharya 2009). However, earlier studies reflected that there was a strong negative correlation ($r = -0.62$ to -0.75) between air temperature and the frequency of oestrus incidence in postpartum buffalo (Squires 2003). There was no available information on the optimum range of environmental temperature that favoured buffalo reproduction or the critical range of environmental temperature that suppressed buffalo reproduction. A very low correlation coefficient between these two parameters obtained in the present study implied that the range of environmental temperature which existed at the study location was favorable for buffalo reproduction during postpartum period.

Relative humidity (RH) and postpartum oestrus: Monthly averages of RH made a biphasic pattern in the year, one from May to November and the other from December to April. The RH was the lowest during April and May and highest during January and August (Table 1). Correlation analysis revealed that monthly postpartum oestrus incidence positively correlated with relative humidity ($r = 0.48$). This implied that RH also had immediate and continuous positive effect on ovarian activity and oestrus expression. When RH was the lowest (April and May), the percentage of buffalo coming to oestrus was lowest. During the period of higher incidence of postpartum oestrus, RH was still at elevated levels. Previous studies have exhibited that RH alone had no effect (Dahama 1990) or a positive non-significant effect

(Patel *et al.* 1996) on incidence of oestrus in buffalo. However, the direct effect of RH on ovarian activity had never been studied previously in buffalo. Therefore, the effect of RH on the basic reproductive physiology in buffalo under controlled environmental conditions needs to be further elucidated.

Vapour pressure (VP) and postpartum oestrus: Like RH, the monthly variation in VP also revealed occurrence of two phases in a year, one during the period from May to October and the other during November to April. The highest VP was recorded during July and the lowest during December (Table 1). Correlation analysis revealed that monthly postpartum oestrus incidence positively correlated with VP ($r = 0.26$). This correlation showed that VP had strong effect on ovarian activity and oestrus expression. However, the relationship between these two factors varied differently during different periods. During July and August, VP was high and oestrus incidence was low where as reciprocal impact was recorded from October to December. Both VP and oestrus incidence were higher during September while in the remaining months, the two variables were relatively low (Table 1). Previous studies on the effect of VP on reproduction of buffalo are very scanty. Roy *et al.* (1972) reported that high percentage of oestrus incidence occurred when VP was at minimum. This is contrary to the present findings which showed that when VP was at minimum, the incidence of oestrus was in declining phase. Thus, it warrants further investigations on the effect of VP on basic reproductive physiology in buffalo.

Number of sunshine hours (SSH) and postpartum oestrus: Two phases in number of SSH occurred during the period from January to June and July to December. The highest number of SSH were recorded from March to May and lowest in January (Table 1). Buffalo are considered as a non-essential seasonal breeder as they exhibit breeding ability throughout the year. However, they behave as a short-day breeder since their ovarian cyclicity is stimulated by short day length via melatonin pathway (Zicarelli 1997). The present investigation showed that during the period from March to May, the number of buffalo coming to oestrus was lowest. Negative correlation between the oestrus incidence and the number of SSH ($r = -0.35$), indicated that number of sunshine hours had immediate and continuous suppressive influence on ovarian activity and oestrus expression. This is in agreement with the findings of an earlier study by Patel *et al.* (1996). It was reported that low concentration of melatonin in blood during the period of higher number of SSH had inhibitory effect on ovarian activity in buffalo (Parmeggiani *et al.* 1993). Paradoxically, supplementation of artificial light during winter and autumn seasons caused strong expression of oestrus via decreasing concentration of plasma melatonin in buffalo heifers (Kassim *et al.* 2008). Therefore, it is not clear about the role of concentration of blood melatonin played on ovarian activity and oestrus expression in buffalo. This

supports the idea that despite seasonal effect, buffalo are capable to express oestrus throughout the year.

Rainfall and postpartum oestrus: The rainy season began in June and continued till September. The highest total rainfall occurred during July (Table 1). It is generally accepted that heavy rainfall makes the environment cool as an immediate effect and more green fodder availability as a long-term effect. Both conditions are considered to be favourable for reproductive activity in buffalo (Roy and Prakash 2007). This study too showed that there was a positive correlation between rainfall and monthly postpartum oestrus incidence ($r = 0.08$), indicating that rainfall had both immediate and continuous effect on ovarian activity and oestrus expression. The present study also showed that during rainy season postpartum buffalo initiated early exhibition of oestrus. As a result, the percentage of buffalo that came to oestrus was gradually increased and maintained at higher percentage for few months after the cessation of rainy season. The results are in consonance with the findings of an early report by Sule *et al.* (2001).

Month and season of calving on calving to first oestrus and conception interval: The mean intervals from calving to first oestrus for buffalo which calved in different months and seasons have been presented in Table 2. The minimum interval from calving to first oestrus was 55.26 ± 3.65 days for buffalo that calved in September and was maximum (161.39 ± 9.04 days) for those who calved in March. The interval from calving to first oestrus was significantly

($P < 0.05$) shorter in monsoon and post-monsoon calvers than in winter and summer calvers. El-Wishy (2007) reviewed the results of previous studies on the influence of season of calving on postpartum acyclicity and postpartum anoestrous period in buffalo and observed these to be rather conflicting.

The mean interval from calving to conception for buffalo which calved in different months and seasons has been presented in Table 2. With respect to season, the conception interval was significantly shorter ($P < 0.05$) in monsoon calvers as compared to their summer calving counterparts. In contrast, a nonsignificant difference was observed between winter and post-monsoon calving buffalo. Ribeiro *et al.* (2003) also observed that there was a significant effect of season and month of calving on calving to conception interval in buffalo. Buffalo that calved in June had longest interval while those who calved in April had shortest interval. It appears that ambient air temperature affects the conception rate in buffaloes. Summer stress reduces the quality of oocytes and the activity of the corpus luteum of pregnancy (Shehab-El-Deen *et al.* 2007). It was found that the intra-uterine environment was compromised in heat stressed cows and there was a decrease in blood flow and an increase in uterine temperature (Ealy *et al.* 1993). These changes can increase early embryonic loss and reduce the success rate of inseminations in summer.

Effect of parity on calving to first oestrus and conception interval: The mean interval from calving to first oestrus for buffalo with different parity order are presented in Table 3. Present study showed that buffalo in first parity had a long interval from calving to first oestrus. Similarly, Devaraj and Janakiraman (1986) reported that buffalo in the first three parities had significantly longer ($P < 0.05$) interval from calving to first oestrus (92.2 ± 2.6 days) as compared to those in fourth to sixth parity (72.2 ± 3.0 days) and seventh to ninth parity (64.9 ± 2.9 days). However, the interval from calving to first oestrus was not significantly different between buffaloes in the first three parities and those in the tenth or more parity. This was due to the fewer number of observations and higher error of variation for buffalo which were in the tenth parity or more. The current investigation also indicated that there was a significant decrease in the interval from calving to first oestrus with increased parity order ($r = -0.24$). Suthar and Kavani (1992) found a highly significant difference in calving to first oestrus between parities with longest interval for animals in third parity and shortest for those in ninth parity. The role of parity order on the interval from calving to first oestrus in buffalo is not clear. However, poor detection of oestrus caused by low attention on buffalo with first parity as they produce low milk could be one of reasons to have comparatively longer intervals.

Like oestrus expression, the mean interval from calving to conception for buffalo with different parity also reflected a similar response (Table 3). The longest interval was

Table 2. Calving to first oestrus interval and calving to conception interval across the month and season of calving in postpartum Murrah buffalo (mean $\pm$ SE)

Season and month	Calving to first oestrus interval (days)	Calving to conception interval (days)
Winter	120.60 ± 7.43^a (106)	167.72 ± 11.58^c (101)
December	88.28 ± 10.87 (44)	138.97 ± 17.33 (39)
January	128.0 ± 15.89 (27)	195.48 ± 28.74 (27)
February	150.91 ± 10.47 (35)	178.34 ± 15.10 (35)
Pre-monsoon (summer)	117.94 ± 4.62^a (141)	180.48 ± 16.78^{ac} (141)
March	161.39 ± 9.04 (36)	269.53 ± 44.28 (36)
April	107.41 ± 7.01 (46)	171.35 ± 29.15 (46)
May	99.63 ± 5.99 (59)	133.25 ± 16.27 (59)
Monsoon	68.09 ± 1.74^b (447)	113.00 ± 6.12^{bc} (446)
June	80.70 ± 3.80 (93)	106.23 ± 9.75 (93)
July	75.63 ± 3.65 (115)	101.08 ± 8.26 (115)
August	63.08 ± 2.52 (131)	113.67 ± 12.09 (130)
September	55.26 ± 3.65 (108)	130.72 ± 16.72 (108)
Post-monsoon	72.88 ± 3.84^b (154)	155.62 ± 14.10^c (153)
October	74.62 ± 4.39 (111)	169.66 ± 18.32 (111)
November	68.26 ± 7.84 (43)	118.52 ± 16.12 (42)

^{a-c}Means within a column with different superscripts differ ($P < 0.05$); figures in parentheses represent the number of observations.

Table 3. Calving to first oestrus interval and calving to conception interval across the parity order in postpartum Murrah buffalo (mean $\pm$ SE)

Parity order	Calving to first oestrus interval (days)	Calving to conception interval (days)
1	103.80 $\pm$ 4.36 (218)	209.36 $\pm$ 14.29 (217)
2	89.77 $\pm$ 4.27 (174)	121.06 $\pm$ 8.07 (172)
3	76.24 $\pm$ 4.06 (133)	127.21 $\pm$ 13.01 (130)
Overall for parity 1–3	92.24 $\pm$ 2.56 ^a (525)	159.52 $\pm$ 7.53 ^a (519)
4	75.63 $\pm$ 4.93 (89)	124.41 $\pm$ 12.71 (89)
5	70.40 $\pm$ 4.86 (65)	101.22 $\pm$ 11.34 (64)
6	68.47 $\pm$ 5.94 (51)	123.06 $\pm$ 21.71 (51)
Overall for parity 4–6	72.17 $\pm$ 3.01 ^{bc} (205)	116.68 $\pm$ 8.51 ^{ac} (204)
7	62.81 $\pm$ 4.11 (43)	100.05 $\pm$ 16.86 (43)
8	68.19 $\pm$ 6.19 (32)	82.47 $\pm$ 11.03 (32)
9	64.50 $\pm$ 4.79 (26)	72.65 $\pm$ 9.68 (26)
Overall for parity 7–9	64.95 $\pm$ 2.88 ^{bcd} (101)	87.43 $\pm$ 8.37 ^{acd} (101)
10	74.50 $\pm$ 9.83 (14)	74.50 $\pm$ 9.83 (14)
11	43.00 $\pm$ 14.01 (3)	43.00 $\pm$ 14.01 (3)
Overall for parity $\leq$ 10	68.94 $\pm$ 8.83 ^{acd} (17)	68.94 $\pm$ 8.83 ^{bcd} (17)
Correlation with parity	- 0.24	- 0.23

^{a-d}Means within a column with different superscripts differ ($P < 0.05$); figures in parentheses represent the number of observations.

recorded for buffalo in first lactation and the shortest in eleventh lactation. Hussain (2007) also observed a similar trend in buffaloes with average calving to conception interval of 226.3, 182.7 and 148.7 days in first, second and third parity, respectively. Generally, first lactation yield is less compared to other lactation yields in bovines. The general hypothesis is that when the milk yield is lower the fertility is higher, cannot be valid for buffalo in first lactation as they have long intervals from calving to oestrus and conception. However, this study showed that there was an inverse relationship between parity order and interval from calving to conception ($r = -0.23$). Decline in length and yield of lactation with increasing age and well-set adaptation of the reproductive tract to the process of pregnancy in later lactations could be the possible reasons for this association (Ribeiro *et al.* 2003). In genetic selection procedures for breeding purpose, animals with regular calvings are usually kept in order to obtain optimum number of lactations, which might be another possible reason that old animals had shorter interval from calving to conception.

Effect of lactation yield on calving to first oestrus and conception interval: The mean interval from calving to first oestrus for buffalo with different lactation yields have been

Table 4. Calving to first oestrus interval and calving to conception interval across the lactation yield in postpartum Murrah buffalo (mean $\pm$ SD)

Lactation yield (kg)	Calving to first oestrus interval (days)	Calving to conception interval (days)
$\leq$ 1000	64.75 $\pm$ 2.64 ^{bdf} (190)	74.77 $\pm$ 5.18 ^{bdf} (190)
1001 – 2000	84.29 $\pm$ 2.51 ^{ade} (445)	141.06 $\pm$ 7.46 ^{ace} (445)
2001 – 3000	100.70 $\pm$ 4.41 ^{ac} (187)	186.48 $\pm$ 12.78 ^{ac} (187)
> 3000	119.89 $\pm$ 10.64 ^a (19)	249.79 $\pm$ 40.69 ^a (19)
Correlation with lactation yield	0.27	0.30

^{a-f}Means within a column with different superscripts differ ($P < 0.05$); figures in parentheses represent the number of observations.

presented in Table 4. Results depict that calving to first oestrus interval was positively correlated with lactation yield. Buffaloes that produced $\leq$ 1000 kg of milk per lactation had shortest interval and that produced >3000 kg of milk per lactation had longest interval. Qureshi *et al.* (1999) also identified a positive relationship between certain postpartum reproductive parameters and milk production.

Regarding calving to conception interval with different lactation yields, buffalo that produced $\leq$ 1000 kg of milk per lactation had significantly ($P < 0.05$) shorter interval as compared to that produced >3000 kg of milk per lactation. This established a positive relationship between milk yield and calving to conception interval. Further, it was found that summer calvers had longest interval from calving to conception and lowest lactation yield compared to their counterparts. High milk production and excellent fertility contribute to the profitability of dairy cattle and buffalo. Although reproductive performance of high milk producing cows has been considered to be low (Singh and Brar 2008) there is evidence that fertility is not essentially impaired in high yielding animals (Windig *et al.* 2005).

Retrospective analysis of farm records and climatic data revealed that even though buffalo calved and exhibited postpartum oestrus throughout the year, pattern variation in postpartum oestrus incidence could be due to seasonal changes in climatic factors. Different climatic factors either alone or in combination had direct or indirect effect on ovarian activity and expression of oestrus affecting postpartum intervals from calving to oestrus and conception. More studies are clearly required on the regulatory role of these factors on postpartum buffalo reproduction.

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