



Seasonal patterns of reproduction and production in Nili-Ravi buffaloes

M H JAN*, S KUMAR, A GUPTA, K L MEHRARA and R MEHTA

ICAR–Central Institute for Research on Buffaloes, Sub-Campus Nabha, Punjab 147 201 India

Received: 05 July 2019; Accepted: 15 November 2019

ABSTRACT

Records of Nili-Ravi buffalo maintained at ICAR-Central Institute for Research on Buffaloes, sub-campus Nabha for the period 2009–2018, were analysed with the aim to study the effect of season on various reproductive and productive parameters. Seasons were categorized as follows: winter –Nov. to Feb.; summer – Mar. to Jun.; and rainy – Jul. to Oct. The average temperature ranged from as high as 32.3°C in summer to as low as 18.4°C in winter. The average humidity ranged from as low as 28.2% in summer to as high as 52.8% in rainy season. Data of 4,203 estruses during this period revealed significant effect on estrus expression with lower expression in summer, and highest during winter. A significant reduction in estrus detection efficiency during summer and rainy seasons as compared to winter was recorded. The conception rate was significantly higher during winter as compared to summer and rainy season. During this period, 1,398 calvings were recorded. It was observed that buffaloes that calved in summer tended to have highest calving to first service interval as well as service period (135 and 167 d, respectively) and lowest in rainy season (78 and 114 d, respectively). The wet and herd averages were significantly higher in winter as compared to summer and rainy. Animals that calved in rainy season had significantly lower lactation length (299±13 d) as compared to summer (373±13 d) and winter (320±17 d). It may be concluded that high temperature and humidity during summer and rainy season exert negative effect on reproductive and productive performance in Nili-Ravi buffaloes.

Keywords: Buffalo, Conception rate, Milk yield, Season, Service period

Buffalo (*Bubalus bubalis*) is an important livestock resource, occupying a critical niche in many agricultural systems, providing milk, meat and work power (Gasparrini 2002). Buffalo is ideal in low-input production systems due to good feed conversion efficiency and relatively low maintenance requirements (Paul *et al.* 2002). Buffalo is a thrifty, versatile, adaptable and productive animal which has drawn national and international attention in the last few decades. The enhanced interest in this species is evident by the popularization of buffalo farming in Mediterranean area, Latin America and Central/Northern Europe (Barile 2005). Despite having high potential, productive and reproductive performance of buffaloes is limited owing to various inherent problems like delayed sexual maturity, silent estrus, reproductive seasonality, problems of heat detection, low conception rate, high thermal and lactation stress, postpartum anestrus and longer intercalving intervals (Singh *et al.* 2000, Nanda *et al.* 2003, Das and Khan 2010).

A prominent factor causing reduced production potential is the seasonality in the pattern of reproductive activity (Barile 2005). The seasonality of performance traits is attributed more due to environmental factors (photoperiods, temperature, relative humidity and rainfall) compared to genetic factors (Das and Khan 2010). The period of day length was negatively correlated with the number of buffalo

expressing estrus and the short periods of artificial darkness reduced the problem of anestrus during long day length (Singh *et al.* 2000). During summer anoestrus, although one or more ovulatory size follicles develop, the follicles fail to ovulate due to endocrine insufficiencies (Ghuman *et al.* 2010). The percentage of buffalo exhibiting anestrus during summer varies between 36.6% and 59.4% (Das and Khan 2010). In fact, seasonal breeding is a survival strategy adopted by many mammals to ensure that their progeny are born at the time of the mildest weather and maximal food availability during the early part of the offspring's life (Wood *et al.* 2006). However, buffalo that calve during the non-breeding season have an extended postpartum anestrus period with a proportion not resuming cyclicity until the following breeding season.

The review of available literature suggests there is no comprehensive study (involving large population over long period of time) on seasonal patterns of reproduction and production in buffalo especially Nili-Ravi buffalo in India. Therefore, the main objective of this study is to analyse seasonality of breeding and productive performance of Nili-Ravi buffalo maintained in an organized herd on the basis of data collected for a decade from 2009 to 2018.

MATERIALS AND METHODS

A herd of Nili-Ravi buffalo is maintained at the Central

*Corresponding author e-mail: mhjan.ivri@gmail.com

Institute for Research on Buffaloes, Sub-Campus, Nabha (Pb), India. The buffaloes were maintained under an intensive system of management, and their nutrient requirements were met as per standard. Data on 1,398 calvings and 4,203 estruses/inseminations of Nili-Ravi buffaloes over a period of 10 years, from 2009 to 2018, were used for this study.

Table 1. Monthly temperatures (mean, max and min, °C), mean relative humidity (RH%), and mean temperature–humidity index (THI%) during the study period (from 2009 to 2018) in Nabha (Pb.)

Month	Temperature (°C)			Mean RH%	Mean THI%	Rainfall (mm)	Sun (h)
	Avg.	Max.	Min.				
Jan.	14.6	22.0	8.9	54.9	58.2	28.7	222.4
Feb.	17.5	25.1	11.2	55.3	62.2	43.6	266.8
Mar.	23.5	31.9	16.0	41.0	69.0	24.1	299.2
Apr.	31.2	38.8	23.9	24.4	75.6	15.4	335.8
May	36.7	43.3	30.0	19.5	80.3	25.7	385.0
Jun.	37.7	43.3	31.8	27.9	83.3	45.8	367.5
Jul.	34.6	39.8	29.8	47.8	83.9	177.5	358.6
Aug.	31.9	36.8	25.8	65.8	83.5	203.7	343.9
Sep.	30.6	36.2	24.9	61.0	80.8	178.4	282.4
Oct.	29.1	35.8	22.9	36.8	75.2	7.5	254.4
Nov.	23.9	30.1	18.2	29.3	68.4	1.4	221.6
Dec.	17.7	24.7	12.4	37.0	61.8	10.0	227.4

The meteorological data during the period of study (2009–2018) was retrieved from World weather online (<https://www.worldweatheronline.com/>). The monthly average of temperature (°C), sunhours (hr), rainfall (mm) and humidity (%) were recorded (Table 1). The temperature humidity index (THI) was calculated by below equation (Kendall and Webster 2009).

$$THI = (1.8 AT + 32) - [(0.55 - 0.0055 RH) \times (1.8 AT - 26)]$$

where AT, mean Air temperature; RH, Relative humidity.

Keeping in view the climatological data, the year was divided into three seasons: winter (November to February),

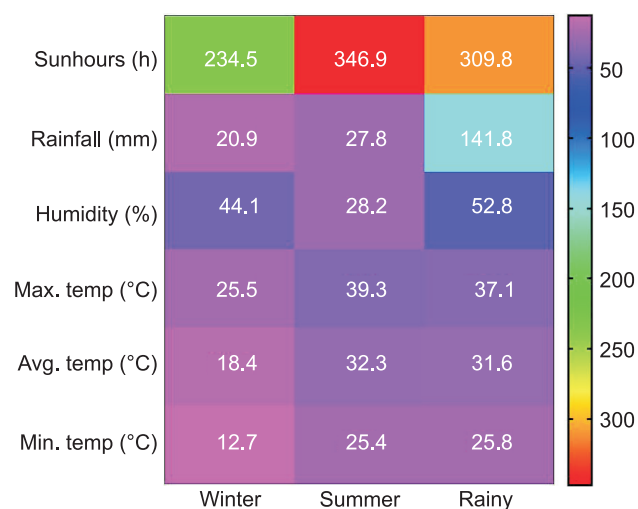


Fig. 1. Average meteorological data across seasons during the period of study (2009–2018).

summer (March to June) and Rainy (July to October) (Fig. 1).

Reproduction parameters

1. *Calving to first service interval*: It is defined as time period (in days) from date of calving to date of first service.
2. *Calving to conception interval/ Service period (SP)*: It is defined as time period (in days) from date of calving to date of successful conception.
3. *Conception rate (CR)*: Conception rate is a measure of a cow's fertility at service. It is calculated by dividing the number of pregnant cows by the total number of inseminations.
4. *Estrus detection efficiency (EDE)*: Estrus detection efficiency is ability of estrus detection procedures adopted in a herd to correctly identify animals in estrus. EDE takes into account percentage distribution of the interestrus/ interservice intervals, and is calculated as per formula described by Parkinson and Barrett (2009).

$$EDE = \frac{b + d}{a + b + c + 2(d + e)} \times 100$$

a, number of interestrus intervals of 2–17 days duration;
b, number of interestrus intervals of 18–24 days duration;
c, number of interestrus intervals of 25–35 days duration;
d, number of interestrus intervals of 36–48 days duration;
e, number of interestrus intervals of more than 48 days duration

Production parameters

1. *Lactation length (LL)*: Lactation length is defined as time period (in days) after calving during which animal produced milk, i.e. time from day of calving to day of drying.
2. *Wet average (WA)*: Wet average is quantity of milk produced on a weekly test day divided by number of lactating animals
3. *Herd average (HA)*: Herd average is quantity of milk produced on a weekly test day divided by number of breedable buffaloes in herd (including both lactating and dry buffaloes).

Statistical analysis: The post calving parameters like calving to first service, service period, services per conception and lactation length were derived based on season of calving, whereas estrus detection efficiency and conception rate on the basis of season of recording. The effect of season on productive and reproductive parameters was analysed by One-way ANOVA followed by post-hoc comparison using Duncan's Multiple range test. Fertility parameters, viz. calving to first estrus and calving to conception periods, were analysed using Kaplan–Meier survival curve analysis, and median values were compared using log rank (Mantel-Cox) test. For calving to first service interval, censoring was considered, when buffaloes died, were culled or not observed in estrus within 200 days of

Table 2. Effect of season on estrus expression and outcome of artificial insemination in Nili-Ravi buffaloes.

Season	Max. Temp (°C)	Humidity (%)	Rainfall (mm)	N	Buffaloes in estrus (%)	Estrus detection efficiency (%)	Conception rate (%)	Number of services per conception
Winter	25.58±0.55	44.13±2.24	20.91±5.18	1747	41.57±3.26 ^c	55.4±3.95 ^b	44.76±1.36 ^b	2.1±0.3
Summer	39.33±0.81	28.20±1.90	27.77±4.98	1111	26.43±1.62 ^a	42.6±2.18 ^a	35.17±2.41 ^a	2.9±0.4
Rainy	37.15±0.46	52.85±2.72	141.78±27.22	1345	32.23±3.38 ^b	44.6±3.11 ^a	36.63±2.62 ^a	2.6±0.3

Different superscripts (a,b,...) indicate significant ($P < 0.05$) difference.

calving. For calving to conception interval, censoring was considered, when buffaloes died, were culled before conception. The conception rate was analysed using Chi-square test. A P -value ≤ 0.05 was considered significant, and $0.05 < P < 0.1$ was considered to indicate a tendency toward significance. The graphs were designed by Graphpad Prism 8.0.1 (GraphPad Software, Inc., San Diego, CA).

RESULTS AND DISCUSSION

Reproductive performance: The present study revealed that Nili-Ravi buffaloes express estrus mostly during winter (41.57%) followed by rainy (32.23%) and summer (26.43%) season. The difference in per cent buffaloes expressing estrus across different seasons was significant ($P < 0.05$). In addition, the estrus detection efficiency (%) was significantly ($P < 0.05$) higher during winter (55.4%) as compared to summer (42.6%) and rainy (42.6%) seasons (Table 2). Buffaloes show low reproductive activity during summer, when intensity of solar radiation is high and duration of sunshine is more (Upadhyay *et al.* 2012, Ghuman and Dharmi 2017). Abayawansa *et al.* (2011) reported negative correlation between monthly postpartum estrus incidences and mean maximum air temperature, suggesting suppressive effect of high ambient temperature on ovarian activity and estrus expression. A recent study also observed that maximum percentage of buffaloes exhibit estrous in the month of November and December whereas, minimum during March and May (Gunwant *et al.* 2018). During periods of greater ambient temperature, the duration of estrus may be shorter and the estrual signs are exhibited only during the night or early morning, which are mostly missed by owners (Perera 2011). In addition, hyperprolactinemia, poor follicular growth, poor availability of green fodder, reduced voluntary intake associated with thermal stress due to high THI is also a cause of subestrus (Phogat *et al.* 2016). Visual observations of signs of estrus and teaser bull are used for detection of estrus at the CIRB farm. It is believed that teaser bulls show poor libido, become sluggish and inactive due to thermal stress (Younis *et al.* 2003). The estrus detection efficiency not only influences the calving pattern but also has an impact on the economics of dairy enterprise (Burke *et al.* 2008). Their economic model predicted that, for a 400-cow herd, there is a benefit of ~US\$695 for every 1% increase in EDE.

Higher incidence of estrus during winter combined with high estrus detection efficiency means maximum

inseminations and greater conception rate during winter and consequently more calvings during rainy season (September and October), (Hassan *et al.* 2007). The maximum conception rate was observed in winter and least in summer (44.76% vs. 35.17%) (Table 2). High temperature humidity index predisposes water buffaloes to develop oxidative stress characterized by modulation of estrous cycle and uterine environment causing defective embryo development, reproductive failure and prolongation of the postpartum anestrus in buffaloes (Megahed *et al.* 2008, Tucker *et al.* 2008). It is believed that buffaloes tend to express peak breeding activity during October and November, when the chances of fertilization or fertility rate at first service is better than the average first service conception rate (FSCR). Buffaloes took numerically more number of services per conception during summer as compared to winter and rainy season, although the difference was not statistically significant ($P > 0.05$, Table 2). In a recent study, the overall pregnancy rate of Murrah buffaloes was in a range of 25 to 33% from April to September and higher pregnancy rate was obtained in a range of 38 to 58% from October to March (Dash *et al.* 2015). During a period of increasing daylight length, a lower function of the corpus luteum (CL) reduces progesterone (P_4) levels and increases embryonic mortality in buffalo cows (Campanile and Neglia 2007). In fact, it has been observed that embryonic loss in buffaloes mated by AI is

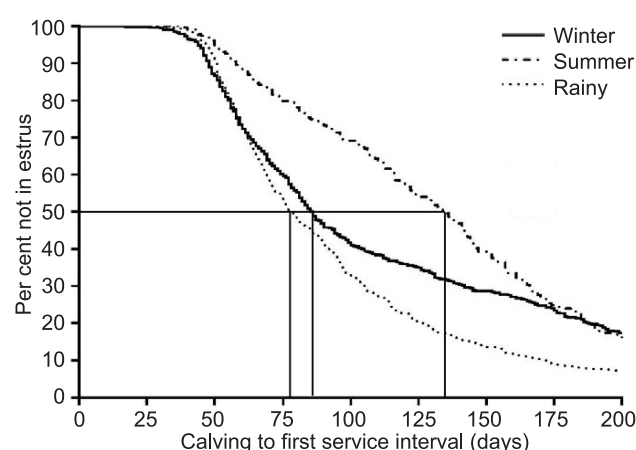


Fig. 2. Survival curves of calving to first service interval in Nili-Ravi buffaloes [winter ($n=535$); summer ($n=232$); rainy ($n=631$)]. Median days to first service were 86 (95% CI: 80.5–91.5), 135 (95% CI: 123.7–146.3) and 78 (95% CI: 73.3–82.7) in buffaloes calved during winter, summer and rainy seasons, respectively (Log-rank test; $\chi^2 = 64.21$, $P < 0.001$).

Table 3. Effect of season on milk yield/day in Nili-Ravi buffalo

Season	Max. Temp (°C)	Humidity (%)	Rainfall (mm)	Wet average (kg)	Herd average (kg)
Winter	25.48±0.55	44.13±2.24	20.91±5.18	8.53±0.13 ^b	6.20±0.10 ^c
Summer	39.33±0.81	28.20±1.90	27.77±4.98	7.69±0.14 ^a	5.40±0.16 ^b
Rainy	37.15±0.46	52.85±2.72	141.78±27.22	7.73±0.15 ^a	4.67±0.15 ^a

Different superscripts (a, b,) indicate significant ($P<0.05$) difference.

20–40% during seasons characterized by high number of light hours (Campanile *et al.* 2005). The mean number of the large follicles, diameter of the ovulatory follicle, mean diameter of mature CL and the overall pregnancy rates were higher in winter and spring than in summer and autumn (Ali 2015).

In the present study, buffaloes calved during the months of summer had the longest days to first service and service period. The median days to first service was significantly ($P<0.001$) higher for buffaloes that calved during summer (135 days) as compared to calvings during winter (86 days) and rainy (78 days) season (Fig. 2). Similarly, buffaloes that calved during summer had significantly ($P<0.05$) higher calving to conception interval (167 days) as compared to winter (144 days), which in turn had significantly ($P<0.001$) higher median days to conception than rainy (114 days) season (Fig. 3). Nili-Ravi buffaloes calved in winter had fewer days open than those calved in summer (Khan *et al.* 2009). Similarly, reports from across India suggest that buffaloes calving in late winter and early summer have lower reproductive efficiency compared to those calving during other periods (Singh and Nanda 1993, Singh *et al.* 2000) and calving during rainy or monsoon season had shorter anoestrus period than other season calvers (Tailor *et al.* 1997). Buffalo that calve during later winter and early summer had significantly delayed resumption of ovarian activity and hence delayed calving to first service interval (Singh and Nanda 1993).

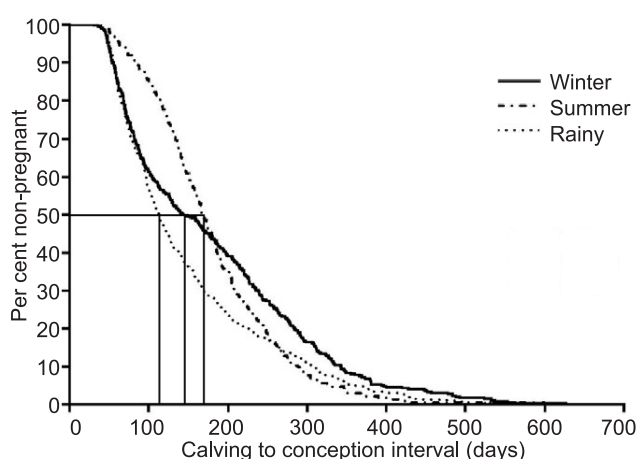


Fig. 3. Survival curves of calving to conception interval in Nili-Ravi buffaloes [winter ($n=535$); summer ($n=232$); rainy ($n=631$)]. Median days to conception were 144 (95% CI: 119.7–168.3), 167 (95% CI: 155.7–178.3) and 114 (95% CI: 106.6–121.4) in buffaloes calved during winter, summer and rainy seasons, respectively (Log-rank test; $\chi^2 = 22.15$, $P<0.001$).

Production performance: Lactation length and dry period have been shown to be affected significantly by season of birth in Egyptian buffaloes (Marai *et al.* 2009). We observed highest lactation length (373 days) in buffaloes calved during summer and least during rainy season (Fig. 4). This may be due to delayed conception and higher days open (calving to conception interval) and consequently higher calving interval in summer calvings. Although, lactation length is longer for summer calvings, milk yield especially peak yield was highest during winter seasons (Kamble *et al.* 2014). The regression values indicate that one unit increase in minimum temperature resulted decrease in lactation length by 3.99 units (Kamble *et al.* 2015). In contrast, Afzal *et al.* (2007) showed no effect of season of calving on lactation length in Nili-Ravi buffaloes.

The highest wet and herd average during winter and lowest during summer and rainy seasons were recorded (Table 3). The highest milk yield was also recorded by Pawar *et al.* (2012) in animals calving in winter season followed by rainy and summer season. A decline in milk yield as a direct result of high environmental temperature resulting in lower milk yield during summer than spring and winter in buffalo was recorded (Marai *et al.* 2009). Bouraoui *et al.* (2002) observed that increase in THI value

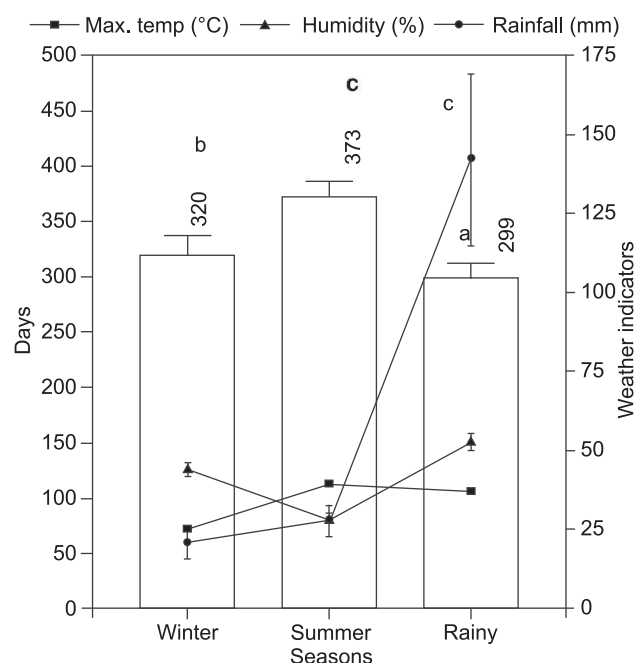


Fig. 4. Effect of season of calving on lactation lengths (days) in Nili-Ravi buffalo.

from 68 to 78 resulted in milk production decrease by 21%. Less availability of nutritious fodder, low nutrient intake, high metabolic pressure to dissipate heat and to maintain body temperature during summer influences the physiological functions of lactating animals and affects not only their milk production but also the efficiency of production, in turn, buffalo profitability (Seerapu *et al.* 2015).

In conclusion, the results demonstrate a seasonal pattern in productive and reproductive performance of Nili-Ravi buffaloes. The above observations are of considerable practical significance for the managers of buffalo farms. The breeding activity should be synchronized in such a way that majority of buffaloes calve during the months of late rainy to early winter season. Various strategies like environmental modification, nutritional, breeding and suckling management, and hormonal therapies have been tried with varying degree of success. The provision of shade, loose housing system and water sprinkling or providing wallowing facilities during hotter part of the day and artificial darkness can help in alleviating the adverse effects of heat stress on buffalo fertility.

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