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RESEARCH ARTICLE

Environmental Factors Affecting Productive Traits and their Trends in Nili-Ravi Buffaloes

Muhammad Khalid Bashir[1,*], Muhammad Sajjad Khan[2], Muhammad Lateef[2], Muhammad Iqbal Mustafa[2], Muhammad Farooq Khalid[1] Shahid-ur-Rehman[2] and Umar Farooq[1]
[1]Sub Campus Toba Tek Singh, University of Agriculture, Faisalabad, Pakistan
[2]Faculty of Animal Husbandry, University of Agriculture, Faisalabad, 38040, Pakistan

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***Corresponding Author:**
khalidbashir@hotmail.com

ABSTRACT

The objective of the study was to determine the environmental factors affecting the productive traits of Nili-Ravi buffalo. Data on 9003 lactation records kept at four Government livestock farms in Punjab province of Pakistan were used to study the effect of environmental factors on productive traits of Nili-Ravi buffaloes. The productive traits were analyzed by the model included herd-year, season of calving and within parity age classes along with lactation length as covariate. Average total milk yield, lactation length and dry period were 1840±08 kg, 278±1 days and 258±2 days, respectively. The herd-year of calving, season of calving (birth) and parity significantly affected milk yield, lactation length and dry period ($P<0.05$). Overall phenotypic trend in milk yield during 1971-2000 was slightly negative (-0.7 liter per year) but there was a wide variation (-25 to 9 liter) among herds and dry period increased by 0.5 days per year, respectively. Phenotypic trend of lactation length was observed same during this period. Productive traits under study affected by herd, year of calving, season of calving and parity. Appropriate data recording is utmost needed for the productive traits i.e. milk yield, lactation length and dry period in order to Improve productivity of buffaloes in future.

INTRODUCTION

The buffalo of Pakistan belongs to the genus *Bubalus bubalis*. It is river type and thrives well in irrigated areas where it has an easy access to water and plenty of green fodder. Pakistan ranks second in the world in buffalo population with an average annual growth rate of 2.5 percent (FAO, 2004). Buffaloes are the main dairy animals in the country and supply about 75 percent of the milk produced. Nili, Ravi, Nili-Ravi (Punjab), Kundi (Sindh) and Azi Khali (NWFP) are the five breeds found in Pakistan. The buffalo population consists mainly of the Nili-Ravi and Kundi breeds. Nili-Ravi buffaloes are 34% of the population while Kundi are 21%. Under the commercial setup average lactation yield of buffalo is about 2500 liters with 6.5 percent fat (Khan, 2001).

Buffalo not only contribute 75 percent of 28.624 million tons of milk produced in the country but also supply 50 percent of the beef produced in the country (GOP, 2004). Buffalo milk is preferred over cow's milk because of higher butter fat percentage (6.7% vs o 4.3%). Buffalo meat is categorized as lean meat and is the cheapest in the term of price structure as compared to mutton and fish. Regarding the draft ability, the buffalo bullock has better traction power, greater stamina and is more docile and better suited for work in deep mud of rice fields and swamp areas (Salah-ud-Din, 1989). Thus buffalo play an important role in the national economy by providing milk, meat and draft power.

The Nili-Ravi buffaloes are high producing dairy animals. The lifetime profitability of buffaloes depends on production per lactation, dry period and lactation length with combination of some reproductive traits. The performance traits of buffaloes are influenced by several environmental factors like year and season of calving, age of animal at calving, lactation number and lactation length. The true genetic merit of the animals may be masked by these factors. The study of environmental factors affecting performance traits of Nili-Ravi buffaloes is therefore very important for genetic evaluations of animals, developing breeding and general management strategies/programs.

In Egyptian buffaloes, lactation milk yield ranged from 1078±36 to 1511±71 kg (Mohamed et al., 1993; Ayyat et al., 1996). Average lactation milk yield in Iraqi buffaloes ranged between 1220±56 to 1497±95 kg. Using the Animal Model procedures for the genetic evaluation, Pilla and Moioli (1992) reported averaged lactation milk yield of 1963.0±3.36 kg in Italian buffaloes. Maximum lactation milk yield (2286.8±4.76 kg) in Italian buffaloes has been reported by Rosati and Van Vleck (1998).

Limited research has been done in the past to evaluate the environmental factors affecting the performance of Nili-Ravi buffalo in Pakistan evaluated performance of Nili-Ravi breed at two institutional herds for 1951 - 1978 and reported that herd, year and season of calving and parity affected (P<0.01) some productive and reproductive traits (milk yield, lactation length, days open, calving interval and services per conception) along with the genetic parameters (Cady et al., 1983). Later, buffaloes maintained at one of the main Military Farm at Okara evaluated for genetic and non-genetic factors (herd, year, season of calving) affecting various performance traits (Salah-ud-Din, 1989). Most other studies on productive performance of Nili-Ravi buffalo (Khan, 1986; Khan, 1997) pertain to Livestock Production Research Institute, Bahdurnagar, District Okara, Pakistan.

Data on pedigree and performance records of Nili-Ravi buffaloes from four Livestock Experiment Stations in Punjab namely Livestock Experiment Station Haroonabad, from 1979-2000; Livestock Experiment Station, Chak Katora, from 1971-2000; Livestock Experiment Station, Khushab, from 1979-2000 and Livestock Production Research Institute Bahadarnagar, from 1971-2000, were utilized

It was planned to identify environmental sources of variation in productive traits and to estimate their phenotypic trends in Nili-Ravi buffaloes kept at four livestock experiment stations in Punjab province of Pakistan.

MATERIALS AND METHODS

Source of data

Data on 9003 lactation records of Nili-Ravi buffaloes from four Livestock Experiment Stations of Punjab, Pakistan namely Livestock Experiment Station, Haroonabad, (LESHA) District Bahawalnagar for (1979-2000); Livestock Experiment Station, Chak Katora, (LESCK) District Bahawalpur for (1971-2000); Livestock Experiment Station, Khushab (LESKH) for (1979-2000) and Livestock Production Research Institute Bahadurnagar, (LPRIBN) District Okara for (1971-2000) in Punjab Province of Pakistan were utilized for the present study.

The LESHA farm is situated in District Bahawalnagar. The area of the farm is generally sandy. The LESCK is situated at 110 km from Bahawalpur. The area belongs to sandy desert in the district Bhawalpur. The LESKH farm is 5 km from Khushab city. District Khushab comprises mainly of hills, plateaus, plains and deserts with river Jhelum flowing on its East. Some of the areas of Tehsil Khushab are low lying and get flooded in rainy season. The soil is sandy (alluvial sedimentation of sand mass), the surface is undulating with sand ridges. At all three farms (LESHA, KESCK and LESKH) the average rainfall ranges from 0- 71 mm in summer and dry to 18 mm in winter. The temperature ranges from 1.5 in winter to 45 °C in summer. The LPRIBN, is 17 km northwest of Okara city. The area is canal irrigated with loamy soil. The climate is relatively dry and gets rain usually during the months of July – September. During summer, day time temperature may go as high as 50 °C in summer and fall as low as 0 °C in winter. Data of 2050 buffaloes for 9003 were collected on date of calving, sire's date of birth, date of drying, dam's date of birth, date of disposal, date of service, number of services per conception and lactation milk yield. The phenotypic traits were lactation milk yield, lactation length and dry period. Data on milk yield was based upon actual weekly milk records. Lactations shorter than 60 days were excluded (5.23 %). In addition to the basic edits of consistency checks for dates and animal's identities, records of buffaloes that had aborted, missed a year due to sickness or other reasons were eliminated as described by Cady et al. (1983).

Data were analyzed to evaluate the influence of different environmental factors i.e. herd, year and season of birth/calving and age at first calving/age code etc on different productive and reproductive traits. The calving months were grouped into four seasons: winter (December to February); spring (March to May); summer (June to August) and autumn (September to November), (Dahlin, 1998).

Season was fitted as a separate fixed effect along with the herd-year (Dahlin, 1998). Preliminary analysis showed no appreciable difference (R^2 varied by 0.02 to 0.06 % for various traits) between model with herd-year-season and herd-year and season as separate fixed effects. Thus, herd-year was chosen instead of herd-year-season which otherwise may have been more appropriate.

The following statistical model was used for yield traits

$$Y_{ijkl} = \mu + HY_i + SOC_j + Age_k + b_1(DIM)_{ijkl} + e_{ijkl}$$

Where,

Y_{ijkl} = Individual observation for any trait

μ = Population mean

HY_i = Fixed effect of herd-year (1-104)

SOC_j = Season of calving (1-4) winter: 1; spring: 2; summer: 3 and autumn: 4

Age_k = Age code (1-30), similar to Iqbal (1996)
$b_1(DIM)_{ijkl}$ = Days in milk as a covariate
e_{ijkl} = Random error associated with each observation
For the analysis of lactation length, the above model was used with milk yield as a covariate (Talbott et al., 1997). For the ≤ 5 lactations and all lactation records, the parity was used as fixed effect instead of age code. To get solutions across herds, for year of calving, season of calving or parities, the above model was modified accordingly.
For the analysis of reproductive traits, age was replaced with parity. For the age at first calving, however, only herd-year and season of birth were included in the model. Analyses were performed using SAS/STAT®, (1998).

RESULTS AND DISCUSSION

Lactation milk yield

Average milk yield increased with parity, peaked in the third lactation and declined in the later parities (Table 1). The overall milk yield averaged 1840±0.8 kg. Herd average milk yield was maximum (2145±12.6 kg) for LPRIBN and minimum (1355±15 kg) for LESKH (Table 2). Overall phenotypic trend in milk yield during 1971-2000 was slightly negative (-0.7 liter per year) but there was a wide variation among herds (Figure 1) and ranged from -25 (in LESCK) to 9 liter (in LESHA). The herd-year effect was the most important fixed effect for all lactation yield traits and significantly ($P<0.01$) affected the total milk yield.
Season of calving also had a significant effect on total milk yield. Analysis of individual parities, however, it was revealed that season of calving did not reach statistical significance for the 5th parity. Maximum milk yield (1865±15 kg) was observed in winter calvers, followed by spring (1803±18 kg), autumn (1761±12 kg) and summer calvers (1745±13 kg) (Figure 2). The total milk yield was 1812±17 kg in first calvers, was maximum (1910±18 kg) in 3rd parity and then declined gradually (Figure 3).
The total lactation milk yield of buffaloes at LPRIBN was similar to earlier studies on Nili-Ravi breed (Cady et al., 1983; Khan, 1998; Naqvi and Shami, 1999) where the total milk yield was 1883±60 and 2083±33 kg. Naqvi and Shami (1999) reported an average total milk yield of 1873 kg for Nili-Ravi buffalo breed at six Military Dairy Farms. Average 305-day milk yield reported by Hussain et al. (2006) was 2191.85±35.55 kg in Azad Kashmir however the number of record was low (376). The total milk yield of Nili-Ravi at LESKH is the lowest (1355 kg) reported for any institutional herds in Pakistan. In Indian Murrah buffaloes, average milk yield was 1863.0±11.5 kg. In Italian buffaloes this figure was 2286.8±4.5 kg (Rosati and Van Vleck, 1998). Total milk yield in Egyptian buffaloes is 1510.6±71.23 kg (Ayyat et al., 1996).
Phenotypic trend for total milk yield observed in the present study was similer to earlier report for LPRIBN (Cady et al., 1983; Khan et al., 1991). Lactation milk yield increased (Cady et al., 1983) from 1954 to 1969; declined from 1970 to 1977 resulting in no improvement over the years. In Iraqi buffaloes milk yield showed a slight decreasing trend in different years (1967-1988) (Juma et al., 1992). Rao and Rao (1996) and Patel and Tripathi (1998) observed decreasing trend in Indian buffaloes for lactation milk yield due to the year of calving. In Italian buffaloes the average milk yield has been increaseing during 1974 to 1996 (Catillo et al., 2001).
Maximum milk yield was observed for buffaloes calving in winter season (1865.5±15.4 kg) and minimum in summer (1745.3±12.6 kg). These trends were similer to the findings of Cady et al. (1983), where maximum (1915 kg) milk yield was observed in winter (October to March) and minimum (1852 kg) in summer (April to September). Khan et al. (1991) reported maximum total milk yield (2298 kg) in buffaloes calving during winter, and minimum (2086 kg) during autumn and also reported maximum (1821±23.4 kg) milk yield in winter and minimum (1712±19.8 kg) milk yield in summer calvers. Patel and Tripathi (1998) also reported maximum milk yield in the winter calvers and minimum in the autumn calvers. In Italian buffaloes milk yield was also maximum in winter (January to March) calvers and minimum in summer calvers (July to September) (Catillo et al., 2002). Previously, RoyChoudhury and Deshmukh (1975), correspondingly, had indicated that Italian buffaloes calving in September- March had more yield as compared to the calving in April-August. In Iran, Eskandari and Karimpour (2012) and Khosroshahi et al. (2011) reported that seasons were highly significant ($P<0.01$) on the milk yield. Similarly, in India, Jain et al. (1985) reported a higher yield in winter calvers. Low milk yield in summer calvers than in winter calvers may be due to depressive effect of high temperature at the debut of lactation and better availability of fodder in winter.
Most of the workers have reported that buffaloes produce more milk in the 3rd to 5th parity (Cady et al., 1983; Khan and Chadury, 2001; Afzal et al., 2007; Khalil et al., 1992; Ayyat et al., 1996: Khosroshahi et al., 2011 and Eskandari and Karimpour, 2012). Contrary reports are also available in the literature indicating that there were no differences among parities for milk production. Swain and Bhatnagar (1983), for example, reported that mean lactation yield for 2nd to 9th parities were similar in Murrah buffaloes. Different reports also indicated that age may be more precise factor to be incorporated into models for lactation milk

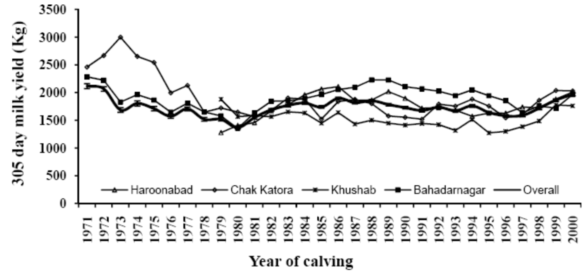

Fig. 1: 305-day milk yield in different herds during different years

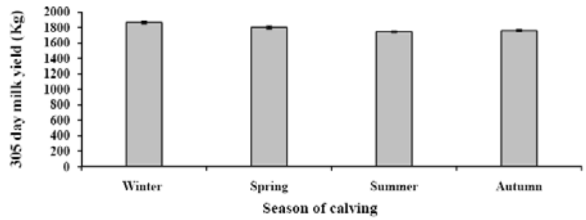

Fig. 2: 305-day milk yield in different seasons

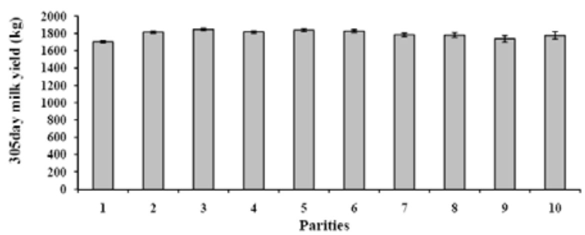

Fig. 3: 305-day milk yield in different parities

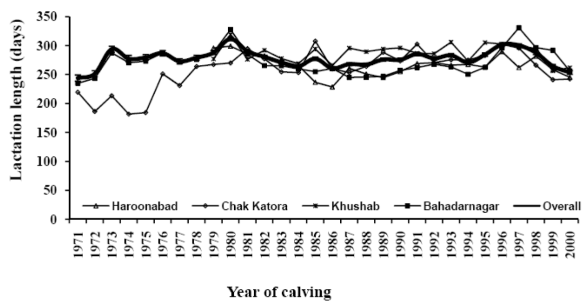

Fig. 4: Length of lactation in different herds during different years

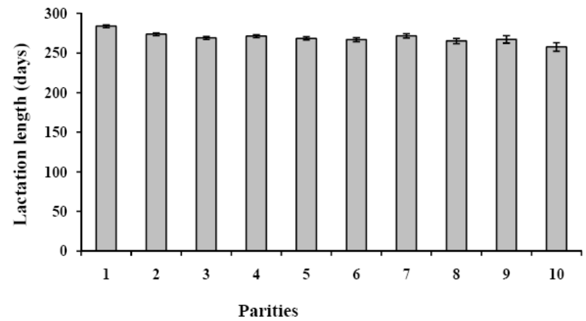

Fig. 5: Lactation length in different parities

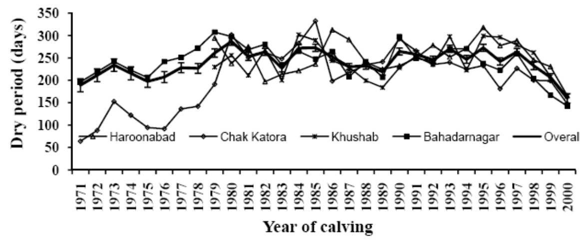

Fig. 6: Dry period in different herds during different years

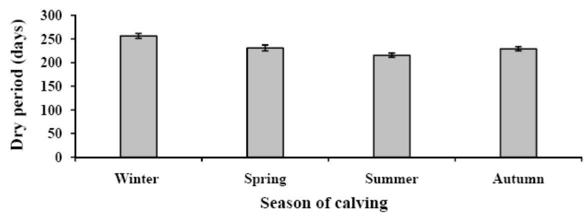

Fig. 7: Dry period in different seasons

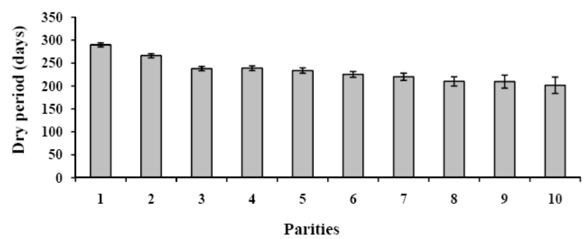

Fig. 8: Dry period in different parities

yield or both parity and age code (Cady et al., 1983; Khan et al., 1997). Attainment of physiological maturity and regularization of cyclic rhythms in reproduction after first lactation are generally attributed reasons for differences of lactation yield in first verses later parties (Tulloh and Holmes, 1992). The culling of animals which had poor production, reproduction and health standards also contribute toward better lactation yield of herd in subsequent lactations. Although, correction of records for parity depends on the amount of information recorded or available, use of parity would be a reasonable choice (Khan, 1997).

The drastic decline in milk yield in 1980 at all Government institutional herds, despite increase in lactation length, was, caused by extraordinary heavy rainfall, which completely destroyed the fodder crops, resulting in a shortage of forage (Cady et al., 1983).

Grouping of months into seasons may have been an important factor for variable lactation yield of buffaloes in different seasons. But poor lactation yield in summer season is generally due to low availability of fodder and high temperature which may goes as high as 50 °C. Grouping into fewer months (more seasons), on the other hand, has disadvantage when contemporaries are defined (Khan, 1997) Variable phenotypic trend in milk

Table 1: Performance of Nili-Ravi buffalo for various productive traits

Traits	No of observations	Mean	CV
Total lactation yield (kg)			
Parity 1	2050	1812±17	36.25
Parity 2	1797	1879±18	37.41
Parity 3	1533	1910±18	35.83
Parity 4	1192	1846±22	35.61
Parity 5	875	1855±25	35.04
Parity ≤5	7446	1859±09	36.84
All parities	9003	1840±08	37.00
Lactation length (days)			
Parity 1	2050	285±2	29.33
Parity 2	1797	283±2	28.74
Parity 3	1533	282±2	27.12
Parity 4	1192	278±2	28.05
Parity 5	875	275±3	27.58
Parity ≤5	7446	281±1	28.93
All parities	9003	278±1	29.01
Dry period (days)	7283	258±2	49.55

yield in these herds lead to conclude that environmental influences i.e. flood, draught, heavy rains, seasonal differences, type of feed, temperature, humidity and level of management. The level of management is bound to vary according to the ability of farm manager, his efficiency in supervision of staff, his system of crop husbandry methods and intensity of culling.

Lactation length

Average lactation length in this study was 278±1 day and ranged from 275 to 285 days (Table 1). Average lactation length was highest (303±1.5 days) at LPRIBN and lowest (252±2 days) at LESKH (Table 2). The overall phenotypic trend during 1971-2000 was slightly positive (0.18 days per year) but varied among the herds (Figure 4) from -0.76 (in LESHA) to 2.3 days (in LESCK).

Season of calving influenced lactation length (P<0.01), however, when parities were analyzed individually, it did not affect lactation length in 3rd, 4th and 5th parities. Maximum lactation length in the present study was observed in the autumn and summer calvers (270±2 and 271±2 days) and minimum (266±2 days) in the winter calvers. Lactation length was maximum in first calvers (283±2 days); it decreased with increase in the parity and reached to the minimum (258±5 days) in ≥10 lactations (Figure 5).

Variation in lactation length has been reported in Pakistani, Egyptian and Indian buffaloes (Cady et al., 1983; Salah-ud-Din, 1989; Metry et al., 1994; Verma and Kherde, 1995) previously. Differences in feed resources and environmental conditions are major determinants of variation among herds. Lower lactation length at LESKH is mainly due to insufficiency of fodder especially in summer season.

Lactation length of Nili-Ravi buffaloes is similar (279 day) to the previous studies (Cady et al., 1983; Afzal et al., 2007). Lactation length of 288 to 301 days in Egyptian (Metry et al., 1994; Hamed, 1994), 248-441 days in Murrah (Silva et al., 1995; Ulaganthan, 1985) and 261 to 379 days in Surti buffaloes (Tailor et al., 1992) has been reported by various workers. The phenotypic trend in lactation length in the present study (Figure 6) was near to zero (0.18 days).

Maximum lactation length in the autumn and summer calvers and minimum in the winter calvers is similar to the study of Khalil et al. (1992), who observed that spring calvers had the longest lactation period in Egyptian buffaloes. In Indian Murrah buffaloes, Dhar and Deshpande (1995) reported that the means for summer (March-June) calvers were significantly higher than for other seasons. Similar results were reported by Narasimharao and Sreemannarayana (1994) where lactation length of buffaloes calving in summer was higher (324 days) than those calving in rainy season (301 days). Urdaneta et al. (1997) reported that under dry tropical area of Venezuela, the buffaloes calved in Summer (May -August) had longer lactation duration than others. This may be due to the better availability of fodder in the later part of lactation which approaches in the winter. Level of milk production may also be an important determining factor.

Dry period

Overall mean of dry period was 258±2 days (Table 1). Maximum dry period (268±2.7 days) was observed at LPRIBN followed by LESKH (258±3.8 days), LESHA (256±4.5 days) and LESCK (241±3.5 days). Overall phenotypic trend for dry period in the present study, was slightly positive (0.5 day per year) but herds varied from -0.9 day (in LPRIBN) to 3.7 days (in LESCK) (Figure 7). Season of calving influenced dry period except for 4th parity. Maximum dry period (257±5 days) was observed in winter calvers (Figure 6). First parity buffaloes had longest dry period (290±4 days) followed by a gradual decline (Figure 8) in later parities.

Dry period is a less frequently studied trait. Herd differences have been reported for Indian (Raheja et al., 1983; Kandasamy et al., 1993) and Egyptian buffaloes (Hamed, 1994). Dutt and Taneja, 1995; Tailor et al., 1992) have been reported that dry period was different in buffaloes calving in different years. Johari and Bhat (1979) have reported shorter dry period in summer calvers, which they attributed to longer lactation length of buffaloes. It is possible because some animals can conceive very early after calving, have longer lactation length and very few dry days. The variation in dry period resulting from season and year of calving may be due to differential climatic conditions and managemental operations (Hussain et al., 2006). First parity buffaloes seem to have poor lactation yield. Increased dry period causes increased calving interval, which in turn reduces the calf crops. Optimizing dry period to 45-60 days, depends on reproductive management (Kanaujia and Balaine, 1975). Parity is an

Table 2: Herd* means for different performance traits of Nili-Ravi buffaloes

Traits	Overall	LESHA	LESCK	LESKH	LPRIBN
Total milk yield (kg)	1840±8.0 (9003)	1821±21.8 (1200)	1896±16.5 (2309)	1417±17.8 (2112)	2145±12.6 (3382)
Lactation length (day)	278±0.8 (9003)	262±2.6 (1200)	279±1.9 (2309)	252±2.1 (2112)	303±1.5 (3382)
Dry period (day)	258±1.6 (7283)	256±4.5 (1008)	241±3.5 (1897)	258±3.8 (1717)	268±2.7 (2661)

* LESHA = Livestock Experiment Station, Haroonabad, LESCK = Livestock Experiment Station, Chak Katora, LESKH = Livestock Experiment Station, Khushab, LPRIBN = Livestock Production Research Institute, Bhadurnagar, Figures in parenthesis are number of observations

important (P<0.01) source of variation in the dry period. Kandasamy et al. (1993) reported that there was gradual decrease in the dry period as parity increased.

Herd differences represent the differences in management practices planned or unplanned. Lower age at first calving in buffaloes at LPRIBN than at LESCK indicates better heifer management at LPRIBN than on LESCK during the specified period. The level of management is bound to vary according to the ability of the farm manager.

Milk production of these buffaloes was below the standards of commercial setup, where high inputs make a difference of about 1000 liters per lactation as compared to yield in the herds under study. Seasonal fluctuation represented both feed supply and effect of temperature and humidity. Buffaloes are adapted to tropical conditions but summer calvers produced 120 liters less milk as compared to those calved in winter. Summer is harsh in Pakistan, especially at the places where these farms were located. Most important reason for better milk production in winter calvers seems to be availability of barseem fodder in abundance.

Variation in mean values and effect of different factors on productive traits indicated a significant effect of environmental factors. Variation in herd, year and season directly influenced the productive and reproductive activities of the animals. This indicates that improvement in productive traits can be achieved by proper management. Poor yielder should be culled from the herds to improve increase the herd averages. The green fodder should be preserved in the form of hay or silage for using during scarcity months.

Authors' contributions

This research paper is based on my PhD research work, the authors included my teachers and coworkers who contributed in data collection, updating, analysis and write-up. All the authors equally contributed to this research paper.

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