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Impact of external influences on reproductive and lactational performance metrics in crossbred Murrah buffaloes, Nepal

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Abstract

Buffaloes are an essential part of rural households with a big impact on the socioeconomic well-being of communities in Nepal. Buffalo farming efficiency could be increased by employing strategic breeding programs and efficient management techniques, whereas such practices are not scientifically done in the rural communities. There are ways to determine whether crossbred Murrah buffaloes are superior, by assessing reproductive and lactational performance matrix. Parity, season, and location all are considered major external influences, which aid in identifying buffaloes with superior genetic makeup. This research was conducted in the Terai and mid-hill districts over three consecutive years during 2017 to 2020. The study included 16,912 pregnant and milking buffaloes, with 10,987 from Terai- Dhanusha district and 5,925 from Mid-hill- Kaski district. Data on desired traits were collected from the Veterinary Hospital Livestock Specialties Center's Artificial Insemination record book and the livestock service section from the Rural Municipality using a set of questionnaires. The data were analyzed by using the mixed technique of the Harvey model.The findings revealed that the overall least squares mean of age at conception (AC), age at first calving (AFC), calving interval (CI), lactation length (LL), lactation milk yield (LMY), standard milk yield (SMY), daily milk yield (DMY), and peak milk yield (PMY) were 35.10±0.56 kg, 975.14±10.54 days, 1287.88±10.50 days, 420.00 ±3.60 days, 276.66±2.32 days, 2097.64±39.88 liters, 2310.59±37.29 liters, 7.5±0.012 liters, and 9.76±0.015 liters, respectively. Age at conception, age at first calving, and calving interval were strongly impacted ($p<0.001$) by location, period, season, and parity. The research findings evident that external influences significantly impact to the reproductive and lactational performance of crossbred Murrah buffaloes. This emphasizes the need to opt improved breeding management along with selection of superior buffaloes to achieve higher milk yield and shorter calving intervals.

KEYWORDS: Crossbred Murrah Buffalo, External influences, Reproduction traits, Lactational parameters

Introduction

Buffaloes are significant in global agriculture since they offer milk, meat, and draft power to millions of people, particularly in developing countries (**FAO, 2020**). Buffaloes, especially crossbred Murrah buffaloes, are important for meeting the dairy needs of rural communities in Nepal, where agriculture is a key part of the economy (**FAO, 2020**). Nepal's gross domestic product (GDP) is derived primarily from agriculture which also employs 66% of the population. Livestock accounts for 12% of GDP, with buffaloes accounting for 6% of the total (**MoALD, 2021**). Further, they state that the buffalo population of Nepal is 52.5 million, contributing to an annual milk production of 1.4 million t and meat production of 0.19 million t which accounts for 57% of milk and 36% of meat production, respectively. Although, Murrah buffalo is the highest milk producing species, but their production and reproduction efficiency varied under different management conditions (**Bishnoi and Singh, 2009**).

Crossbred Murrah buffaloes commonly inhabit low hills and Terai regions, especially in areas with milk marketing potential. While indigenous buffalo breeds generally have lower milk productivity, averaging 2.85 liters per animal per day. The Murrah buffalo can produce 1500 liters of milk per lactation period under similar management conditions (**Nirmal et al., 2018**). Looking at the grassroot level, 35% of the population consists of exotic Murrah buffaloes in Nepal with the remaining 65% being indigenous (**Neopane and Pokharel, 2006**) buffaloes that were largely transformed into crossbreed Murrah buffaloes through natural/artificial selection and adaptation under socio-agroecological conditions.

The Nepalese rural farmers face the issues of crossbred and Murrah buffaloes- having delayed puberty, seasonal breeding, and, ultimately, having low productivity. Thus, these crucial aspects of buffalo rearing and management are quite important to consider from research perspectives. Such research studies are highly relevant for genetic improvement, management practices, and policy decisions as they are a significant source of milk and meat in Nepal (**Sah and Nakao, 2006**).

Indeed, insufficient consideration of non-genetic factors affecting Murrah buffalo traits is hindering productivity improvements. Factors such as climate, genotype, nutrition, and herd management practices all influence the reproductive traits of buffaloes and can be utilized to identify genetically superior animals. Taking this circumstance into account this study was done to understand and analyze the impact of external influences on reproductive and lactational performance metrics in crossbred Murrah buffaloes in different domains aiming to optimizing productivity interventions and breeding plans.

Materials and Methods

Study area

This research was conducted in the Terai of Dhanusha and the mid-hill districts of Kaski, Nepal. These districts lie at altitudes ranging from 78 meters in Terai to 450-3937 meters in mid-hill regions above sea level for Dhanusha and Kaski, respectively. The Dhanusha district belongs to the Madhesh Province, Nepal, at latitude 2650′31.56″ North and longitude 8602′09.60″ East, while the Kaski district is located at latitude 28.2622 N and longitude 84.0167 E.

The Terai is hot summers and moderate winters, often reaching highs of above 400C.The region boasts a subtropical climate. Winters are milder, with temperatures ranging from 7˚C to 23°C, and precipitation ranging from 1500 mm to 3000 mm. With annual rainfall ranging from 1500 mm to 2500 mm and temperatures fluctuating between 15˚C and 25˚C, the mid-hill region enjoys a temperate environment characterized by distinct seasons (**Sah et al., 2024**).

Study location and the duration

The data on economic traits of crossbred Murrah buffaloes were collected from animal breeding record sheet of buffaloes for the period of 2017 to 2020, maintained at the Veterinary Hospital & Livestock Specialties Center, and buffaloes rearing farmers of different rural municipality in in Terai, and hill of Nepal.

Production system information

Data related to production system of Murrah buffaloes were collected through direct interviews with buffalo-rearing farmers in two different regions, Terai and Hill, using a prepared questionnaire sheet to be answered verbally. The study encompassed crossbred Murrah buffaloes from these two locations of Kaski and Dhanusha, totaling 16,912 animals. We gathered information on reproductive and productive traits from 16,912 lactating buffaloes. Performance records of 10,987 buffaloes were sourced from the Veterinary Hospital & Livestock Specialties Center in Terai, while 5,925 were obtained from rural municipality in the hill district of Kaski. Data collection included information on all buffaloes born and calved at the farm, with a focus on those rearing between one and up to 100 milking buffaloes over a period of three years.

Herd management

Buffaloes were housed on large farms, with a minimum of one to 100 animals. They grazed on locally available grasses/fodder for 4 to 6 hours daily and received commercial concentrates at the 1.5 kg and roughages twice daily. The feed varied based on the animal's condition, with a chemical composition of 16% crude protein, 3% fat, 10-12% crude fiber, and 12% moisture content. Water was readily available, and buffaloes were artificially inseminated during estrus.

Agro-climatic seasons

Four distinct seasons were used for the study: summer (June to August), autumn (September to November), winter (December to February), and spring (March to May). In this study early parity has been defined as the first and second lactation, mid-parity as the third and fourth lactation, and late-parity as five or more lactations.

Statistical analysis

All the data we collected were entered in MS Excel using different sheets and data were cleaned for better readability. The data were also analyzed using animal models through the use of R software (Harvey's Henderson Least Squares and Maximum Likelihood, LSMMML PC-2; (**Harvey, 1990**). The model was used to evaluate the effects of parity, location, and season on reproductive/lactational performance.

$Yijk = \mu + Bi + Pj + (BP)ij + eijk$

where

Yijk is the observation on the k^{th} parity of ith breed;

μ is the overall mean;

Bi is the fixed effect of i^{th} breed of buffalo;

Pj is the fixed effect of j^{th} parity;

(BP) ij is the effect of interaction between i^{th} breed and j^{th} parity; and

eijk is the random error that is assumed to be normally and independently distributed (NID).

Results

Reproduction traits and their findings

Age at conception and age at first calving

The results of this study revealed that the overall mean age at conception and age of first calving of buffalo was 975.14± 10.54 and 1287.88±10.50 days, respectively (Table 1). The findings also revealed notable variations of the both traits of crossbred Murrah buffalo across different locations, seasons, and parities (Table 1). The age at first calving between the Terai region and the Hill region was such that the Terai region exhibited a significantly longer duration ($p<0.001$) compared to the Hill region (Table 1). The year also influenced this trait, with 2020 showing a higher age at first calving (Table 1). Likewise, the ages at first calving differed across seasons, and the least-square means for the second third parity were 1317.97 ± 0.97 days (Table 1). The Terai region showed a 24.75% higher age at conception compared to the Hill region. Additionally, the age at conception varied significantly across different time periods and seasons, with the highest mean in summer and the lowest in spring. Parity also had a significant effect, with the lowest mean observed in the 2nd parity and the highest in the 3rd during spring (Table 1).

Table 1: Least Square Means and standard error for reproductive traits of the crossbred Murrrah buffaloes considered in this research, Kaski and Dhanusha district, Nepal

Factors	N	AC (days)	AFC (days)	GL (days)	CI (days)
Overall μ	16912	975.14±0.54	1287.88±10.50	312.72±0.41	420.00±3.60
Location		***	***	***	***
Terai	10987	1291.22±10.52	1385.53±10.52	312.62±0 .41	422.34±3.61
Hill	5925	971.70±10.55	1284.54±10.51	312.83±0.41	417.65±3.61
Period		***	***	***	***
2018	4404	972.47±10.57	1285.24±10.53	312.76 ±0.41	423.93±3.61
2019	5117	971.97 ±10.57	1284.79±10.53	312.81±0.41	420.61±3.61
2020	7391	980.99±10.57	1293.61±10.52	312.60±0.41	415.45±3.61
Season		***	***	***	***
Summer	1964	983.77±10.63	1296.54±10.59	312.73± 0.41	419.90±3.63
Autumn	8316	969.41±10.56	1296.54±10.59	313.00±0.41	420.25±3.61
Winter	5315	973.75±10.56	1282.41±10.51	312.73±0.41	417.29±3.61

Spring	1317	973.65±10.67	1286.09±10.63	312.44±0.39	422.55±3.65
Parity		***	***	NS	***
First	6867	1006.06±0.89	1318.35±0.89	312.26±0.35	391.41±0.44
Second	5709	1005.71±0.98	1317.97±0.97	312.28±0.38	396.83±0.43
Third	4330	1009.76±1.06	1322.05±1.06	312.26±0.41	395.99±0.43
CV		6.41	4.87	0.81	5.26
R2		0.013	0.012	0.007	0.041

Note: Significant at 1% level ($p<0.01$): ***; AC (Age at conception), AFC (Age of first calving), GL (Gestation length), CL (Calving length); NS: Non significant at 5% level ($p>0.05$)

Gestation Length

The overall mean gestation length was 312.72±0.41 days (Table 1). Findings also revealed that location had a significant impact to the gestation length of crossbred Murrah buffaloes, with the hill region having a slightly higher gestation length (table 1). The year also significantly influenced gestation length, with 2019 having a higher length of 312.81±0.41 days. Seasons have a significant effect on gestation length ($p<0.05$), with the highest mean observed in autumn and the lowest in winter. Likewise, status of the parity of the buffalo revealed that the least square mean of gestation length in the 1st, 2nd, and 3rd parities were statistically similar ($p>0.05$) (Table 1).

Calving interval

Results of this study showed that calving interval for crossbred Murrah buffaloes was longer in the Terai region compared to the Hill region, and there were significant variations ($p<0.05$) between the two regions (Table 1). Likewise, the effect of the year to the calving interval was such that 2018 had a notably longer interval of 423.93±3.61 days (Table 1). Moreover, the seasons were found to have a significant impact ($p<0.05$) on the calving interval, with the longest interval occurring in spring and the shortest in winter. Additionally, the calving interval varied significantly based on parity as well (Table 1).

Lactational performance matrix

Lactation length

The overall least squares mean of lactation length (LL) of crossbred Murrah buffaloes in this study was 276.66± 2.32 days (Table 2). The findings revealed that the location had a significant impact on buffalo lactation length. The Terai region had the longest lactation period at 278.50 days, with the shortest being observed in another mid-hill region (Table 2). The year of calving did not have a significant effect on lactation length, but 2019 showed a longer average duration followed by 2020 (Table 2). Furthermore, the season significantly affected ($p<0.001$) the length of lactation, with summer having the longest duration at 273.33±2.34 days, followed by autumn and winter (Table 2). The lactation length was also significantly influenced by parity ($p<0.001$) (Table 2).

Lactation milk yield

The results of this study showed the overall mean of lactation milk yield of crossbred Murrah buffaloes as 2097.64±39.88 liters (Table 2). The findings also revealed the significant impact ($p<0.001$) of lactation milk yield on Murrah buffaloes in the Terai and hill regions. Accordingly, buffaloes in the Terai region demonstrated a 5.26 percent increase in milk yield compared to those in the hill regions (Table 2). Notably, buffaloes calving in 2018 and 2019 showed longer lactation milk yield values, while winter emerged as the most productive season for milk yield. The study findings also revealed that the first parity exhibited the highest yield, with the optimal lactation milk yield found in the second parity (Table 2).

Table 2: Least Square Means and standard error for productive traits of the crossbred Murrrah buffaloes considered in this research, Kaski and Dhanusha district, Nepal

Factors	N	LL (days)	LMY (l)	SMY (l)	DMY (l)	PMY (l)
Overall μ	16912	276.66±2.32	2097.64±39.88	2310.59±37.29	7.5±0.012	9.76±0.015
Location		***	***	***	***	***
Dhanusa	10987	274.82±2.33	2154.37±39.95	2388.68±37.36	7.83±0.04	10.15±0.16
Kaski	5925	278.50±2.32	2040.92±39.90	2232.49±37.32	7.3±0.01	9.37±0.016
Period		***	***	***	***	***

2018	4404	275.52±2.33	2133.57±39.97	2360.39±37.38	7.73±0.001	10.07±0.001
2019	5117	277.95±2.33	2078.00±39.98	2277.29±37.39	7.46±0.001	9.71±0.001
2020	7391	276.51±2.33	2081.36±39.96	2294.08±37.36	7.46±0.001	9.49±0.001
Season		***	***	***	***	***
Summer	1964	273.33±2.34	2096.40±40.19	2338.83±37.59	7.43±0.01	9.94±0.016
Autumn	8316	279.41±2.32	2154.03±39.94	2348.66±37.36	7.49±0.01	9.97±0.016
Winter	5315	278.12±2.32	2088.06±39.92	2286.39±37.33	7.70±0.01	9.60± 0.016
Spring	1317	275.78±2.35	2052.08±40.34	2268.48±37.73	7.66± 0.07	9.53±0.016
Parity		***	***	***	***	***
First	6867	279.73±0.19	2175.50±3.38	2371.87±3.16	7.77±0 .01	9.98±0 .08
Second	5709	279.48±0.21	2179.72±3.71	2378.26±3.46	7.79±0.01	9.41±0.014
Third	4330	278.99±0.23	2161.58±4.02	2361.84±3.76	7.74±0.01	9.93±0.016
CV		4.86	11.05	9.50	9.51	9.68
R^2		0.001	0.078	0.128	0.127	0.196

Note: Significant at 1% level (p<0.01): ***: LL (Lactation length), LMY (Lactation milk yield), SMY (Standard milk yield), DMY (Daily milk yield), PMY (Daily milk yield)

Standard milk yield

The findings of our study showed that crossbred Murrah buffaloes had an average standard milk yield of 2310.59 ± 37.29 liters (Table 2). The location, specifically the Terai and Hill regions, significantly influenced (p<0.001) the standard milk yield, with the exhibition of a 6.50% increase in milk yield compared to the Hill regions. Additionally, the year also had outstanding impact on the standard milk yield, with higher values observed in 2018 and 2020. Seasonal variations were obvious, with the highest standard milk yield recorded in winter (2348.66 ± 37.36 liters), and lowest in summer. Furthermore, the findings also revealed that the second parity achieved the highest standard milk yield compared to the other parities (Table 2).

Daily milk yield

The results we found was such that the overall least squares mean of daily milk yield was 7.5±0.012 liters (Table 2). Accordingly, crossbred Murrah buffaloes in Terai produced 6.75% more daily milk yield compared to those in mid-hill Nepal. The study findings also revealed that the year and season had significant effects (p<0.001) on daily milk yield, with Terai experiencing longer values with the seasonal variations that well affected the milk yield (Table 2). Specifically, we also found highest milk yield during winter and lowest during summer. Likewise, the daily milk yield in the 1st, 2nd, and 3rd parity was significantly different, with the 2nd parity producing the highest amount of milk (Table 2).

Peak milk yield

The findings of this study showed that the peak milk yield for crossbred Murrah buffaloes was 9.76±0.015 liters (Table 2). In the Terai and hill regions, the peak milk yield was 7.83±0.04 and 7.3±0.01 liters, respectively, showing a 6.7% increase in the Terai (Table 2). The year also had a significant impact (p<0.001) on the peak milk yield, with a higher value o during 2018. Likewise, peak milk yield varied significantly with the season, with higher average yields in winter and spring. On the other hand, peak milk yield was obtained in the 1st parity. Detail of the lactational performance matrix of crossbred Murrah buffaloes has been presented in Table (2).

Milk constituents

Overall mean of the fat, protein and lactose content of milk of Murrah buffaloes considered in this study was 7.21±0.0091, 3.68±0.0018, and 4.75±0.0017, respectively. The fat, protein and lactose content in buffalo milk showed a significant variation (p<0.001) between Terai and hill, with minor difference. There was no significant difference (p>0.001) in fat and lactose content across the years (Table 3). On the other hand, protein content was significantly varied (p<0.001) across the three years with 2019 recording the highest percentage and 2018 the lowest (Table 3). Likewise, the fat and protein content in milk of Murrah buffaloes varied significantly (p<0.001) across different seasons, but not the lactose content. Accordingly, summer and spring had slightly higher fat percentages compared to autumn and winter. On the other hand, there was no significant difference in the fat content of buffalo milk across different parities (p>0.3475). The fat, protein and lactose content were not significantly (p>0.001) different among different parities (Table 3)

Table 3: Least square means and standard error for milk constituents of the Murrrah buffaloes considered in this research, Kaski and Dhanusha district, Nepal

Factors	N	Fat (%)	Protein (%)	Lactose (%)
Overall μ	16912	7.21±0.0091	3.68±0.0018	4.75±0.0017
Location		***	***	***
Terai	10987	7.23±0.0091	3.68±0.0018	4.75±0.0017
Hill	5925	7.19±0.0091	3.69±0.0018	4.55±0.0014
Period		NS	***	NS
2018	4404	7.20±0.0091	3.67±0.0018	4.75±0.0017
2019	5117	7.15±0.0091	3.70±0.0018	4.75±0.0017
2020	7391	7.28±0.0091	3.68±0.0018	4.76±0.0017
Season		***	***	***
Summer	1964	7.21±0 .0092	3.69± 0 .0018	4.77±0.0017
Autumn	8316	7.18±0 .0092	3.67±0.0018	4.75±0.0017
Winter	5315	7.23±0.0091	3.69±0.0018	4.75±0.0017
Spring	1317	7.22±0.0092	3.68±0.0018	4.75±0.0017
Parity		NS	NS	NS
First	6867	7.30±0.0077	3.64±0.0018	4.77±0.0015
Second	5709	7.29±0.0085	3.64±0.0018	4.77±0.0015
Third	4330	7.29±0.0092	3.64±0.0018	4.77±0.0015
CV		8.57	2.69	2.28
R^2		0.075	0.007	0.008

Note: Significant at 1% level ($p<0.01$): ***; NS: Not significant at 1% level ($p>0.01$); CV: Coefficient of variation, N: Number of observations

Discussion

The overall mean age at conception for crossbred Murrah buffaloes, was 975.14±10.54 days. Likewise, the age at first conception for crossbred Murrah buffaloes was 2.9±0.7 years greater than the present study (**Adhikari et al., 2017**) (Table 1). Genetics, a healthy diet, stress, and environment are primary factors influencing puberty onset, with hormones, particularly gonadotropins and sex steroids, playing a crucial role (**Balamurugan, 2016**). River buffaloes typically reach puberty between the ages of 15 and 18 months, while swamp buffaloes reach puberty between the ages of 21 and 24 months (**Borghese, 2005**).

The range of the average age at first calving in Murrah buffalo was significantly higher than present results (Table 1), ranging from 1307.18±12.39 days to 1578.7±20.3 days (**Thiruvenkadan, 2015**), respectively. The age at first calving can be reduced through proper nutritional and health management of growing heifers (**Zicarelli, 2006**). The decrease in AFC resulting in a decrease in the cost of raising the animals to reach a productive life and an increase in the annual genetic gain (**Sarkar et al., 2006**). In this sense, our findings suggested that even under normal rearing practices in Hills and Terai of Nepal, age at first calving could be managed even from the existing population.

The average gestation length of Graded Murrah buffaloes maintained under field conditions in India was 308.68 ± 0.27 days (**Bhave et al., 2018**), but it was comparatively higher in our study. The average gestation length of crossbred, Nilli Ravi, and Murrah buffalo in the Bangladesh revealed 313.40±4.97, 313.65± 5.16, and 311.59±6.17 days, respectively, (Harun et al., 2019) aligning with our finding (Table 1). Available literature also suggests that the importance of temperature, humidity, and seasonal variation with combined effect of proper nutrition and management practices are crucial to maintain gestation length of buffaloes (**Kataria et al., 2017 and Harun et al., 2019**). In this sense, gestation length can be further managed by reducing the days by following the appropriate management practices and by considering appropriate weather conditions.

Our findings support the normal duration of calving intervals in crossbred Murrah buffaloes (**Adhikari, 2017**) (Table 1). Our study confirms that a combination of genetic, non-genetic, and environmental factors influences the calving interval (**Sharma and Sirohi, 2015**). The availability of quality fodder and nutrition, regular health service can help to minimize the calving intervals in well-nourished buffaloes (**Gautam and Kumar, 2017**). In this sense, as we report that crossbred Murrah buffaloes have moderate variability in reproductive traits, with the lowest CV observed for conception and gestation period we can well implement selection strategies and follow improved management practices that could improve economic importance of these traits.

In our study, the observed overall LSM for lactation length (Table 2) was in contrast with finding of other researchers. According to **Kaur et al., (2020)** observed that the LSM for LL of 340.48±14.14 days. This finding revealed that parity plays a significant role in determining the duration of lactation in crossbred Murrah buffaloes. Additionally, researcher reported factors that could influence lactation length, such as the year of calving, dry period, sex of the calf, and season of calving in water buffaloes (**Zicarelli, 2006**).

Our findings also revealed that the mean lactation milk yield was 2097.64±39.88 which is quite lower (1838.45±32.33kg) than those reported by **Sigdel et al., (2015)**, (Table 2). **Paudel et al., (2012)** also reported lactation milk yield of 1726.11 ± 45.89 liters in crossbred Murrah buffaloes. According to **Kaur et al. (2020)** reported that the LMY of 2465.48±130.72 kg Murrah buffaloes in Haryana, India had a total lactation yield as high as 2486 L in fourth parity and as low as 2061 L in the sixth parity (**Verma et al., 2017**). Higher values of lactation milk yield in Murrah Buffalo were reported as 2260±701 kg by **Pawar et al., (2012)**. Furthermore, buffaloes that calved in the autumn season are less influenced by heat stress during lactation, exhibiting the highest lactation milk yield, followed by those calving in summer and winter (**Thiruvenkadan et al., 2015**), contrasts with our findings.

Hayashi (2006) reported high yield in the second parity (2301 liters) while the low yield was recorded in the fifth-sixth parity (1176 liters) over the standard 305 days of milk yield in Murrah and indigenous breeds of the Terai region in Nepal. Interestingly, the first parity had the lowest 305-day milk yield 1810.88±25.19 kg and highest 305-day milk yield of 2156.88±30.88 kg was recorded on fourth parity which contrasts with our current findings (**Jakhar et al., 2016**).
These inconsistencies might have several other factors affecting variation in standard milk yield. **Yadav et al. (2013)** reported that, Murrah buffaloes produced mean daily milk yield of 8.842±0.089 in 2nd parity which was highest with respect to the parity. These values are quite close to our findings. Whereas **Prativa et al., (2022)** reported an average milk production of 9 litters.by the Murrah buffaloes.
We also recorded that the overall least squares mean (LSM) for peak milk yield (PMY) (Table 2) was consistent with the findings of previous researcher as the authors had reported LSM values for PMY in Murrah buffaloes ranging from 7.92± 0.016 kg to 10.55±0.07 kg (Kaur et al.,2020) as well and whereas **Thiruvenkadan (2011)** had highlighted the influence of the season of calving, location, and parity on peak yield.

The variability ($p>0.001$) in milk yield is significant and varies depending on factors such as the type of buffalo, year, calving season, buffalo interaction during gestation, lactation length, and lactating age at maturity. The variation observed in management practices, such as the availability of feeds and fodders, may account for variations in peak yield.
Our findings regarding the average values of milk fat percentages were (7.65±0.05%) in line with the average fat content of buffalo milk (5.13%) ranging 2.0 to 8.31% as reported by Bhattarai (2020). On the other hand, **Upadhyay et al. (2015)** reported a higher fat content of 7.96±0.07% in Murrah buffaloes, which is somehow similar to our findings. On the other hand, Yadav et al. (2013) recorded the milk protein level as 3.4±0.24 g% and 3.55±0.20 g%, respectively, during calving in summer and autumn seasons, and the seasonal difference was significant. Likewise, **Sodi, (2008)** reported mean lactose% in between 4.5% and 5.0% in buffaloes from India, which was similar to our findings.

Conclusions

The external influences such as season of calving, parity, and age at first calving significantly impact to the reproductive and lactational performance of crossbred Murrah buffaloes, particularly visibly in Nepal's Terai regions that well indicated the need to consider for a supply of better feed quality along with effective management practices in order to obtaining higher milk yield with shorter calving intervals. Conversely, the Hill region's cooler climate and limited feed could well result in longer lactation lengths and extended calving intervals, necessitating to consider region-specific management strategies for Murrah buffalo rearing. Buffaloes calving in spring and autumn showed better productivity mainly due to favourable conditions whereas younger buffaloes at first calving had better lifetime productivity, underscoring the importance of managing the age at first calving. These critical findings would add ways in establishing a sound breeding policy.The recommendation of this research is to monitor long-term environmental impacts on reproductive and productive traits to understand and mitigate adverse effects on buffalo by covering more niche specific variation in weather parameters.

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Novelty Statement: The researches work on the subject focuses external factors like season of calving, parity, and age at first calving significantly impact the reproductive and lactational performance of crossbred Murrah buffaloes, accentuating the need for region-specific management to optimize milk yield and reduce calving intervals in Nepal

Authors' Contribution (ACF)
Deo Nandan Sah managed the survey data and prepared the draft. Mohan Prasad Sharma performed the conceptualization of data. Nirajan Bhattarai completed the data analysis and reviewed the results. Nabaraj Devkota contributed to the editing and finalization of the draft manuscript. All authors read and approved the final version of the manuscript.

Conflict of interest
The author declares that there is no conflict of interest regarding research.

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