


Genetic and Non-Genetic Factors on Productive and Reproductive Performance of Indigenous Buffalo

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Received 3 Nov 2020, Revised 20 March 2021, Accepted 25 April 2021,
Published 30 April 2021

Scientific Editors: Nirajan Bhattarai, Saroj Sapkota, Neena Gorkhali

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The authors declare that there is no conflict of interest.



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ABSTRACT

Indigenous buffalo is the black gold of Nepal because of its important contribution to the livelihood of the rural farmers and agricultural economy of the country. A study was done to investigate the performance of indigenous buffalo found in high-hill of the western districts of Nepal. Further, effect of genetic and non-genetic factors on productive and reproductive performance of indigenous buffalo was accessed. This study was done in four districts: Myagdi, Baglung, Parbat and Kaski for 2 consecutive years from 2016 to 2017. A semi-structured and questionnaire survey format was prepared and was filled with verbal answers from 142 farmers on a different aspect of buffalo farming. Further, recording formats were distributed to enumerators for the recording of different information that cannot be collected from the survey. Total of 201 indigenous buffaloes (132 Lime and 69 Parkote) and minimum of 25 buffaloes in each site were measured for determining productive and reproductive performance. Further, 65 collected milk samples were subjected to Animal Nutrition Laboratory of DoAR, Lumle for determination of milk composition. Results of the findings revealed that there was a high variation in productive and reproductive performance of indigenous buffalo. Lactation milk yield of Lime buffalo was observed slightly higher (1180.90 ± 27.94 L) than Parkote buffalo (1170.56 ± 42.29 L) but was non-significant ($p > 0.05$). Lactation yield of indigenous buffalo in Ramja, Parbat (1254.73 ± 38.43 L) was observed significantly higher ($P < 0.002$) than other research locations. Genetic evaluation of indigenous buffaloes and selection of better performers help in increasing productivity and lead to conservation by competitive advantage of indigenous buffaloes. Non-genetic factors play an important role in the productive and reproductive performance of indigenous buffalo and need to account for these effects to select buffalo for its genetic merit.

Keywords: Non-genetic factors, Productive, Reproductive, Lactation Milk Yield

सारांश

स्थानिय भैंसीले ग्रामिण कृषकहरूको जीविकोपार्जन र देशको अर्थतन्त्रमा महत्त्वपूर्ण भूमिका खेल्दछ त्यसैले यो नेपालको कालो सुनहो। स्थानिय भैंसीको उत्पादन पत्ता लगाउने उदेश्यले पश्चिम नेपालको उच्च पहाडमा एउटा अनुसन्धान गरियो। यससँगै आनुवांशिक र अरु वातावरणीय तत्त्वहरूले भैंसीको उत्पादन र प्रजननमा पार्ने असरहरूको अनुसन्धान गरियो। यो अनुसन्धान चार पहाडी जिल्लाहरू म्याग्दी, बागलुंग, पर्वत र कास्कीमा लगातार दुई वर्ष इ.स. २०१६-२०१७ सालमा गरिएको थियो। अर्धसंरचित घरधुरी सर्वेक्षण फारम तयार गरियो र १४२ जना कृषकहरूले मौखिक भन्नुभएका कुराहरूले फारम भरियो। घरधुरी सर्वेक्षणबाट संकलन गर्न कठिन कुराहरू रिपोर्ट गर्नको लागि पशु उत्पादन फारम तयार गरियो र गणनाकर्तालाई हस्तान्तरण गरियो। भैंसीको उत्पादन र प्रजनन क्षमता पत्ता लगाउन २०१ भैंसीहरू (१३२ लिमे र ६९ पारकोटे) र प्रत्येक क्षेत्रमा कम्तिमा २५ भैंसीहरूको मापन गरियो। दुधको संरचना पत्ता लगाउन थप ६५ वटा दुधका नमुनाहरू भैंसीको पशुआहार प्रयोगशाला, लुम्लेमा लिएर आइयो। अनुसन्धानबाट स्थानिय भैंसीको उत्पादन र प्रजनन क्षमतामा धेरै नै फरक रहेको पाइयो। लिमे भैंसीको प्रतिबित दुध उत्पादन (1180.90 ± 27.94 लि.), पारकोटे भैंसीको भन्दा धेरै (1170.56 ± 42.29 लि.) पाइयो तर तथ्यांक शास्त्रको आधारमा भिन्न नभएको (सम्भावना > 0.005) पाइयो। भैंसीको प्रतिबित दुध उत्पादन राम्रा पर्वतमा अरु ठाउँको

भन्दा धेरै (१२५४. ७३ ±३८. ३३लि.) पाइयो र तथ्यांकशास्त्रको आधारमा उल्लेखनिय रूपमा राम्रो (नहुनेसम्भावना<०.००२) पाइयो। आनुवांशिकको आधारमा राम्रो उत्पादन दिने भैसीको छनोट गरेमा भैसीको उत्पादकत्वो बिर्दो भई स्थानिय भैसी पनि दुध उत्पादनमा पर्तिस्पर्धि हुनेछ र स्थानिय भैसीको संरक्षण हुने देखिन्छ। विभिन्न वातावरणीय तत्तोहरुले समेत स्थानिय भैसीको उत्पादन र प्रजनन क्षमतामा फरक पार्ने हुँदा स्थानिय भैसीको छनोट गर्दा ति तत्तोहरुलाई मध्यनजर गरेमा आनुवांशिकतमा उत्कृष्ट भैसी छनोट गर्न सकिन्छ।

INTRODUCTION

Buffalo is a major livestock commodity among 35 livestock species (Joshi et al 2020) in Nepal where buffalo population in-country is estimated to be 5.30 million (MLD, 2018/19). Buffalo is an important livestock commodity of Nepal, it alone contributes about 63% and 52 % of national annual milk and meat production respectively (MoALD, 2018/19). It is believed that nearly half of the households of the country keep buffaloes primarily for milk, meat, manure, skin, traction and ploughing agricultural land. Most of the Nepalese people have preferred buffalo milk to cattle milk due to its appealing white color and richness in fat and solid not fat which has a good taste and fetches a higher price in the market. In addition, people from a remote area of the country want to keep buffaloes more than cattle for milking because buffalo milk can be profitable even by making ghee. Native buffalo of a country can be broadly classified into three groups based on their breed characteristics: Lime, Parkote and Gaddi. These breeds are hilly buffalo and reared by the farmers of the mid and high hills region of Nepal above 1000 m asl. Lime and Parkote buffaloes have been characterized to the extent of being phenotypically recognizable and are abundantly found in the western mid-hills of Nepal. Among the existing buffalo population, indigenous buffalo and their intermediate types contribute around 64% (Neupane et al 2007). Paudel (2017) also reported that there are more than 65% of local buffalo in Nepal.

The pure breed Lime is believed to have originated from wild Arna (*Bubalus arnii*) and has been domesticated throughout the known history of Nepal (Rasali, 1998). These buffaloes can be found more towards the higher altitude; mid-hills and high in the country. It has been estimated that about 35% of the total indigenous buffalo population in the hills and mountains of the country are Lime and only 25% of these are Parkote (Shrestha et al 2003, Rasali 1998, Rasali, 2000). Parkote buffalo are more common in the mid-hill and river valleys of Nepal. There is limited genetic improvement program in indigenous buffalo to increase the production and productivity of these buffaloes. Further, farmers are practicing rampant crossbreeding with Murrah to increase the production and productivity of these animals thus resulting decrease in pure breed in the hills and mountains. Similarly, genetic effect such as breed effect and non-genetic factors such as location, parity and year play an important role in the productive and reproductive performance of buffalo and should be taken into account to select the best animal for its genetic merit. Therefore, this study aims to access the productive and reproductive performance of indigenous buffalo in farmer's managed condition in the mid-hills of western region of Nepal. Further, we examined the effects of different genetic and non-genetic factors on the productive and reproductive performance of the buffalo.

MATERIALS AND METHODS

Selection of site and farmers

In close collaboration with respective District livestock Service Offices of selected location, four sites: Ramche of Myagdi district, Tarakhola of Baglung district, Ramja, Deurali of Parbat district and Lwang Ghalel of Kaski district were considered for study during consecutive years from 2016 to 2017. These sites were also considered as conservation sites of indigenous buffalo by District Livestock Service Offices (DLSO) of the respective district. All sites fall in the high hill region: 1400 - 2100 m asl of Nepal, which is the most prominent production system for indigenous buffalo.

Production system information

A semi-structured and open-ended questionnaire survey format was developed and was verbally asked to a total of 142 farmers from four districts. Further, those farmers who have been rearing at least one indigenous milking buffalo and who agree to comply as per protocol: agree to help recorder in keeping fortnightly milk record, keeping milk sample at regular interval and maintaining reproductive records, were selected for the study. We could not record milk production performance from all the farmers because of

one or more difficulties faced in each site. Total number of farmers in each location is presented in **Table 1**.

Table 1. Total number of household considered in a survey

Location	Altitude (m asl)	Total households
Ramche of Myagdi	1,800	31
Tarakhola of Baglung	2,100	39
Ramja, Deurali of Parbat	1,500	40
Lwang Ghalel of Kaski	1,600	32

Production and reproduction performance

Minimum of 25 buffaloes in each site was used for recording the production and reproductive performance (**Table 2**). Only those buffaloes which were calved after the commencement of research, were considered for recording.

Table 2. Number of buffaloes considered for recording productive and reproductive performance

Location	Lime	Parkote	Total
Myagdi	9 (7)	18 (9)	43
Baglung	21 (14)	7 (6)	48
Parbat	39 (21)	11(2)	73
Kaski	12 (9)	9 (7)	37
Total	132	69	201

Note: Number in parenthesis indicates number of recording taken in the second year

Milk production performance

A recording format was developed and enumerators were trained to keep records of production and reproduction performance. We provided a uniform milk recording jug to all enumerators for recording the productive performance of buffalo at fortnightly intervals also called test day milk yield. Milk was measured after 15 minutes of milking to allow enough time to settle the milk bubbles to minimize error during recording. First fortnightly milk recording was done after 15 days of calving in the morning and evening and successive milk recordings were followed thereafter. Some extra days of milk after earlier recording were not counted if we cannot take the next test day record, and that record was considered as the last test day record. Further, if farmers practice providing milk to buffalo calf directly from the teat, then extra milk from that teat was also added in that particular test day record. Finally, we multiply the total number of test days recordings by 15 to get lactation milk yield (LMY).

Milk composition

A total of 65 representative milk samples containing 28 samples from Lime and 37 milk samples from Parkote buffalo were collected from the aforementioned sites. Milk samples were collected by thoroughly stirring a milking can after milking of buffalo. Milk samples were then used to determine percentage fat, protein, and solids not fat (SNF) using Lactoscan milk analyzer (MilkAnalyzer, www.mikotonic.com, serial No 11-16,4245, Bulgaria). Milk traits considered in the study were as mentioned in **Table 3**.

Table 3. Milk traits considered in this study

LMY	Lactation milk yield (305 days)
SNF	Solid, Not Fat
Fat %	Percentage of fat in the milk
Protein%	Percentage of protein
AFS	Age at first service of the female
AFC	Age at first calving
CI	The interval between successive calving

Data analysis

Collected data were entered in Microsoft excel and analyzed by maximum likelihood using the animal model from R software. The linear model used for the study on different productive traits are;

$$Y_{ijklm} = \alpha_i + \beta_j + \gamma_k + \delta_l + e_{ijklm}$$

Where, Y_{ijklm} = Effect of m^{th} observation on i^{th} breed, j^{th} location, k^{th} parity and l^{th} year

μ = General mean

α_i = Effect of i^{th} breed

β_j = Effect of j^{th} location

γ_k = Effect of k^{th} parity

δ_l = Effect of l^{th} year

e_{ijklm} = random error assumed to be normally distributed with 0 means and common variance σ^2 .

RESULTS

Brief description of farmers managed production system

This system consists of keeping at least one buffalo up to 5 buffaloes in the majority of the household and raising these animals by family members. This is low input and low output production system; farmers fed their animals by using traditional feedstuffs like rice/millet straw, cooked homemade concentrate (Kundo) and different fodder species, and return from animals are also low to medium due to lack of adequate nutrients all-round the year. Further, some farmers practice keeping their animals in the nearby jungle during the dry period of the animals to reduce the cost of feed and save time to take care of their animals. Breeding of the animals takes place mostly by natural mating using buffalo bull available in the vicinity. This is a subsistence livestock production system prevalent in the high hills region of Nepal to get enough nutrients from animal sources and get an extra source of income to support the family.

Production performance of indigenous buffaloes

The productive performance of indigenous buffaloes is presented in **Table 4**. It was observed that the lactation milk yield of Lime buffalo was higher 1180.90 ± 27.94 L than Parkote buffalo 1170.56 ± 42.29 L, but the effect of breed on lactation milk yield (LMY) was non-significant ($p > 0.05$). Further, the result showed that the lactation milk yield of buffalo in Ramja, Parbat was higher 1254.73 ± 38.43 L than other locations, and was significantly different ($p < 0.002$) than other locations. Moreover, the result showed that milk production of indigenous buffalo was the highest in 3rd and 4th parity and decrease after 4th parity; but the effect of parity on lactation milk yield was non-significant ($p > 0.05$). The reason behind the non-significant effect of parity on lactation milk yield could be due to less observation in the latter part of lactation hindered estimation of correct means. The result of the finding was in agreement with other findings that the milk yield of indigenous buffalo decrease after 4th parity (Shrestha et al 2005).

Table 4. Effect of genetic and non-genetic factors on the productive performance of indigenous buffalo

Parameters	No. of Observations	Milk yield (L) \pm SE	Minimum	Maximum
Breed				
Lime	132	1180.90 \pm 27.94	497.15	2063.83
Parkote	69	1170.56 \pm 42.29	362.61	1972.33
P-value		0.615		
Location				
Ramche, Myagdi	43	1206.33 \pm 60.99	472.47	1972.33
Tarakhola, Baglung	48	1194.37 \pm 41.44	457.57	1952.0
Ramja, Parbat	73	1254.73 \pm 38.43	636.14	2063.83
Lwang Ghalel, Kaski	37	868.93 \pm 48.29	362.61	1695.29
P-value		0.002		
Year				
2016	126	1215.27 \pm 25.24	2063.83	362.61
2017	75	1113.56 \pm 27.51	1695.44	379.55
P-Value		0.0384		

Parameters	No. of Observations	Milk yield (L) \pm SE	Minimum	Maximum
Parity				
1	24	1045.31 \pm 83.63	379.56	1851.79
2	41	1163.74 \pm 52.03	362.61	2063.83
3	36	1235.37 \pm 55.80	550.02	2063.83
4	24	1269.99 \pm 78.29	472.47	1972.33
5	28	1222.65 \pm 61.64	615.92	1952.00
6	20	1122.72 \pm 61.41	751.32	1662.25
7	8	1258.46 \pm 65.62	950.52	1525.39
8	8	1152.77 \pm 114.97	705.57	1695.29
9	6	925.95 \pm 130.62	457.50	1298.43
P-value		0.569		
AIC	1830	BIC	1846	
Log-likelihood	-909			

We observed that indigenous buffalo produce high milk production from October to February (Figure 1). This can be explained by the fact that most of the buffalo calved by November and give high milk production for 5 months from the onset of their lactation. Further, green forage and fodder are available up to February in most of the farmer's household and production of the buffalo decreases in the absence of green forage and fodder. We didn't observe the practice of making silage for feeding their buffalo in the lean season in the survey household and most of the farmers provide very little concentrate for their animals. This also explains the fact that the lower productivity of buffalo after February is not only genetic but also the impact of feed scarcity.

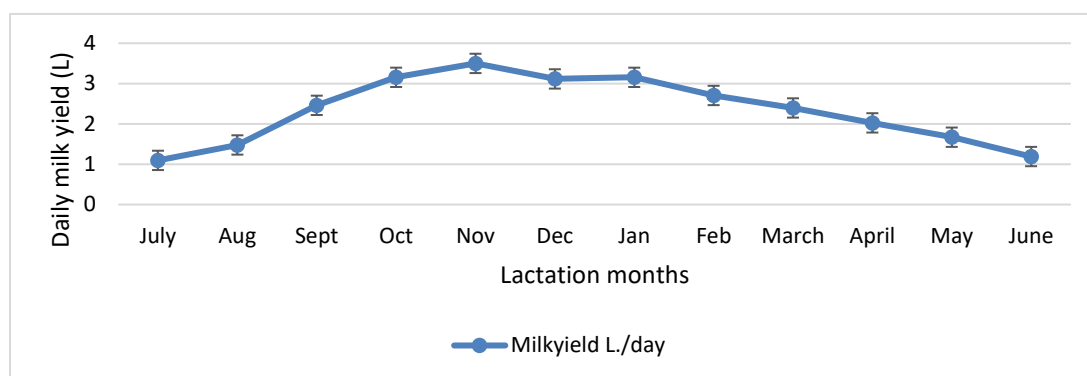


Figure 1. Peak milk yield of indigenous buffalo

Lactation length of indigenous buffalo

The average lactation length of indigenous buffalo was observed 9.87 months, but the effect of breed on lactation length was non-significant (Table 5).

Table 5. Effect of non-genetic factors on lactation length of indigenous buffalo

Parameters	No. of observations	Lactation length (months \pm SE)
Breed		
Lime	65	9.90 \pm 0.28
Parkote	58	9.82 \pm 0.38
P-value		0.865
Location		
Ramche, Myagdi	43	10.15 \pm 0.41
Tarakhola, Baglung	48	9.57 \pm 0.21
Ramja, Parbat	73	8.83 \pm 0.40
Lwang Ghalel, Kaski	37	10.23 \pm 0.88
p-value		0.865

Reproductive performance of Indigenous buffalo

The reproductive performance of indigenous buffaloes across breeds is presented in **Table 6**. It was observed that the average age at first service, age at first calving, and calving interval of indigenous buffalo were 3.15 years, 4.15 years and 13.94 months respectively and was non-significant across breeds.

Table 6. Reproductive performance of indigenous buffaloes across breeds

Traits	No. of Observation		Lime	Parkote	Total	P-Value
	Lime	Parkote	Mean \pm SE	Mean \pm SE	Mean \pm SE	
Age at 1 st Service (Year)	104	72	3.15 \pm 0.07	3.14 \pm 0.08	3.15 \pm 0.05	0.915
Age at 1 st Calving (Year)	104	72	4.14 \pm 0.07	4.15 \pm 0.08	4.14 \pm 0.05	0.865
Calving Interval (Month)	87	53	14.00 \pm 0.34	13.83 \pm 0.37	13.94 \pm 0.25	0.737

The reproductive performance of indigenous buffaloes across different locations is presented in **Table 7**. It was observed that age at first service, age at first calving and calving interval of buffalo in Parbat district was 2.92 \pm 0.08 years, 3.90 \pm 0.08 years and 12.97 \pm 0.39 months and was significantly better (<0.001) than other locations.

Table 7. Reproductive performance of indigenous buffaloes across different locations

Location/Reproductive traits	No. of Obs.	Baglung Mean \pm SE	Myagdi Mean \pm SE	Parbat Mean \pm SE	Kaski Mean \pm SE	Total Mean \pm SE	P-Value
Age at 1 st service (year)	176	3.61 \pm 0.07	2.85 \pm 0.10	2.92 \pm 0.08	3.13 \pm 0.17	3.15 \pm 0.05	<0.001
Age at 1 st calving (year)	176	4.62 \pm 0.70	3.84 \pm 0.10	3.90 \pm 0.08	4.14 \pm 0.17	4.14 \pm 0.54	<0.001
Calving Interval (month)	140	14.40 \pm 0.37	13.67 \pm 0.47	12.97 \pm 0.39	15.48 \pm 0.92	13.93 \pm 0.25	0.007

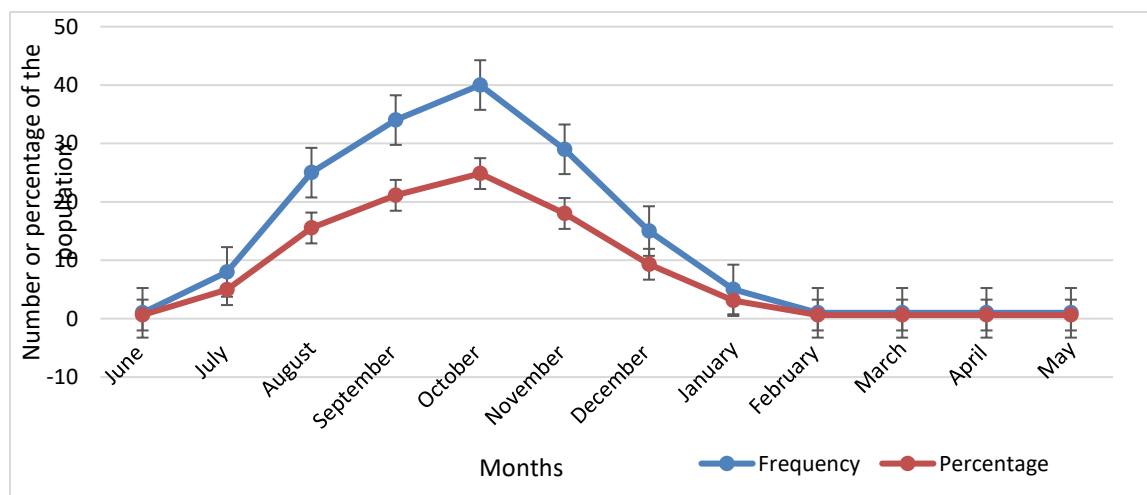


Figure 2. Calving month of indigenous buffalo

It was observed that buffalo are seasonal breeders as most of the indigenous buffalo calved from July month to December month (**Figure 2**). There are many reasons behind the seasonal breeding of the buffalo, one of the reasons is availability of green forage and fodder during the rainy season. Further, low cholesterol level was observed in buffalo during stress period (Shah et al., 2017), which affect the biosynthesis of steroid hormone and ovarian functional activity (Doisy 1972).

Milk composition of indigenous buffalo

It was observed that the milk composition of indigenous buffaloes was enriched with high fat, Solid not fat (SNF), lactose, and protein content (**Table 8**). We observed a very high-fat content of indigenous buffalo than Murrah and other cross-breed buffalo found in other studies (Ref).

Table 8. Breed-wise milk composition of indigenous buffalo

Breed	No. of Obs.	Fat	SNF	Lactose	Protein
Lime	28	8.73±0.31	8.17±0.40	3.39±0.07	3.42±0.07
Parkote	37	8.39±0.49	7.78±0.25	3.44±0.11	3.46±0.11
Total	65	8.54±0.31	7.93±0.22	3.42±0.07	3.44±0.07
P-Value		0.599	0.348	0.744	0.791

It was observed that buffaloes from Baglung districts have high fat and SNF content, 9.36±0.59 and 8.04±0.22 respectively but the milk composition across districts was non-significant (Table 9).

Table 9. Location-wise milk composition of indigenous buffalo

Location	No. of Obs.	Fat	SNF	Lactose	Protein
Myagdi	19	7.96±0.56	7.78±0.29	3.40±0.12	3.47±0.14
Baglung	20	9.36±0.59	8.04±0.22	3.59±0.11	3.53±0.10
Parbat	14	7.76±0.49	7.32±0.25	3.26±0.11	3.35±0.13
Kaski	12	9.01±0.80	8.70±0.99	3.33±0.2	3.36±0.22
Total	65	8.54±0.31	7.93±0.22	3.41±0.07	3.44±0.07
P-value		0.172	0.256	0.361	0.760

DISCUSSION

We observed a high variation in lactation milk yield (362.61-2063.83 L) for both Lime and Parkote buffalo, which indicates that there is a high potential for genetic improvement through selection within the breeds. Therefore, there is no need to cross-breed these animals to increase production performance for short-term benefit. Further, both breeds have similar productive performance and there is no benefit of selecting one breed over another. Rasali (1998) observed a similar finding for average milk production of 995 L. of indigenous buffalo in the western hills of Nepal. A similar finding was also observed by (Joshi et al 1992). Shrestha et al (2005) also observed the milk yield of indigenous buffalo Lime, Parkote and Murrah cross 961.7 L, 1022 L, 1073 L respectively in western hills from 2001-2003 in his study in six hilly districts of Nepal. Paudel (2017) observed a higher lactation milk yield of 1615±205 L for Lime and 1800±215 L for Parkote buffalo in northern Arghakhanchi under improved production system. These higher results might be due to higher temperatures and good management in Arghakhanchi than in the current research sites. In high hills, fodder is mostly available in the summer and autumn season and animals are fed with mostly dry roughages in the winter season whereas in mid-hills duration of forage and fodder availability is higher.

Different non-genetic factors such as location, year and parity play an important role in the productive and reproductive performance of indigenous buffalo and these factors need to be accounted for the selection and improvement of indigenous buffalo for its genetic merit. High milk production of indigenous buffalo in Ramja, Parbat can be justified by the fact that Ramja, Parbat is warmer than other locations and most of the energy animals obtain from the feed was utilized in milk production while in other locations energy produced from feed was also utilized in the generation of heat to keep their body warm. Shrestha et al (2005) also observed that Lime, Parkote and Murrah cross produced 961.7, 1022, 1073 liters lactation milk yield respectively in the western hills from 2001-2003. Rasali (1996) also reported significant variation in the milk yield of indigenous buffalo in different agro-ecological sites. Amatya et al (2000) observed better lactation performance of buffaloes in the river basins compared to those in the mid and high hills. Effect of the year on lactation milk yield was also observed significant ($p < 0.0384$) with higher milk production in 2016 than in 2017. Lactation length of indigenous buffalo was observed reasonable and corresponds with the finding from the previous authors (Shrestha et al 2003). Reason behind the non-significant effect of locations on lactation length could be due to the selection of similar locations of high hill regions in all four sites and feed availability in all locations was also nearly similar. Result from current research contradicts the finding from (Shrestha et al 2002), who observed significant effects of location on the lactation length of indigenous buffaloes.

The result indicates that the reproductive performance of indigenous buffalo was also affected by non-genetic factor and need to consider for selection of buffalo. Result from the current study was slightly

better than the result observed by (Shrestha et al 2003), 4.5 years and 602 days respectively for age at first calving and calving interval for indigenous buffaloes in the mid-hills region of Nepal. Shrestha et al (2003) also observed non-significant effects of breeds on age at first calving. Amatya et al (2000) also observed a slightly higher age at first calving of Parkote buffalo than Lime buffalo the effect of breed on calving interval was non-significant which corresponds to the finding of the current research.

The milk composition of indigenous buffalo was observed much better and farmers can be benefitted by selling both milk and milk products. Shah et al (2016) also observed a similar finding for the milk composition of indigenous buffalo. The reason behind the non-significant effect of locations on milk composition could be due to a few observations taken to investigate the significance of milk composition.

CONCLUSION

Indigenous buffaloes are important livestock germplasm of Nepal. Further, these animals can survive and produce well in the harsh climate of the mid-hills and high-hills. It was observed that there is a high variation in milk yield, milk composition and reproductive performance of these breeds in farmer's condition. Maximum milk production from these animals was observed more than 2000 L. Average milk production from these animals can be improved by the selection of superior stock. Further, it was observed that different non-genetic factors such as location, year play an important role in the production and productivity of these animals and these factors need to be considered while selecting better animals for breeding purposes.

ACKNOWLEDGEMENTS

Co-operation obtained from the participatory farmers, officers and technicians of respective DLSO are gratefully acknowledged. Authors are grateful to NARC for the financial support to conduct the research. Authors are also thankful to staff of Animal Husbandry Unit of RARS, Lumle, NARC for implementing the research activities.

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