Productive and reproductive traits of yak types in Bhutan: characteristics and comparisons

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ABSTRACT
The study characterized and compared productive and reproductive traits of genetically different types of yaks of eastern, central and western Bhutan. The mean daily milk yield, lactation length and lactation yield per cow were 1 kg, 234 days and 153 kg, respectively. The only reproductive traits that differed significantly amongst yak types were age at puberty and postpartum oestrus period. The yak of eastern Bhutan attained puberty earlier in less than 3 years compared with the yaks of central and western Bhutan. The postpartum oestrus period of yaks of eastern Bhutan was longer. Yaks of central and western Bhutan showed a postpartum oestrus period of about 150 days whereas it was close to 170 days for yaks of eastern Bhutan. Mean age at first calving for all yak types was 4–5 years with mean calving interval of approximately 1.3 years. Mean gestation period was about 256 days for all yak types. Mean heat interval was about 21 days and the number of services per conception was a little over 1.5. There is a need to introduce forage and nutrition development programmes to exploit fully the genetic potential of yaks, besides putting in place an appropriate breeding programme and adequate veterinary services.

Introduction

Productive and reproductive traits of cattle determine the profitability of a dairy enterprise. These traits provide scientific basis for cattle breeding and are influenced by feed, genetics, disease and management practices. In developing countries, livestock productivity is constrained generally by the low genetic capacity of indigenous animals. Regular assessment of productive and reproductive performance of cattle is required to ensure success of dairy production. Recognizing the importance of these traits, several studies reported the productive and reproductive performance of both indigenous (Mondal et al. 2005; Garoma 2014) and crossbred cattle (Sultana et al. 2001; Uddin et al. 2008; Tadesse et al. 2010; Haque et al. 2011); however, these studies are confined to the cattle production systems in temperate and tropical environments. There is lack of adequate studies exploring these traits of yak (Poephagus grunniens) in the alpine Himalayan region.

Yak farming is a sustainable enterprise and sustains the livelihood of rural communities in the high Himalayan Mountains. Yaks are well adapted to the extremely harsh alpine condition and play a vital role in the economy of pastoral communities. Depending on breed, location and type of management, the productive and reproductive traits of yak are found to differ. In central Asia, a mature female yak weighs in the range of 200–320 kg while males are heavier by 30–50% (Wiener 2013). The average milk yields range from 200 to 400 L for the first six months following calving (Wiener 2013). The first oestrus of a majority of central Asian yaks occurs when cows are two years old and first calving at the age of four years. However, these traits of central Asian yaks differ from those of the yaks in the Himalayas. In Nepal, the average body weights of male and female yaks are 300 and 225 kg, respectively (Kharel et al. 2011). The first oestrus of a female yak in Nepal is reported to occur at the age of three years and first calving at the age of about less than four years. The gestation period is less than 9 months and the lactation milk yield per cow is 720 kg. The results of these studies are an evidence that yaks differ in productive and reproductive traits between regions.

In Bhutan, based on genetic makeup, Dorji (2000) categorized yak populations into two, yak of eastern, and yak of central and western region. Dorji (2000) also reported that the two yak populations differ from each other in body dimension, coat colour, horn pattern and woolliness. However, there is lack of studies characterizing the productive and reproductive traits of yak breeds in Bhutan. The only succinct information on these traits of Bhutanese yak is provided by Gyamtsho (2000) who estimated the bodyweight of a matured male at 400–500 kg and a matured female at 250–300 kg. Gyamtsho (2000) also estimated the lactation yield of an annual calving yak at 150 kg and the alternate year calving yak at 360 kg. Oestrus was reportedly affected by climate, pasture availability and altitude, but calving took place at 4–5 years of age. The gestation period was similar to the Nepalese yak. However, Gyamtsho (2000) focused only on yaks of western Bhutan and not the yak breeds of eastern and central Bhutan. To date, the knowledge gap continues to exist with no studies undertaken to adequately characterize or compare the productive and reproductive traits of different yak breeds in Bhutan. Dorji (2000)
acknowledges the significant contributions of yak farming to the pastoral economies and to the nation as a whole, and suggests the need to conduct a comprehensive study to generate empirical evidence on yak performances. It is feared that the lack of adequate scientific information on the subject might deter proper planning and effective implementation of yak development plans and policies. To address the knowledge gap, a study was conducted with the primary objective to characterize and compare the productive and reproductive traits of yaks from eastern, central and western regions of Bhutan.

**Materials and methods**

**Description and selection of study sites**

The main yak-rearing districts of northern Bhutan were purposively selected for the study (Figure 1). Generally, all study sites have rugged topography with the mean maximum temperature of 20°C, which is recorded in summer and the mean minimum of −10°C in winter. Summer is moderately warm and wet followed by freezing cold and dry winters. The annual rainfall shows a unimodal distribution pattern, with the maximum precipitation from June to September. The topography is characterized by rugged mountains with snow-clad peaks, steep slopes, narrow gorges and flat, narrow valley bottoms.

A two-stage sampling technique was used to identify and select sites for the study. The main criteria used for site selection were high yak population and easy access. In the first stage, through consultative discussions with the district livestock development workers, 5 of the 10 yak-rearing districts in Bhutan were selected. The districts were Bumthang, Tashigang, Wangdue Phodrang, Paro and Gasa (Figure 1). In the second stage, within each district, specific yak-rearing sites were selected with the help of village elders. A total of eight administrative blocks were selected to represent uniformly the different yak-rearing regions. The administrative block of Merak was selected to represent the eastern region, Chumey, Chokor and Ura for the central region, Sephu for west central region, and Tsento, Laya and Lunana for the western region. The study area selected lies at altitudes between 3000 m at the lowest points to over 7000 m at the snow peaks. Some of the administrative blocks are far flung with about two days’ walk from the nearest motorable roads.

**Data collection**

A total of 96 respondents, mostly elderly herders, were selected after consultative discussions with the livestock extension officers of respective study sites. These herders have reared yaks for more than 25 years in the high elevation.

The survey was administered through a non-structured questionnaire. The questionnaire was divided into two sections. The first section dealt with questions related with production parameters mainly milk production by animals. To verify if the milk production data of survey report agreed with the actual milk production, the daily milk production per yak was measured in summer for all 96 herds in all three regions. In each region, the survey covered 32 households. Milk yield was measured with the traditional method using hands and plastic buckets of known capacity. The measurements were carried out only once in the morning. After milking, the yaks are let loose for free grazing on grassland meadows until evening when they are herded back to their sheds. Yak management is similar across the regions.

For estimating the lactation length, respondents were asked how long they milked their cows after calving. The lactation yield of an animal was determined using the information of average daily milk yield of summer and winter months and the lactation length. In order to avoid overestimation of lactation yield, the measured milk production data were used and not the survey data. The lactation yield of a yak was estimated for the peak milk production period of four months in summer.
and the lowest milk production period of 3.66 months in winter. Therefore, the mean lactation yield was calculated as:

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\text{Lactation yield per yak (kg)} = \frac{\text{Number of peak milk production months} \times \text{Average daily milk production (kg) in peak months} + \text{Number of low milk production months} \times \text{Average daily milk production (kg) in low months}}{\text{Number of days in a month}}
\]

The second section of the questionnaire dealt with questions on reproductive parameters such as breeding time, calving interval, number of breeding services required to impregnate cows, length of heat cycle and gestation period, time taken by a cow to come to heat after calving, month of calving and number of services needed per conception. The questionnaire also sought information on time of the year when cows were usually bred in the herd.

**Data analysis**

The dataset was tested for normalcy and homogeneity of variances using Shapiro–Wilk and Levene’s tests, respectively. Wherever required, data were logarithmically transformed to meet the assumptions of ANOVA. Differences in the means of productive and reproductive traits between three regions were assessed with one-way ANOVAs. Differences between means were considered significant if \( P \) values were lower than .05. The entire dataset was analysed with SPSS 22 (Landau and Everett 2004).

**Results and discussions**

**Production characteristics**

The average seasonal daily milk production, average lactation length and lactation yield of yaks from different regions are presented in Table 1. The peak milk production period was between June and October, owing to conducive environment in terms of both favourable climate and availability of abundant forages. The average daily milk productions as per the survey report were 1.27, 1.19 and 1.15 kg, and the measured average daily milk productions were 1.08, 1.01 and 0.94 kg, for eastern, western and central yaks, respectively. Daily milk production both in winter and summer did not differ significantly between yaks of the three regions. Yaks are generally milked once in a day, but it was reported that occasionally yaks in Laya and Lunana in the western region were milked twice daily. This study shows that the daily milk production is almost similar between yak breeds in spite of breeds being genetically different. Although the measured daily milk production was lower than the survey data, they did not differ significantly, which indicates that the survey data are a good estimate. Therefore, it is justified to estimate the overall average daily milk production from three yak breeds, which calculates to about 1 kg per yak cow.

To a great extent, the average daily milk production of western yak agrees with the report of Gyamtsho (1996) who estimated milk production of same yak breed at 1.2 kg in July and 0.90 kg in October. However, both measured and survey milk production data from the eastern and central yaks were higher than those reported by Dorji (2000) for the same yak breeds. Dorji (2000) estimated milk production of eastern and central yaks at 0.74 and 0.58 kg, respectively. The measured milk production of the central yak compares well with the daily milk production of 1.09 kg of a yak in the Bumthang district (Wangdi 2015). The daily milk production of three yak breeds also compares well with the Tibetan yak but is much lower than the Bazhou yak in China. Li and Wiener (1995) recorded the highest daily milk yield of 2.6 kg per animal from the Bazhou yak of Xinjiang in China and the lowest yield of 0.9 kg from the Alpine yak in Tibet.

The overall mean lactation length was about 234 days. Breed wise, the mean lactation lengths were over 244, 232 and 226 days for eastern, central and western yaks, respectively. Although nonsignificant amongst breeds, the lactation length was longer for eastern yak. This could be largely explained by the presence of a large population of zom in eastern region. The zom is a cross between a Yak (Poephagus grunniens) and a Tibetan bull (Bos taurus). The zom is reported to have longer lactation length and produce higher daily milk of lower density as compared to a yak, which could be linked to heterosis resulting from crossbreeding (Wangdi 2015). Besides, the zom is also known to calve earlier in the spring season and

**Table 1.** Productive and reproductive traits of different yak types in Bhutan.

| Parameters                     | LSM (Eastern yak) | SEM | LSM (Western yak) | SEM | LSM (Central yak) | SEM | Significance (p-value) |
|-------------------------------|------------------|-----|------------------|-----|------------------|-----|----------------------|
| **Productive traits**         |                  |     |                  |     |                  |     |                      |
| Summer average daily milk (L) | 1.27             | 0.05| 1.19             | 0.03| 1.15             | 0.04| ≥0.05                |
| Winter average daily milk (L) | 0.33             | 0.15| 0.31             | 0.16| 0.30             | 0.17| ≥0.05                |
| Lactation length (days)       | 244.3            | 4.58| 232.4            | 3.05| 226.6            | 3.05| ≥0.05                |
| Average lactation yield per cow (L) | 154.9         | 20.0| 145.2            | 25.0| 140.3            | 25.0| ≥0.05                |
| **Reproductive traits**       |                  |     |                  |     |                  |     |                      |
| Age at puberty (days)         | 1082.5a          | 29.9| 1123.3a          | 29.6| 1001.3a          | 32.6| ≤0.01                |
| Age at calving (days)         | 2529.0           | 56.6| 2646.0           | 58.04| 2540.0          | 70.08| ≥0.05                |
| Calving interval (days)       | 480.9            | 7.02| 484.6            | 7.93| 493.8            | 9.76| ≥0.05                |
| Gestation period (days)       | 256.6            | 0.83| 257.4            | 0.82| 252.8            | 0.57| ≥0.05                |
| Postpartum oestrus period (days) | 148.8b           | 4.64| 151.5b           | 4.49| 168.6b          | 7.78| ≤0.05                |
| Heat interval (days)          | 21.14            | 0.15| 21.1             | 0.12| 21.1            | 0.14| ≥0.05                |
| Services per conception (no.) | 1.57             | 0.09| 1.65             | 0.09| 1.49             | 0.10| ≥0.05                |

Notes: Figures inside the cells represent least square mean (LSM) ± standard error of means (SEM). LSM followed by different letters are significantly different.

\*p≤0.05, **p≤0.01, ns-non significant.
may have contributed to longer lactation length. Indra and Magash (2000) provide evidence on the dependence of lactation length on calving date. The authors reported that the cows calving in February or March had lactation length of 283 days whereas cows calving in April had lactation length of 231 days.

The importance of determining the lactation yield is to gain a deeper insight into the productivity capacity of a dairy animal. Besides, the lactation yield also indicates the viability of a dairy farm business. The overall mean lactation yield was about 153 kg. The mean lactation yields were over 154, 140 and 145 kg for eastern, central and western yaks, respectively. The lactation yield of the eastern yak is higher than that of the annual calving yak of western Bhutan but lower than that of the alternate year calving yak. Amongst the causes outlined by Li et al. (2011), difference in breeds, parity and body condition feature as some of the main causes of differences in lactation yield. The lactation yield of the western yak in this study agrees with the yield reported by Gyamtsho (1996) for the annual calving yak of same breed. Gyamtsho (1996) estimated the lactation yield of western yak at 130–150 kg milk (120–180 days of milking) for the annual calving yak and 220–250 kg milk (300–360 days of milking) for the alternate year calving yak.

Reproductive characteristics

The reproductive traits of yak breeds from different regions are presented in Table 1. Puberty for the eastern yak occurred at over 1000 days equating to less than 3 years after birth, which is significantly earlier than the yaks of central and western regions. Since the age at first puberty is an important determinant of reproductive efficiency (Mukasa-Mugerwa et al. 1989), our results indicate that the yaks of eastern Bhutan are reproducitively efficient. Attaining puberty at a later age would mean economic loss due to long non-productive period. Yaks of central and western Bhutan have larger body size than the yaks of eastern Bhutan (Dorji 2000). Although a yak with a larger body size is known to attain puberty earlier than a yak with a small body size (Zhang 1989), our results show that smaller yaks of eastern Bhutan attain puberty earlier than the yaks of central and western Bhutan. The contradiction may be explained by the genetic makeup of the breed. Most yaks of eastern Bhutan are cross-breeds of Bos taurus and the breed of Bos taurus is reported to attain puberty earlier (Randel 2005), which might explain why the yak of eastern Bhutan, although smaller, attains puberty earlier than the yak of central and western Bhutan.

The age at first calving was not significantly different between yak breeds. Generally, a yak gave birth to the first calf at the age of 4–5 years. Age at first calving is one of the most important economic traits of dairy animals (Singh et al. 1986). Gyamtsho (1996) reported that the female yaks of western Bhutan are mated for the first time at the age of 3 years or during the fourth warm season after birth. Gyamtsho (1996) also reported about 18% of yaks calving annually and 81% calving in alternative years. Similarly, the respondents of this study revealed that 15% of yaks calve annually and 80% calve in alternative years (data not shown). Majority of calving occurred in the months of May, June and July.

Calving interval did not differ significantly amongst yak breeds. The mean calving interval ranged from 480 to 490 days, which equates to about 1.3 years. The calving interval of this study is lower than the estimate of Gyaltshen and Battarai (2003) who reported a calving interval of about 2 years for the yak of western Bhutan. The calving interval is also shorter than that of 1.53–1.70 years reported for the yaks of Nepal (Shrestha et al. 1996; Neopane et al. 1999).

Gestation period also did not differ amongst yak breeds. The mean gestation period was about 256 days, which is within the mean gestation period range of 240–270 days reported for yaks of western Bhutan (Gyamtsho 1996). The mean gestation period also compares well with that of Zhao (2000) and Joshi et al. (1994) who reported a gestation period of 258 days.

Postpartum oestrus period differed significantly amongst breeds. The overall mean postpartum oestrus period was about 155 days. The period was significantly shorter for the yaks of western Bhutan. Generally, the postpartum oestrus period in this study is much longer than the postpartum oestrus period reported by Zhao (2000) for yaks with both good body condition (over 70 days) or poor body condition (over 122 days). Similar to the report of Cai Li (1989), respondents revealed that, with the exception of cows that have calved in the early spring and with good health conditions prior to calving, the cows that calved generally do not show oestrus in the same year. The longer postpartum oestrus period indicates a poor animal health aspect and poor nutrition. The postpartum anestrus period was also found to be affected by the suckling and energy intake during late pregnancy and after parturition (Zi 2003). However, postpartum anestrus period of this study needs to be validated further since this study noted the lack of proper herd record, poor monitoring by herdsmen and also ignorance of silent heat exhibited by yaks.

The heat interval did not differ significantly amongst breeds. The mean heat interval was about 21 days (ranges 18–28 days), which is quite similar to the heat interval of about 20 days reported by Zhao (2000). However, it is important to note that the signs of heat in yak are less obvious than in other cattle, and detection by herdsmen was reported to be unreliable (Katzina and Maturova 1989). Zhao (2000) reported a great variation in the oestrus cycle length as one of the problems in yak reproduction, greatly affected by the environment where the onset of oestrus is delayed during the unfavourable weather and advanced during the favourable circumstances.

The mean number of services per conception was 1.58. Yaks are bred naturally in the open, where breeding bulls are let loose with the breedable female population in the herd for free mating. Gyamtsho (1996) estimated conception rate of about 80% or more in the yak herd of eastern Bhutan. The conception rate in yak was found to be good with most females in heat successfully conceiving after being served several times either by the same or different bulls (Gyamtsho 1996). High conception rates of over 94% had been observed in Mongolia (Magash 1990) and China (Yu et al. 1993).

Conclusion

The yak breeds of Bhutan may differ genetically amongst each other but they are similar in productive and reproductive traits.
The only reproductive traits that differed amongst yak breeds were age at puberty and postpartum oestrus period. A yak of eastern Bhutan attains puberty earlier but the postpartum oestrus period is longer than the yaks of central and western Bhutan. The performance of yaks in Bhutan is relatively poor in several aspects and poor nutrition appears to be the main reason. It is a known fact that poor nutrition increases the susceptibility of dairy cows to health problem and physiological stress and affects the overall production and reproduction. However, currently, in the absence of comprehensive empirical data on productive and reproductive traits of yaks, the findings of this study may guide and help plan yak development programmes and policies. Drawing experience from this study, there is a need for a proper record keeping on the future performances of productive and productive traits. Improvement in yak production warrants improvement in management practices followed currently by herdiers. Government needs to introduce and implement forage and nutrition development programmes to exploit fully the genetic potential of yaks, besides putting in place an appropriate breeding programme and adequate veterinary services.

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Disclosure statement

No potential conflict of interest was reported by the authors.

References

Dorji T. 2000. Genotypic and phenotypic characterization of the yak (Bos grunniens) and yak farming systems in Bhutan [MSc Thesis]. Melbourne, Victoria, Australia: Institute of Land and Food Resources, The University of Melbourne.

Garoma S. 2014. Reproductive and productive performance of Kereyu Sanga cattle in Fentalle District of Oromia Region, Ethiopia. J Cell Anim Biol. 8(2):28–33.

Gyaltshen T., Battarai BN. 2003. Yak herders in Soe Yaksa. In: Suttie JM, Rome, Italy: FAO; p. 267–275.

Gyamtsho P. 1996. Assessment of the condition and potential for improvement of high altitude rangeland of Bhutan. Diss. ETH No 11726, Zurich.

Gyamtsho P. 2000. Economy of yak herdiers. J. Bhutan Studies. 2(1):90–135.

Haque MN, Haque MR, Parvin A, Hussain MM. 2001. A comparative study on productive and reproductive performance of different crossbred and indigenous dairy cows under small scale dairy farm conditions. Pak J Biol Sci. 4(4):222–225.

Mukasa-Mugerwa E. 1989. A review of reproductive performance of female Bos indicus (Zebu) cattle. ILCA Monograph No. 6. Addis Ababa: International Livestock Center for Africa. p. 2.

Neopane SP, Pokharel PK, Shrestha S. 1999. Evaluation of productive performance of Yak at Solukhumbu. In: Neopane SP, Khanal RC, editors. Proceedings of the Third National Workshop on Livestock and Fisheries Research in Nepal; June 26–28. Lalitpur: NASRI.

Randel RD. 2005. Reproduction of Bos indicus breeds and crosses. In: Procedings, applied reproductive strategies in beef cattle; November 12 and 13. College Station: Texas A&M University.

Shrestha BS, Kshatri KS, Shrestha NP, Sherchand L. 1996. Morphological characteristics and productive and reproductive performance of Yak/Nak. In: Kuvar BS, Shrestha HR, editors. Proceedings of the 1st National Workshop on Livestock/Fisheries Research in Nepal; May 7–9. Lalitpur: National Animal Science Research Institute; p. 73–80.

Singh A, Taylor CM, Singh BN. 1986. Factors affecting some reproduction traits in Malvi cattle. Indian Vet J. 63:388–392.

Sultana N, Rashid MM, Hossain SMJ. 2001. A comparative study on productive and reproductive performance of different crossbred and indigenous dairy cows under small scale dairy farm conditions. Pak J Biol Sci. 4(8):1036–1037.

Tadesse S, Fesaha G, Abebe A, Hailu B, Dejen W. 2010. Assessment of productive and reproductive performances of cross breed dairy cows in Debre Tabor town. J. Biol Agric Healthcare. 4(23):112–114.

Uddin MK, Wadud A, Begum D, Siddiki MSR, Rashid MH. 2008. Productive and reproductive performance of indigenous and crossbred cattle in Comilla district. Bangladesh J Anim Sci. 37(1):39–43.

Wangdi J. 2015. Milk quality from Yak and Zom milk in Bhutan. Livest Res Rural Dev. 27. Article #2; [accessed 2015 Nov 19]. http://www.lrrd.org/lrrd27/1/wang27002.html.

Wiener G. 2013. The yak, an essential element of the high altitude regions of Central Asia. [accessed 2015 Nov 8]. http://emscat.revues.org/2038.

Yu SJ, Huang YM, Chen BX. 1993. Reproductive patterns of the yak. I. reproductive phenomena of the female yak. Br Vet J. 149:579–583.

Zhang R. 1989. China: the yak. Lanzhou: Gansu Scientific and Technology Press. 386 pp.

Zhao XX. 2000. An overview of the reproductive performance. In: Zhao XX, Zhang RC, editors. Recent advances in yak reproduction. Ithaca, NY: International Veterinary Information Service. Available from: http://www.ivis.org.

Zi XD. 2003. Reproduction in female yaks (Bos grunniens) and opportunities for improvement. Theriogenology. 59:1303–1312.