Global Scientific and Academic Research Journal of Multidisciplinary Studies
ISSN: 2583-4088 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journals-gsarjms-home/

Complex Factors Affecting Yaks Reproduction

By

Kamran Hussain[1], Munir Hussain[1], Muhammad Suhail[1], Adnan Ahmed Solangi[1], Salahudeen Ayubi[1], Afaq Ahmad[1], Muhammad Hussain[1], Ruhullah, Kamil Sharif[1], Muhammad Sajid[2]

[1]Faculty of Animal Husbandry and Veterinary Sciences Sindh Agriculture University Tandojam, Pakistan.
[2]Faculty of Veterinary Science University of Agriculture Faisalabad, Pakistan.

Article History

Received: 15/02/2025
Accepted: 21/02/2025
Published: 24/02/2025

Vol – 4 Issue –2

PP: - 90-93

DOI:10.5281/zenodo.14916686

Abstract
Yaks are indispensable to high-altitude communities, providing essential resources such as milk, meat, and transportation. However, their reproductive efficiency is influenced by a multitude of factors, including climate change, nutrition, genetics, and physiology. This review synthesizes current knowledge on the aspects and factors affecting yak reproduction, with a focus on high-altitude ecosystems. An in-depth literature analysis reveals that climate change, nutritional deficiencies, and genetic factors impact yak fertility. The review also depicts the importance of mineral supplements, particularly calcium and phosphorus, in maintaining reproductive health. These findings have pivotal implications for developing strategies to enhance yak reproductive performance, ensuring the sustainability of yak herding in high-altitude regions. Certainly, this review contributes to a deeper understanding of the complex interplay between environmental, nutritional, and genetic factors influencing yak reproductive biology.

Keywords: *Yak Reproduction, High-Altitude Ecosystems, Climate Change Impact, Nutritional Influences, Reproductive Efficiency.*

Introduction

The yak (Bos grunniens), an herbivorous animal native to the high-altitude regions of the Himalayas and surrounding areas (2,500–5,500 meters above sea level), is one of the most considerable domesticated animals globally. The yak, a unique breed that inhabits the alpine pastoral area of the Tibetan Plateau, is one of the rare bovine breeds adapted to high altitudes and cold climates. The adaptive process is extremely complex, consisting of several components that exhibit stable and unique genetic characteristics for regulating the physiological, biochemical, and morphological mechanisms of adaption to a high altitude as shown in Figure 1. Yaks grow rich in environments above the tree line, where frost is intermittent, and provide vital resources such as meat, milk, transportation, shelter (hair), and fuel. Consequently, yak herding is integral to Tibetan culture and serves as a cornerstone of economic stability in mountainous regions. Theoretically, yaks can produce one calf annually, given their gestation period of 250–260 days. However, in practice, they hardly breed once every two years or twice every three years (Zheng, 1986; Cai & Wiener, 1995). Yaks are often crossbred with domestic cattle to produce F1 hybrids known as "dzo", which are valued for their increased milk production and adaptability to lower altitudes (2,500–3,500 meters above sea level) (Rhode et al., 2007). Worldwide, the yak population was estimated at 14.2 million in 2003, with the majority found in China and Mongolia (Wiener et al., 2003). Domestic yaks are also prevalent in Afghanistan, Bhutan, India, Kyrgyzstan, Nepal, Pakistan, Russia, and Tajikistan (Joshi et al., 2020). In Pakistan, yak herding is primarily practiced in the alpine and subalpine regions of Gilgit-Baltistan and Chitral (Khan et al., 2016). Yak reproduction is closely tied to seasonal and climatic conditions, making them seasonal breeders (Wangdi, 2018). Challenges arise during late gestation and early lactation due to winter fodder shortages, which lead to nutritional imbalances and reduced fertility. This is exacerbated by the mobilization of maternal body reserves, further impacting reproductive success (Lopreiato, 2020). Fertility in yak herds is largely determined by the proportion of cows exhibiting estrus in the same year they calve. A study in Sichuan found that 78% of female yaks conceived after the first service, while 15% and 7% conceived after the second and third services, respectively. This review examines the reproductive biology of yaks, focusing on main factors such as climate, nutrition, and seasonal breeding patterns that significantly influence fertility. It also explores the challenges posed by nutritional limitations during late gestation and early lactation, adversely affecting reproductive outcomes. By understanding these factors, the review aims to identify strategies for improving yak reproductive performance and ensuring the sustainability of yak herding in high-altitude ecosystems.

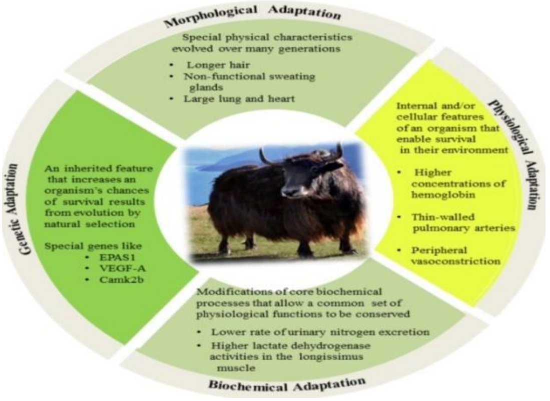

Figure 1. Schematic representation of the yak adaptation to high-altitude environmental stress in comparison to a closely related species (Bos indicus or cattle).

Environmental Influence

Climate change and altitude significantly impact yak reproduction.

Climate Change

Yak reproductive patterns are closely linked to climatic conditions (Wangdi, 2018). During winter, yaks can lose up to 25% of their body weight, and mortality rates increase due to harsh conditions (Zou, 2019). Optimal reproductive performance occurs at temperatures below 5°C, with the hottest month not exceeding 13°C (Wiener, 2003). However, temperature fluctuations limit herbage growth, which is a critical resource for supplemental feed (Miao, 2015; Krishna, 2010). From October to March, winter pastures are often covered in snow, leading to feed shortages and delayed mating seasons. Increased food availability can trigger an early breeding season (Bomford, 1987). Thus, climate change profoundly affects yak reproduction, necessitating supplemental nutrition to mitigate its impact.

Altitude:

High-altitude environments pose unique challenges, including hypobaric hypoxia, cold stress, and oxidative stress, which weaken the immune system and increase disease susceptibility (Mishra, 2010). These conditions also impair normal physiological functions, including reproduction and fecundity (Parraguez, 2005). To address these challenges, strategies such as antioxidant-rich diets (e.g., vitamins E, C, and selenium), shaded shelters, selective breeding for hypoxia resistance, and oxygen therapy can enhance yak adaptation and reproductive performance.

Nutrition and Yak Fertility

Yaks in Tibet are typically fed through two systems: traditional grazing and house feeding. Grazing yaks rely on natural pastures, which are high in crude fiber but low in protein (Palmioli, 2021). In contrast, house-fed yaks receive nutrient-rich diets, improving their overall health and productivity (Mumford, 2020). Nutritional variations influence animal performance and meat quality (Cheng, 2021; Fu, 2022). Blood metabolites and gut microbiota composition are also affected by dietary patterns, with the gut testis axis playing a crucial role in male fertility (Li, 2022; Zhang, 2022). Studies suggest that gut microbiota and blood metabolites collectively regulate semen quality (Han, 2021). Yaks exhibit remarkable adaptability by modulating their blood metabolome and gut microbiota, which are vital for health and reproductive success. This adaptability underscores the intricate relationship between nutrition, metabolism, and reproductive performance.

Genetics and Fertility in Yaks

Genetic selection plays a pivotal role in improving yak fertility. Wiener (1994) proposed that a cow's total calf output by age five could serve as a metric for reproductive efficiency, emphasizing early and regular calving. However, inbreeding is common in smallholder yak farms in China, India, Nepal, and Bhutan, often due to the prolonged use of a single sire (J Anim Sci, 1993; Chen, 1994; Pal, 1994). Inbreeding coefficients above 0.108 reduce calving rates from 56.7% to 43.0%, while coefficients above 0.125 decrease calf survival from 93.5% to 66.7% (Chen, 1994).

Physiology and Yak Reproduction

The yak reproductive system exhibits dynamic physiological changes. HIF-1α protein expression varies across estrous cycles, peaking in the ovary and fallopian tube during the luteal phase and in the uterus during pregnancy (Fan et al., 2020). Proteins like Bcl-2 and Bax play critical roles in fetal and placental development, showing dynamic expression in pregnant and postpartum yaks (Fan et al., 2017). FSHR protein expression peaks during estrus declines in diestrus, and rises again in proestrus (Abudureyimu et al., 2018). Postpartum, female yaks experience a negative energy balance, leading to excessive fatty acid mobilization and low reproductive hormone levels, which delay the recovery of reproductive function (Shu, 2022).

Minerals and Reproductive Health in Yaks

Calcium (Ca) and phosphorus (P) deficiencies disrupt reproductive processes, including gamete maturation and fetal development (De Clercq, 2018; Call, 1978). In yaks, inadequate mineral intake during winter depletes body reserves, impairing reproductive potential. Supplementation with Ca and P enhances reproductive efficiency in ruminants (Pinedo, 2017; Dunn, 1992). Calcitonin regulates serum calcium levels, with hypercalcemia reducing Ca concentrations by inhibiting bone resorption and promoting urinary excretion (Findlay, 2004; Murray, 2008). Maintaining adequate mineral levels is crucial for yak reproductive health.

Conclusion

Yak reproduction is influenced by a complex interplay of environmental, nutritional, genetic, and physiological factors. Climate change and altitude-induced stressors, such as hypobaric hypoxia and oxidative stress, significantly impact fertility. Nutritional deficiencies, particularly during late gestation and early lactation, further exacerbate reproductive challenges. Genetic selection and mineral supplementation, especially calcium and phosphorus, are crucial for improving reproduction or growth. By addressing these factors through selected strategies—such as antioxidant-rich diets, selective breeding, and mineral supplementation—yak herders can increase reproductive efficiency and ensure the sustainability of yak production in high-altitude ecosystems. This review underscores the need for integrated ways to abate the challenges faced by yak herding communities, finally contributing to preserving this meaningful and vital resource.

Authors contributions

First Author: Kamran Hussain, Conceptualized and wrote the manuscript.

2nd Author: Munir Hussain, Muhammad Suhail, help in arranging the data and also help is writing.

Adnan Ahmed Solangi, Salahudeen Ayubi, Afaq Ahmad: Help in arranging references.

Muhammad Hussain, Ruhullah, Kamil Sharif: Contribute in reviewing the final manuscript.

References

1. Cai L, Wiener G. The yalk. Bangkok: RAP Publication; 1995.
2. Zheng PL. Bovine breeds in China. Shanghai: Scientific and Technical Publishers; 1986.
3. Rhode, D., D. B. Madsen, P. J. Brantingham, and T.Dargye. 2007. Yaks, Yak Dung, and Prehistoric Human Habitation of the Tibetan Plateau. Developments in Quaternary Sciences 9:205–224. DOI: 10.1016/S1571-0866(07)09013-6.
4. Wiener, G., Jianlin, H., & Ruijun, L. (2003). The yak (2nd Ed.). FAO Regional Office for Asia and the Pacific (RAP).
5. Joshi, S., L. Shrestha, N. Bisht, Ning Wu, M. Ismail, T. Dorji, G. Dangol, and R. Long. 2020. Ethnic and Cultural Diversity amongst Yak Herding Communities in the Asian Highlands. Sustainability 12(3):957. DOI: 10.3390/su12030957.
6. Khan, B., Abbas, S., Khan, Z.M., Khan, G., Anjum, M., Baig, S., Jamal, S. (2016). 'Indigenous Practices of Yak Breeding in Gilgit-Baltistan: Current status and future prospects for transboundary yak husbandry in the Karakoram-Pamir mountain area'. In Wu, N; Shaoliang, Y; Joshi, S; Bisht, N (2016). Yak on the Move, Transboundary Challenges and Opportunities for Yak Raising in a Changing Hindu Kush-Himalayan Region. ICIMOD, Kathmandu, Nepal.
7. Wangdi, J.; Wangchuk, K. Productive and reproductive traits of yak types in Bhutan: Characteristics and comparisons. J. Appl. Anim. Res. 2018, 46, 893–89.
8. Lopreiato, V, Mezzetti, M, Cattaneo, L, Ferronato, G, Minuti, A, and Trevisi, E. Role of nutraceuticals during the transition period of dairy cows: a review. J Anim Sci Biotechnol. (2020) 11:96. doi: 10.1186/s40104-020-00501-x.
9. Wangdi, J.; Wangchuk, K. Productive and reproductive traits of yak types in Bhutan: Characteristics and comparisons. J. Appl. Anim. Res. 2018, 46, 893–897.
10. Zou, H.; Hu, R.; Wang, Z.; Shah, A.M.; Zeng, S.; Peng, Q.; Xue, B.; Wang, L.; Zhang, X.; Wang, X. Effects of nutritional deprivation and re-alimentation on the feed efficiency, blood biochemistry, and rumen microflora in yaks (Bos grunniens). Animals 2019, 9, 807.
11. Wiener, G.; Han, J.; Long, R. The Yak; FAO Regional Office for Asia and the Pacific: Bangkok, Thailand, 2003.
12. Miao, F.; Guo, Z.; Xue, R.; Wang, X.; Shen, Y. Effects of grazing and precipitation on herbage biomass, herbage nutritive value, and Yak performance in an alpine meadow on the Qinghai–Tibetan Plateau. PLoS ONE 2015, 10, e0127275.
13. Krishna, G.; Ramesh, K.; Chakravarty, P.; Chouhan, V.; Jayakumar, S. Effect of environment on reproductive traits in yaks. Indian J. Anim. Sci. 2010, 80, 123–124.
14. Wiener, G. The yak, an essential element of the high altitude regions of Central Asia. Etudes Mongoles ET Siberienne 2013.
15. M. BomfordFood and reproduction of wild house mice I. Diet and breeding seasons in various habitats on irrigated cereal farms in New South WalesAust. Wildl. Res. (1987).
16. Krishnan, G.; Paul, V.; Biswas, T.K.; Chouhan, V.S.; Das, P.J.; Sejian, V. Adaptation strategies of yak to seasonally driven environmental temperatures in its natural habitat. Int. J. Biometeorol. 2018, 62, 1497–1506. [Google Scholar] [CrossRef] [PubMed].
17. Mishra, K.P.; Ganju, L. Influence of High Altitude Exposure on the Immune System: A Review. Immunol. Investig. 2010, 39, 219–234. [Google Scholar] [CrossRef].
18. Parraguez, V.H.; Atlagich, M.; Díaz, R.; Bruzzone, M.E.; Behn, C.; Raggi, L.A. Effect of hypobaric hypoxia on lamb intrauterine growth: Comparison between high- and low-altitude native ewes. Reprod. Fertil. Dev. 2005, 17, 497–505. [Google Scholar] [CrossRef].
19. Palmioli E, Dall'Aglio C, Bellesi M, Tardella FM, Moscatelli S, Scocco P, et al. The apelinergic system immuno-detection in the abomasum and duodenum of sheep grazing on semi-natural pasture. Animals (Basel). (2021) 11:3173. doi: 10.3390/ani11113173PubMed Abstract | CrossRef Full Text | Google Scholar.
20. Mumford SL, Johnstone E, Kim K, Ahmad M, Salmon S, Summers K, et al. A prospective cohort study to evaluate the impact of diet, exercise, and lifestyle on fertility: design and baseline

characteristics. Am J Epidemiol. (2020) 189:1254–65. doi: 10.1093/aje/kwaa073PubMed Abstract | CrossRef Full Text | Google Scholar.

21. Cheng J, Wang L, Wang S, Chen R, Zhang T, Ma H, et al. Transcriptomic analysis of thigh muscle of Lueyang black-bone chicken in free-range and caged feeding. Anim Biotechnol. (2021) 2021:1–11. doi: 10.1080/10495398.2021.1993235PubMed Abstract | CrossRef Full Text | Google Scholar.
22. Fu Y, Yin J, Zhao N, Xue G, Zhang R, Li J, et al. Effects of transport time and feeding type on weight loss, meat quality and behavior of broilers. Anim Biosci. (2022) 35:1039–47. doi: 10.5713/ab.21.0381PubMed Abstract | CrossRef Full Text | Google Scholar.
23. Li X, Cheng W, Shang H, Wei H, Deng C. The interplay between androgen and gut microbiota: is there a microbiota-gut-testis axis. Reprod Sci. (2022) 29:1674–84. doi: 10.1007/s43032-021-00624-0PubMed Abstract | CrossRef Full Text | Google Scholar.
24. Zhang T, Sun P, Geng Q, Fan H, Gong Y, Hu Y, et al. Disrupted spermatogenesis in a metabolic syndrome model: the role of vitamin A metabolism in the gut-testis axis. Gut. (2022) 71:78–87. doi: 10.1136/gutjnl-2020-323347PubMed Abstract | CrossRef Full Text | Google Scholar.
25. Han H, Zhong R, Zhou Y, Xiong B, Chen L, Jiang Y, et al. Hydroxytyrosol benefits boar semen quality via improving gut microbiota and blood metabolome. Front Nutr. (2021) 8:815922. doi: 10.3389/fnut.2021.815922PubMed Abstract | CrossRef Full Text | Google Scholar.
26. Wiener G.Opportunities and constraints for genetic improvement with reference to the yak.In:Proceedings of the First International Congress on Yak.Lanzhou,China;1994,p.35-44.
27. Corpus luteum function and fertility of post suckled beef cows.J Anim Sci 1993:2579-85.
28. Chen YK,Tang ML,Yuan YQ,Liu B.Preliminary study on the effect of inbreeding on reproductiveperformance of yak females.China Yak 1994;2:14-7 [in Chinese].
29. Pal RN,Barari SK,Biswas D.Yak(Poephagus gunniens L.)Husbandry in India.Asian Livest 1994; 10:126-8.
30. Fan JF, et al. The expression of hypoxia-inducible factor-1 alpha in primary reproductive organs of the female yak (Bos grunniens) at different reproductive stages. Reprod Domest Anim. 2020; 55(10):1371–82. Article CAS PubMed Google Scholar.
31. Fan JF, et al. Bcl-2/Bax protein and mRNA expression in yak (Bos grunniens) placentomes. Theriogenology. 2017; 104:23–9. Article CAS PubMed Google Scholar.
32. Shu S, Fu C, Wang G, Peng W. The effects of postpartum yak metabolism on reproductive system recovery. Metabolites. 2022; 12(11).
33. Abudureyimu A, et al. Expression and localization of follicle-stimulating hormone receptor in the yak uterus during different stages of the oestrous cycle. Reprod Domest Anim. 2018; 53(6):1539–45. Article CAS PubMed Google Scholar.
34. De Clercq K., Vriens J. Establishing life is a calcium-dependent TRiP: Transient receptor potential channels in reproduction. Biochim. Biophys. Acta. Mol. Cell Res. 2018; 1865:1815–1829. doi: 10.1016/j.bbamcr.2018.08.005. [DOI] [PubMed] [Google Scholar].
35. Call J.W., Butcher J.E., Blake J.T., Smart R.A., Shupe J.L. Phosphorus influence on growth and reproduction of beef cattle. J. Anim. Sci. 1978; 47:216–225. doi: 10.2527/jas1978.471216x. [DOI] [PubMed] [Google Scholar].
36. Pinedo P., Velez J., Solano G., Rodriguez N., Naves J., Schuenemann G.M., Risco C. Effect of oral calcium administration on the cure and reproductive performance of Holstein cows diagnosed with puerperal metritis. J. Dairy Sci. 2017; 100:2917–2927. doi: 10.3168/jds.2016-11577. [DOI] [PubMed] [Google Scholar].
37. Dunn T.G., Moss G.E. Effects of nutrient deficiencies and excesses on reproductive efficiency of livestock. J. Anim. Sci. 1992; 70:1580–1593. doi: 10.2527/1992.7051580x. [DOI] [PubMed] [Google Scholar].
38. Findlay D.M., Sexton P.M. Calcitonin. Growth Factors. 2004; 22:217–224. doi: 10.1080/08977190410001728033. [DOI] [PubMed] [Google Scholar].
39. Murray R.D., Horsfield J.E., McCormick W.D., Williams H.J., Ward D. Historical and current perspectives on the treatment, control and pathogenesis of milk fever in dairy cattle. Vet. Rec. 2008; 163:561–565. doi: 10.1136/vr.163.19.561. [DOI] [PubMed] [Google Scholar].

*Corresponding Author: **Kamran Hussain**