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Yak mortality in free-range grazing systems: A case study in Laya Block, Bhutan

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Abstract

Yak farming is economically and culturally vital to highland communities, providing protein-rich products in harsh environments. Despite their resilience, yak mortality presents a serious challenge. This study aims to examine the causes of yak mortality to inform effective management strategies for sustaining this essential species. Data were collected through face-to-face interviews using semi-structured questionnaires via the Epicollect5 mobile application. All 53 herders from Laya Block were interviewed to gather information on mortality causes, herders' characteristics, and income. Approximately 94.3 % of herders reported yak mortality, with an annual mortality rate of 7.9 % and a mean loss of 5.3 yaks per household. Yak mortality is primarily caused by wildlife depredation, which accounts for 58.8 % of total proportional mortality. On average, each household loses 3.1 yaks annually to wildlife predation, representing a 4.6 % mortality rate relative to the total yak population. The second leading cause is Gid (Coenurosis), responsible for 23.7 % of deaths, with an average of 1.2 yak losses per household and a 1.9 % mortality rate per total population. Other factors such as winter fodder shortages, accidents, harsh winter conditions, and natural causes contribute smaller shares to the overall yak mortality. However, no significant difference in mortality rates was observed between the two leading causes across age groups ($p > 0.05$), indicating equal vulnerability and highlighting the urgent need for intervention strategies to mitigate these challenges and promote the conservation of this vital ruminant species in highland communities.

Keywords: block, herders, highland, mortality, yak

1 Introduction

The yak (*Bos grunniens*) is a unique ruminant animal found in the high altitudes of the Himalayas and the Tibetan Plateau. It plays an important role in the economy of the highland communities, ensuring their daily livelihood (Rai *et al*., 2023) as the land is not much suitable for crop production in this region (Joshi *et al*., 2020). Yak provide essential foods such as, milk, meat and dairy products like cheese, dried hard cheese (locally called chuugo) and whey. These are the main source of protein for the highland populations (Wangdi & Wangchuk, 2018). The long outer fur of yak is used to make rope, tents, bags, and coats. These materials are also used to make blankets and clothes (Rhode *et al*., 2007). Yak also provide essential services, including the transportation of goods and agricultural traction (Derville & Bonnemaire, 2010). Beyond their practical uses, yaks also symbolise the uniqueness and aesthetic qualities of highland traditions and culture (Joshi *et al*., 2020).

Likewise, in 11 highland districts of Bhutan, traditional yak husbandry is practiced, with an estimated population of 30,328 yaks and 7,435 cattle-yak hybrids (locally called *Zo* for male and *Zom* for female animals) (National Statistics Bureau - NSB, 2022). In these region, yak farming serves as the primary source of income for highland communities (Gyamtsho, 2000). Yaks are reared for a various purpose, including the production of milk and meat, the generation of draft power, the supply of hides and dung. Furthermore, the milk is processed into various yak dairy products such as butter, cheese, dried hard cheese (locally called *chuugo*), fermented milk cream (locally called *phelu* in the western yak-growing region), and fermented cheese (called *yidpa* locally in the eastern region). The yak are not only source of

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economy of the highland communities, but they also serve as crucial part in their tradition and culture (Wangchuk *et al*., 2013). To highlight the connections between highland cultures, traditions, and yak farming, the Royal Highland Festival in Bhutan was introduced in 2016. The event aims to empower highland communities by unlocking economic opportunities (Dema *et al*., 2024). For example, tourism and the sale of yak-based products are significant contributors to the income of yak herders during the festival (Wangdi *et al*., 2021).

Yaks thrive at an altitude ranging from 2,500 to 6,000 m above sea level, in cold and humid climatic zone (Wangda, 2018) and are the only large livestock animals capable of surviving such adverse environmental conditions (Krishnan *et al*., 2016). Due to their natural adaptability to high-altitude conditions, yaks are typically left to graze freely in vast rangelands with minimal supervision from herders. Only lactating females and young calves are usually gathered and tethered at night for protection and ease of milking. They exhibit high adaptability to extreme climatic conditions, demonstrating resistant to cold winters, anoxic conditions, and disease risks (Wang *et al*., 2019). However, despite their resilience, yak mortality remains a significant problem affecting the sustainability of yak farming in highland communities (Dorji *et al*., 2021; Dorji *et al*., 2022; Gyembo *et al*., 2023). The complex interplay of environmental, nutritional, genetic, and infectious diseases contributes to yak mortality, presenting a multifaceted challenge that requires extensive scientific investigation.

Several studies have reported on the yak mortality due to wildlife predation, diseases, winter fodder shortage, harsh climatic conditions, accidents and natural causes (Namgail *et al*., 2007; Kinga *et al*., 2022; Dorji *et al*., 2021; Kharel *et al*., 2000). However, previous reports have not comprehensively covered the different causes of yak mortality. Further, previous research has not studied yak mortality in Laya block. Therefore, the current study aims to explore various causes of yak mortality, assess the mortality rate, and understand the factors causing yak mortality. This understanding is critical for developing effective management strategies to sustain and protect this culturally and economically important species.

2 Materials and methods

2.1 Study area

The study was conducted in Laya block, situated in the northwestern region of Bhutan (latitude 28° 68’ 04.00" N, longitude 89° 41’ 00.00" E), approximately 5–6 hours away on foot from the nearest road point. This block, nestled at an altitude of 3000 m above sea level., spans 981.5 km² and is entirely encompassed within the Jigme Dorji Wangchuk National Park, designated as a protected area in Bhutan. The communities residing in this block predominantly rely on cordyceps[1] collection and engage in agricultural activities maintaining livestock, primarily horses and yaks, to sustain their livelihoods.

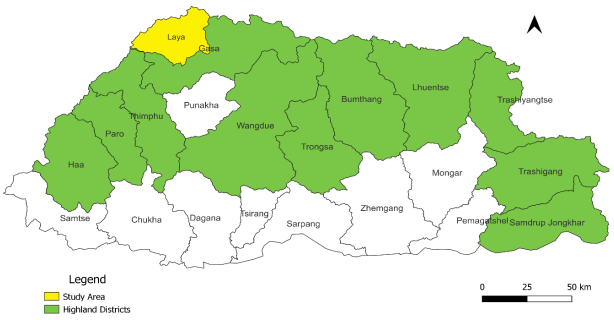

Fig. 1: *The Bhutan map showing study site (Laya) and highland districts.*

2.2 Data collection

The data were collected through face-to-face interviews using a set of semi-structured questionnaires developed in web-based mobile application called Epicollect5. Then the questionnaire was translated into the Dzongkha dialect (Bhutanese National Language) for interviews, as most of the herders lack formal education.

This study employed survey sampling, interviewing all 53 herders in Laya Block. Yak herd visits took place in October 2023, documenting yak mortality over the preceding year (October 2022 – October 2023). Information on respondents’ characteristics and income sources was collected to assess potential correlations with yak mortality. Additionally, data on possible causes of mortality were gathered.

For gid disease also known as coenurosis, losses were categorised by age into three groups: 0–1 year, 1–2 years, and 2–3 years, as only yak calves are susceptible. Wildlife depredation losses were grouped into young (0–3 years), adult females (above 3 years), and adult males (above 3 years). Sex differentiation was not possible for young yaks due to data limitations. Other mortality causes were recorded solely by loss numbers, and data on mortality from other diseases were not collected due to herders’ limited knowledge of their prognosis.

[1]It is a fungus found in the high-altitude regions of Bhutan, valued for its medicinal properties and known for its high market price.

Table 1: *Yak losses due to various causes in Laya block (Oct 2022 to Oct 2023).*

Causes of mortality	*Mean mortality per household*	*Mortality rate per total population (%)*	*Proportional mortality rate (%)*
Wildlife depredation	3.2	4.6	58.8
Gid (Coenurosis)	1.3	1.9	23.7
Winter fodder shortage	0.1	0.2	2.2
Accident	0.3	0.5	6.5
Harsh winter climatic condition	0.2	0.2	2.9
Natural death (old age)	0.3	0.5	6.1

2.3 Data analysis

Data were entered into Microsoft excel 2016 and then exported to Jamovi (version 2.3.24) for analysis. Numerical data, such as the age of respondents, herd size, and number of mortalities, underwent normality checks using the Shapiro-Wilk test. Respondents' income sources, education levels, and both annual mortality rate per herd and proportional mortality were presented as percentages. The mean was used to summarize the number of yak losses attributed to various causes, median was used to present yaks, horses, and utility dogs owned by the herders as data deviates from the normality. To compare the yak mortality caused by different potential factors, Kruskal-Wallis H tests were conducted. Additionally, Mann-Whitney U tests were employed to compare mortality between the two primary causes (gid and wildlife depredation) at a significance level of $\alpha = 05$.

3 Results

3.1 Herders' characteristics

In October 2023, a total of 53 herds were surveyed. The median age of the herders was 50 years. Among the herders engaged in yak herding, 60.4 % were female and 39.6 % were male. Regarding education, the majority of herders (79.0 %) had not received any formal education. However, some had attended formal education, including primary school (11.3 %), secondary school (5.7 %), and monastic education (3.8 %). The survey also revealed a total of 3,495 yaks, with a median of 54.5 yaks per household. Additionally, households owned a median of 9 horses and 2 utility dogs each.

3.2 Herders' income

The survey revealed diverse income sources for herders, including yak farming, cordyceps collection, pack pony charges, business activities, and collection of herbs and medicinal plants. More than half of the herders (75.5 %) reported that their topmost important sources of income from the sales of yak based-products (*Chuugo*, butter, yak-fur). Conversely, a smaller proportion of herders considered cordyceps (15.1 %) and pack pony (5.7 %) as their topmost main source of income. When asked about their second most important source of income, half of the herders (58.5 %) identified the sales of cordyceps. Fewer herders reported that charges from pack pony services (22.6 %) and yak farming (16.9 %) were their second most important sources of income. The survey also recorded various third most important income sources among herders. For 25 herders (47.2 %), charges from pack pony services were identified as their third most important income source. Few herders reported their third most important income sources as the collection of medicinal and herbal plants (26.4 %), sales of cordyceps (13.2 %), yak farming (7.5 %), and business activities (5.7 %).

3.3 Yak mortality

The majority of herders (94.3 %) reported that they had experienced yak mortality, while a few (5.7 %) did not encounter any yak mortality within the one-year period from October 2022 to October 2023. In total, 279 yaks died, resulting in an overall mortality rate of 7.9 % for the year and with the mean of 5.3 per herd. It was recorded that more yaks died in herds managed by females (62.4 %) than by males (37.6 %). Yak mortality due to Gid disease varies based on the herders' level of education. A higher number of yaks died in the group of herders without any formal education (62.1 %) compared to those with primary (9.1 %), monastic (3.0 %), and secondary education (4.5 %).

The study identified wildlife depredation and gid disease as the main causes for yak mortality followed by other factors like accidents, extreme climatic conditions, natural death and winter fodder shortage (Table 1). Further, identified multiple causes of yak mortality, with wildlife predation emerging as a major threat (Table 1). Predators such as the Himalayan wolf (*Canis himalayensis*), Tibetan black bear (*Ursus thibetanus*), snow leopard (*Panthera uncia*), and dholes (*Cuon alpinus*) were found to be frequently preying

on yaks, contributing significantly to high mortality rates. Overall, there was no significant difference in the mortality rate relative to the total population between the two main categories of mortality causes ($p > 0.05$). However, the proportion of deaths caused by wildlife depredation was significantly higher compared to other causes ($p < 0.05$) (Table 1).

Among all, wildlife predation has contributed to yak mortality across all age groups (Figure 2). Young yak calves dominated the highest mortality rate (40.2 %), followed by adult females (30.5 %) and adult males (29.3 %). Similarly, Gid disease caused slightly higher mortality in calves aged 1–2 years (53.0 %) compared to those aged 0–1 years (25.8 %) and 2–3 years (21.2 %) (Fig. 3). However, no significant differences in mortality due to Gid disease were observed across age groups ($p > 0.05$).

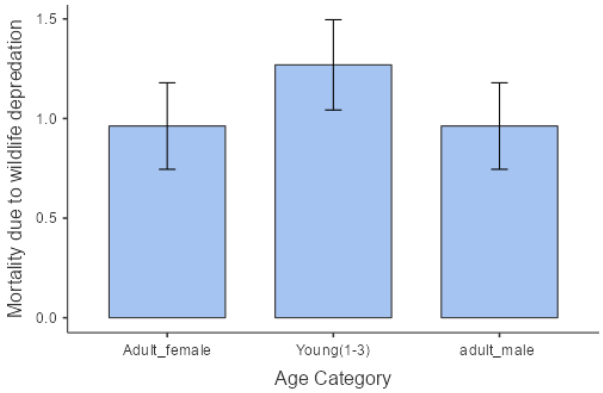

Fig. 2: *Yak mortality caused by wildlife predation.*

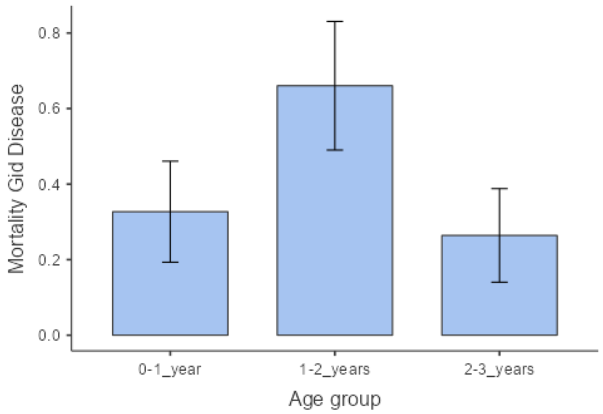

Fig. 3: *Yak mortality caused by gid disease.*

4 Discussion

This study is essential for analysing and assessing yak mortality patterns. Additionally, examining the relationship between herders' social characteristics and mortality rates plays a crucial role in developing effective strategies to sustain yak farming. In the current study, the majority of respondents (94.3 %) reported experiencing yak mortality, which contrasts with a lower mortality rate of 77 % recorded in selected rangeland areas of Bhutan (Kinga *et al.*, 2022). This variation may be attributed to multiple factors, including differences in environmental conditions, predator presence, disease prevalence, management practices, and human activities. For example, predator presence emerged as a significant factor affecting yak mortality rates, as yaks become vulnerable to the various types of predators (Namgail *et al.*, 2007). Environmental conditions such as harsh winter climates and fodder shortages also play crucial roles in influencing yak mortality rates. These conditions can weaken animal's immune system, making them more susceptible to diseases and environmental stressors that can lead to cause mortality (Shah *et al.*, 2023). The variations observed among variables, such as the rate of mortality, can be attributed to a multitude of environmental and management factors. These include climatic conditions, altitude, and grazing patterns, all of which significantly influence the health and well-being of yak populations. Moreover, the study highlighted that the social characteristics of herders' influence yak mortality rates. It was observed that higher yak mortality occurred in herds owned by women, potentially due to differences in resource access. Additionally, herders with no formal education were found to have limited awareness of yak diseases, which may contribute to increased mortality rates. The study also revealed that involvement in multiple economic activities often led to labour shortages, resulting in yaks being unattended. This lack of supervision placed the yaks at higher risk of wildlife depredation and diseases.

4.1 Mortality by wildlife depredation

While wildlife depredation emerges as a topmost contributor to yak mortality (Table 1). This finding is consistent with previous study where high yak mortality due to wildlife predation reported under Jigme Singye Wangchuk National Park at Bumthang district (Wang & Macdonald, 2006). Notably, the presence of several apex predators, including the Himalayan wolf, Tibetan black bear, Snow leopard, and Dholes has been reported as a primary cause of yak deaths in this study area. Specifically, the Himalayan wolf, snow leopard, and Dholes are frequent causes of yak mortality in this region. These apex predators target vulnerable yak individuals, including both calves and adults resulting in significant losses to yak populations and posing a considerable challenge to herders' livelihoods. Interestingly, these findings align with previous reports from Ladakh, India, where

the wolf, snow leopard, and dholes were identified as the primary predators causing livestock losses (Namgail *et al*., 2007). This consistency across different regions highlights the universal challenges faced by highlanders in mitigating human-wildlife conflicts and protecting livestock from predation. The protected parks in Bhutan, governed by strict conservation laws and regulations that reflect the Bhutanese government's strong commitment to conservation. This dedication is closely tied to cultural and religious values that emphasize environmental conservation. However, the combination of conservation policies within these areas has resulted in increased livestock losses to wild carnivores, leading to conflicts between local communities and wildlife (Wang & Macdonald, 2006). The reported data reveals a similar average mortality rate of adult female yaks (0.9 %) and adult male yaks (0.9 %) due to wildlife depredation. Similarly, mortality rate for young yak calves (1.3 %) was reported slightly higher than for adult yaks. However, Kruskal – Walis test indicates no significant differences in mortality among age groups (P<.05), suggesting that wildlife predators pose a threat to yaks of all ages. Despite this notable impact, detailed information on the specific predators involved and seasonal mortality due to predators remains elusive in this study as constrained by herders' limited records on seasonal bases.

4.2 Yak mortality by gid disease

The study identified gid disease as the second leading cause of yak mortality in the Laya block. This parasitic disease is prevalent among highland ruminants, particularly affecting young yak calves under three years of age. It poses a significant threat to yak-farming communities, often leading to substantial economic losses. Several studies have documented gid disease as a contributing factor to high yak mortality rates in highland communities (Zhang *et al*., 2019; Wangdi & Wangchuk 2021; Abbas *et al*., 2024). The findings of this study align with previous reports, including those by Wangdi & Wangchuk (2021), which indicate a high prevalence of gid disease among yaks in the Laya block. The high mortality rate due to gid disease can be attributed to the remoteness of yak herds from the nearest animal health facilities. Furthermore, recent studies have highlighted the alarming rates of gid disease affecting yak populations in the Lingshi (70 %) and Sephu (65 %) blocks, as reported by Wangmo & Norbu (2024). These reports highlight the significant health challenges faced by yaks in these areas, where lack of effective local treatment have negative implications for both yak production and mortality. Although surgical intervention and deworming remain the primary treatment and preventive measures, the remote locations of yak herds often limit access to these kind of animal health services (Dorji *et al*., 2022). Hence, the consistency between these earlier findings and the result of our study reinforces the importance of continued research and intervention efforts to address the gid disease burden in yak populations in highland regions.

4.3 Other factors causing yak mortality

Other contributing factors like winter fodder shortage, harsh winter climatic conditions, accidents, and natural death also caused yak mortality. The mortality among yaks due to fodder shortage and cold weather tends to reach its peak during the winter season, which typically spans from December to February. This finding agrees with previous research indicating that a shortage of grass during winter can lead to malnutrition among yaks, significantly increasing the likelihood of mortality (Shah *et al*., 2023). Additionally, herders have consistently noted that a significant portion of mortality due to old age coincides with this period, particularly when there is a deficiency in essential nutrition. Conversely, mortality attributed to accidents appears to occur consistently throughout the year, irrespective of the seasonal variations.

5 Conclusion

This study concludes that yak mortality in Laya block is primarily caused by wildlife predation and gid disease, which both contribute significant challenges to the sustainability of yak farming in highland regions. These findings suggest for strategic mitigation plans and robust policy interventions from relevant government agencies to address wildlife depredation issues. In addition, the results emphasize the importance of strengthening the outreach of animal health services in remote areas and promoting preventive measures such as the regular deworming of definitive hosts to control gid disease.

Moreover, other contributing factors such as accidental deaths, natural aging, winter fodder shortages, and harsh climatic conditions underscore the complexity of yak mortality and the need for comprehensive management approaches. These insights highlight the urgent need for targeted improvements in local herd management practices to reduce yak mortality effectively. Specifically, sustainable pasture management like rotational grazing and improved fodder availability to mitigate winter fodder shortages. Finally, further research focusing on seasonal variations in yak mortality is recommended to develop more precise and effective intervention that ensure the long-term sustainability and economic viability of yak farming.

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