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Research Article

Livestock depredation and community responses in Bhimsen rural municipality, Gorkha district, Nepal

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ABSTRACT

Conflict between humans and wildlife is a major problem for global wildlife conservation. Conflicts between humans and leopards are common throughout their global range. In Bhimsen Rural Municipality, Gorkha district, Nepal, this study was conducted during 2020-2021 to evaluate livestock depredation by common leopards (*Panthera pardus*), its causes, and locally implemented mitigation measures. A questionnaire survey was used to triangulate the data from livestock owners' compensation claims submitted to the Division Forest Office (DFO) Gorkha and the Manaslu Conservation Area Office, Manaslu Gorkha (n=113). Goats accounted for the majority of the 91 animals that were killed (mean = 82.5, 91%), followed by cattle (mean = 5, 5.5%) and buffaloes (mean = 3, 3.3%). With the highest monthly losses in December (mean = 15.0) and January (mean = 13.5), depredation peaked in the afternoon (12–5 PM, 33.9%) and late at night (12–5 AM, 20.15%). The conversion of crop land into forest (24.8%), an increase in leopard populations (22.1%), and a decrease in wild prey (20.4%) were the primary apparent causes of the majority of the incidents (58%), which happened within 100 meters of forest edges. Predator-proof corrals (23%) and active guarding (19.5%) were local mitigation measures. The distance from the forest and the incidence of cattle depredation were inversely correlated. The respondents' attitudes toward leopard conservation were favorable. Based on these results, the study suggests improving local conflict-resolution skills and bolstering livestock protection close to forests.

Keywords: Conflict, livestock depredation, perception

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INTRODUCTION

The common leopard (*Panthera pardus*) is among the most adaptable and widely distributed wild cats, occupying diverse habitats such as rainforests, deserts, urban fringes, and remote mountain ranges (Nowell & Jackson, 1996). The adaptability of common leopards stems from their varied diet, which includes arthropods, amphibians, and carrion, their minimal dependence on free water, and their smaller size compared to other big cats, which allows them to thrive in smaller areas. Despite being the smallest of the 'big cats', they have the broadest distribution among wild cat species, thriving in environments ranging from deserts and mountains to jungles and swamps. Individual leopards can be identified by their unique spot patterns. Their distinctive black spots contrast with a pale background and white underparts, with small, solid black spots on the head, throat, chest, and lower limbs, and larger patches on the belly. The back, flanks, and upper limbs display pale-centered rosettes that vary in shape and size. Leopard appearances differ significantly across their range, often reflecting their

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habitat. Melanism, a common and striking variation, is frequent in forest and mountainous populations and is most common in Asia. Melanistic leopards, known as 'black panthers', are entirely black and sometimes mistakenly considered a separate subspecies. Leopards in savanna regions tend to be reddish or yellow-brown, desert leopards pale cream or yellow-brown, those from cooler regions grey, and rainforest and high-mountain leopards dark golden. Leopards in open countries are generally larger than their forest-dwelling counterparts. Leopards are exceptional predators, with long, well-muscled bodies, thick limbs, and broad, powerful paws. Their powerful jaws can kill and dismember prey, while long, sensitive whiskers help them navigate and hunt at night. Long eyebrow hairs protect their eyes from vegetation. Leopards are agile climbers, using their heavily-muscled shoulders and forelimbs to climb, pin down prey, and haul it into trees (Khorozyan *et al.*, 2015).

Human-wildlife conflict (HWC) is a global conservation challenge, often escalating where humans and wildlife, particularly large carnivores, share landscapes and resources (Inskip & Zimmerman, 2009). Key drivers include habitat modification, depletion of natural prey, and growth of human and livestock populations (Treves & Karanth, 2003; Kabir *et al.*, 2014). Common manifestations such as livestock depredation lead to significant economic losses, erode local tolerance for wildlife, and can trigger retaliatory killings, creating a detrimental cycle for both people and conservation (Barua *et al.*, 2013; Kshettry *et al.*, 2017). In Bhimsen Rural Municipality, Gorkha District, Nepal, livestock depredation by the common leopard (*Panthera pardus*) has become a pressing socio-ecological and economic issue, threatening local livelihoods and hindering for leopard conservation. While human-leopard conflict is documented globally and in other regions of Nepal, a detailed assessment of its spatiotemporal patterns, underlying drivers, and the efficacy of local mitigation and compensation measures within the mid-hill landscape of Bhimsen Rural Municipality remains lacking. This gap hinders the development of targeted, evidence-based management strategies for this area. This study provides novel, localized insights by integrating official compensation records with community survey data to triangulate depredation patterns, economic impacts, and the perceived effectiveness of responses in a specific rural Nepalese context.

This research was therefore conducted to address the identified knowledge gap, with the following specific objectives: 1) to quantify the spatiotemporal patterns and economic impact of livestock depredation by leopards in Bhimsen Rural Municipality; 2) to identify the primary perceived causes of conflict and evaluate the effectiveness of locally adopted mitigation measures; 3) to assess community perceptions towards leopards and the existing governmental compensation scheme; and 4) to provide evidence-based recommendations to reduce conflict and foster sustainable human-leopard coexistence in the study area.

MATERIALS AND METHODS

Study Area

The study was conducted in Bhimsen Rural Municipality, Gorkha District, Gandaki Province, central Nepal (28.03°N, 84.72°E; Figure 1). The municipality was formed through the merger of six former Village Development Committees-Masel, Tandrang, Ashrang, Dhawa, Baguwa, and Borlang,and currently comprises eight administrative wards, with its headquarters located at Ghyampesal. The area lies within the mid-hill region of Nepal at an average elevation of approximately 900 m above sea level and experiences a tropical to subtropical climate. Land use is characterized by a mosaic of forest, agricultural land, and human settlements, creating conditions conducive to interactions between leopards and livestock-owning communities.

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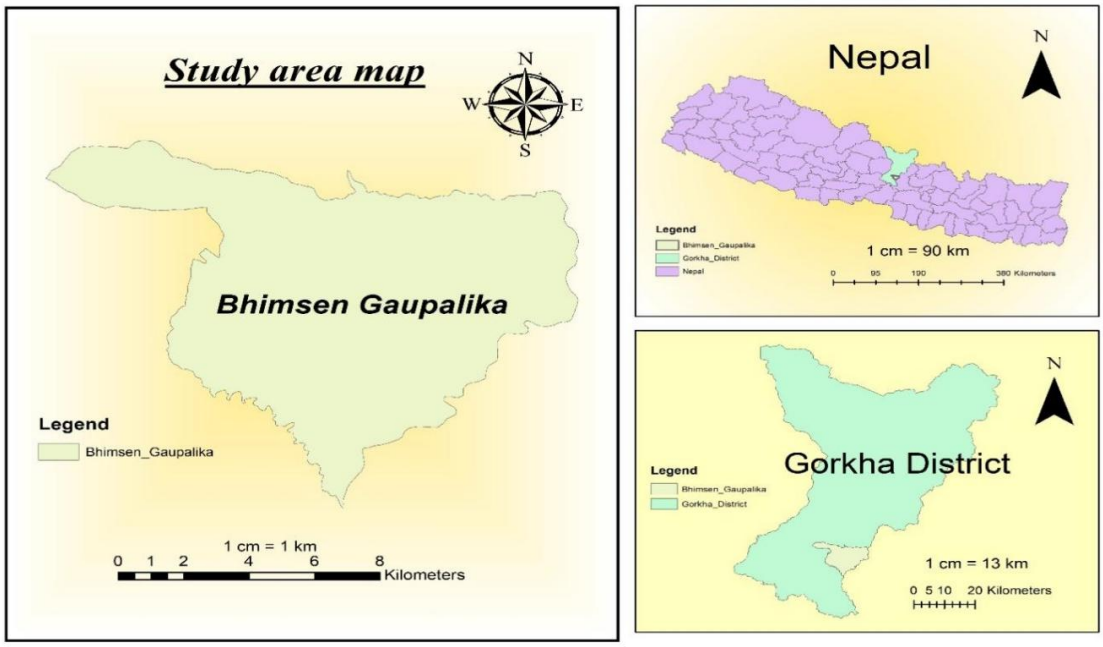

Figure 1: Map of the study area

Design of the Study

A mixed-methods approach was used, integrating qualitative key-informant interviews, household surveys, and quantitative analysis of official compensation data. This method enabled comparison of local views and experiences of human-leopard conflict with actual depredation statistics.

Sources and Gathering of Data

Records of Compensation

Official compensation claim records kept by the Division Forest Office (DFO), Gorkha, and the Manaslu Conservation Area Office provided secondary data on cattle depredation. The type of livestock, the quantity of animals lost, the date and place of events, and the amount of compensation paid were all recorded in these records. The analysis only included validated and authorized accusations of depredation by common leopards (*Panthera pardus*).

Household Survey

A total of 113 livestock-owning households that had suffered leopard depredation were purposively selected for interviews based on compensation records. To gather data on livestock management practices, the timing and location of depredation events, economic losses, mitigation measures implemented, perceptions of conflict drivers, attitudes toward leopard conservation, and experiences with the compensation process, a semi-structured questionnaire was administered to household heads. Interviews were conducted in the local language, and the questionnaire was pre-tested in a neighbouring village to ensure uniformity and clarity.

Key Informant Interviews and Field Observations

To contextualize household-level findings and to understand institutional perspectives on conflict management and compensation procedures, key informant interviews were conducted with local leaders, members of community forest user groups, teachers, and DFO officials. Using a standardized observation checklist to reduce observer bias, field observations were

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conducted to record livestock shelters, settlement proximity to forest boundaries, and obvious indicators of conflict.

RESULTS AND DISCUSSION

Livestock Depredation by Leopards

The descriptive statistics of livestock killed by leopards between 2020 and 2021 are shown in Table 1. With a mean loss of 82.5 livestock and relatively slight variation across years (SD = 0.71), goats were the most commonly depredated livestock. With a mean of five animals and no inter-annual variation (SD = 0.00), cattle depredation was low and constant. Buffalo depredation was comparatively low but highly variable (mean = 3.0; SD = 4.24), indicating that it occurred in 2021 but was absent in 2020. Overall, the annual average livestock depredation was 91 animals, with moderate variability (SD = 4.24), indicating year-to-year variations in leopard-caused livestock losses. These findings align with earlier studies by Qamar *et al.* (2012), Ayaz (2005), and Dar *et al.* (2009), who also reported high depredation rates on goats. The higher depredation on goats could be attributed to their close resemblance to the leopard's natural prey, such as the spotted deer in the study area (Qamar *et al.*, 2012). Additionally, smaller animals, such as goats, can be more easily dragged to a safe location than larger livestock, such as cattle and buffalo (Qamar *et al.*, 2012; Sangay & Vernes, 2008).

Table 1: Descriptive Statistics of Livestock killed by leopard (2020–2021)

Livestock	Mean (n)	Min (n)	Max (n)	SD
Goats	82.5	82	83	0.71
Buffaloes	3	0	6	4.24
Cattle	5	5	5	0
Total Depredation	91	88	94	4.24

Temporal Patterns of Livestock Depredation

Table 2 shows that the incidence percentage by time of day for 2020 and 2021 showed distinct temporal patterns. The afternoon (12–5 PM, 33.9%) had the highest average incidence, followed by late night (12–5 AM, 20.15%), suggesting that these times are most likely to happen.

Table 2: Descriptive Statistics of Incidence Percentage by Time of Day (2020–2021)

Time of Day	Mean (%)	Min (%)	Max (%)	SD (%)
Early morning (5–8 AM)	8.25	5.9	10.6	3.33
Morning (8–12 AM)	7.7	7.6	7.8	0.14
Afternoon (12–5 PM)	33.9	31.4	36.4	3.53
Evening (5–7 PM)	12.6	7.6	17.6	7
Night (7–12 PM)	9.2	7.8	10.6	1.98
Late night (12–5 AM)	20.15	17.6	22.7	3.97
Unknown	8.15	4.5	11.8	5.09

On the other hand, the lowest and most consistent incidence (7.7% ± 0.14) was observed in the morning (8–12 AM), suggesting lower activity at this time. The evening (5–7 PM, 12.6%) and early morning (5–8 AM, 8.25%) showed a moderate incidence, but the night (7–12 PM, 9.2%) and unknown times (8.15%) displayed varying values, indicating variations over the course of the two years. All things considered, the statistics show that incidence is strongly time-dependent, peaking in the afternoon and late at night. Overall, more than 50% of depredations were recorded during the daytime, supporting the findings of Sidhu *et al.* (2017).

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Monthly and Seasonal Trends

Table 3 shows distinct monthly variation in livestock depredation between 2020 and 2021. The winter months had the highest incident of depredation, especially in December (mean = 15.0) and January (mean = 13.5), while April (mean = 4.0) and July (mean = 4.5) had the lowest. January and October showed the highest inter-annual variation, indicating varying depredation pressure across years during these months. On the other hand, there was no difference in the depredation numbers for April and August across the year. Overall, there was a seasonal trend in livestock depredation, with comparatively lower and stable incidences in the spring and midsummer and greater and more unpredictable incidents in the winter. Livestock depredation was highest during November-December, consistent with findings in Bhutan (Sangay & Vernes, 2008) and Pakistan (Qamar *et al.*, 2012). During the winter months, depredation rates increased due to fluctuations in prey populations and scarce food and water resources during dry periods (Acharya, Paudel, *et al.*, 2016).

Table 3: Month-wise livestock depredation over two years (2020 and 2021)

Month	Mean	Min	Max	SD
January	13.5	8	19	7.78
February	9.5	8	11	2.12
March	5.5	5	6	0.71
April	4	4	4	0
May	6.5	5	8	2.12
June	6.5	5	8	2.12
July	4.5	4	5	0.71
August	9	9	9	0
September	7.5	6	9	2.12
October	5.5	3	8	3.54
November	8.5	7	10	2.12
December	15	13	17	2.83

Spatial Patterns of Livestock Depredation

Incident Locations

The majority (60%) of incidents occurred on livestock farms, 38% on private lands, and only 2% in national forests (Figure 2). It was also found that people living near the core areas of leopard populations faced higher rates of livestock depredation (Suryawanshi *et al.*, 2013; Sidhu *et al.*, 2017; Aryal & Pokharel, 2019). Most livestock depredation incidents occurred when animals were grazed in or around forest areas.

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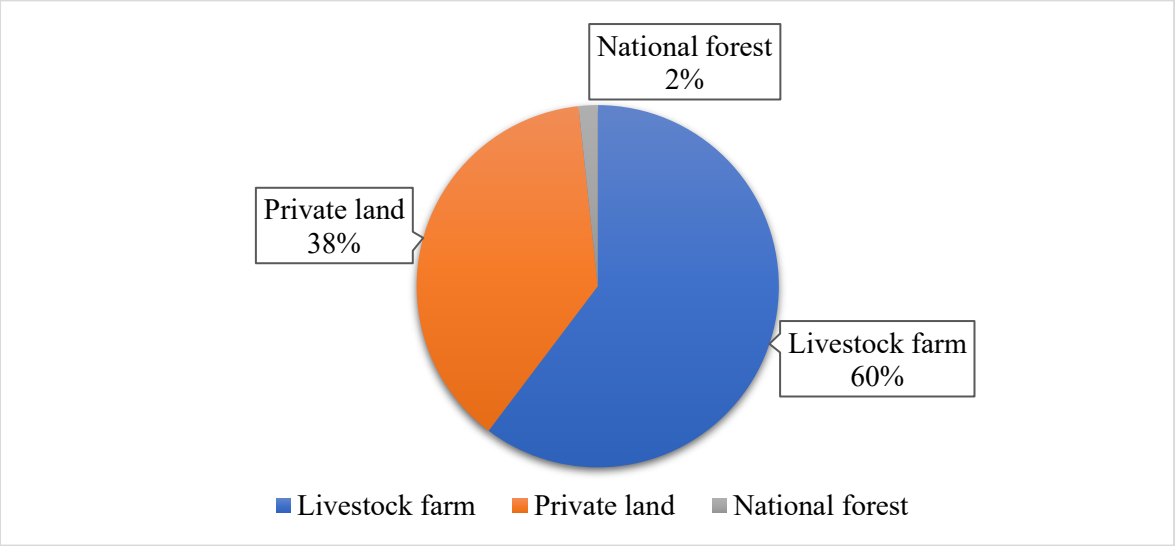

Figure 2: Incident's locations

Proximity to Forests

The descriptive statistics of livestock depredation incidences by distance from the closest forest for the years 2020–2021 are compiled in Table 4. With a mean incidence of 58%, most depredation events occurred within 100 meters of the forest border, suggesting a strong spatial association between depredation and proximity to forests. The percentage of incidents that occurred between 100 and 500 meters from the forest was moderate (mean = 18%) and exhibited similar inter-annual variability. After 500 meters from the forest, the number of depredation occurrences drastically decreased. With mean values of 12.5% and 11.5%, respectively, and no variation between years (SD = 0.71), incidents reported at 501 m–1 km and >1 km distances were comparatively low. Earlier studies also demonstrated a strong link between livestock damage and proximity to forests (Subedi *et al.*, 2020). The common leopard (*Panthera pardus*) often resides near human settlements (Odden & Wegge, 2005; Merkrbu, 2021). Several studies indicate that leopard home ranges sometimes partially or entirely overlap with human-use areas, facilitated by the species' dietary flexibility. Leopards readily prey on domestic animals, particularly dogs, which can constitute a significant part of their diet (Karanth *et al.*, 2012; Kumbhojkar *et al.*, 2019). Predation of domestic animals by leopards is common in many Asian and African countries (Khorozyan *et al.*, 2015; Kshettry *et al.*, 2017; Dar *et al.*, 2020). Such predation, especially on livestock, causes economic losses (Dar *et al.*, 2020), affects the livelihoods and social well-being of people (Barua *et al.*, 2013; Kshettry *et al.*, 2017), engenders negative attitudes towards carnivores, and may lead to retaliatory killings by poisoning or other means (Bista *et al.*, 2021).

Table 4: Descriptive Statistics of Distance of Livestock Depredation Incidence from Nearest Forest (2020–2021)

Distance from forest	Mean (%)	Min (%)	Max (%)	SD
< 100 m	58	55	61	4.24
100–500 m	18	15	21	4.24
501 m–1 km	12.5	12	13	0.71
> 1 km	11.5	11	12	0.71

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Perceived Causes of Livestock Depredation

Out of 113 respondents, 24.8% (N=28) believed that the conversion of cultivated land into forest land was the primary cause of livestock depredation. Another 22.1% (N=25) attributed it to the increasing number of common leopards, while 20.4% (N=23) reported that the decreasing wild prey population was the third major cause (Table 5).

Table 5: Causes of livestock depredation

Causes of depredation	No. of respondents	Respondents%	Rank
A. Conversion of cultivated land into forest land	28	24.8	1
B. Increasing no. of common leopard	25	22.1	2
C. Decreasing wild prey population	23	20.4	3
D. Habitat sharing between leopard and livestock	15	13.3	4
E. Deforestation/Encroachment/Habitat fragmentation/Habitat loss	13	11.5	5
F. Poor conditions of corrals/sheds	5	4.4	6
G. Expansion of human settlement nearby forest	4	3.5	7
Total	113	100.0	

During harsh winter weather, leopards are compelled to move closer to human settlements (Qamar *et al.*, 2012), leading to increased depredation incidents. Smaller animals can be quickly dragged to a safe place compared to larger livestock species such as cattle and buffalo (Sangay & Vernes, 2008; Qamar *et al.*, 2012). The relationship between leopard habitat use and the relative abundance of dogs is variable. Although dogs can attract leopards (Athreya *et al.*, 2015), they may also repel them (Bista *et al.*, 2021). Forests in the mid-hills of Nepal generally support sparse populations of wild prey (Acharya *et al.*, 2016), which may push leopards into human-dominated habitats where they can more easily prey on domestic animals (Kabir *et al.*, 2014).

Mitigation and Guarding Measures

Among the respondents, 23% indicated that corralling animals in predator-proof enclosures at night was an practical measure, while 19.5% cited creating disturbances as a traditional technique to deter predators. Various traditional techniques are locally adopted by communities to combat livestock depredation by common leopards. Guarding measures, including chasing, predator-proof animal pens, fox lights, and mesh wire fencing, were identified as the most intensively and effectively used methods in the study area (Merkebu, 2021).

CONCLUSION

In Bhimsen Rural Municipality, goats suffered the highest levels of livestock depredation by leopards, which peaked in the afternoon and late at night. This issue occurred more frequently in winter and was concentrated near forest borders. Livestock depredation is affected by factors such as distance to forests, seasonal changes, livestock types, and management systems. While mitigation strategies like predator-proof pens, fencing, and vegetation management around settlement areas seem to be effective. It is important to approach the results with caution due to the observational data-collection methods used. Protecting natural prey and their habitats can also help reduce leopards' dependence on livestock.

Community awareness and compensation programs play a supportive role in cushioning economic losses and developing a certain level of tolerance for leopards. Selective intervention and better livestock management practices are most likely to improve the relationship between humans and leopards. Notably, the study faces limitations due to its reliance on compensation records and perception-based responses to address leopard attacks. On the whole, a combination of best husbandry practices, locally adapted mitigation measures, and institutional support may help achieve sustainable human-leopard coexistence in the mid-hill landscape of Nepal.

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Authors' Contribution

C. P. Patel designed the research and conducted it in the field. G. Kafle supervised the overall research, report and article preparation. C. P. Patel analyzed the data and together with G. Kafle, prepared the whole manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

Ethics Approval Statement

This study involved human participants who provided informed consent. All procedures were conducted in accordance with institutional ethical guidelines, and necessary approvals were obtained from the relevant ethics committee.

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