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COMMUNICATION

First camera-trap records of Dhole *Cuon alpinus* (Pallas, 1811) (Mammalia: Canidae) and Spotted Linsang *Prionodon pardicolor* (Hodgson, 1831) (Mammalia: Carnivora: Prionodontidae) in Makalu Barun National Park, Nepal

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Abstract: The Dhole *Cuon alpinus* and Spotted Linsang *Prionodon pardicolor* are two elusive carnivores inhabiting the forests of southern and southeastern Asia. Despite their ecological roles and conservation significance, both species remain under-researched, particularly in Nepal. From 2019 to 2024, a biodiversity survey using 10 camera traps in the Barun Valley of Makalu Barun National Park (over 5,508 camera-days) provided the first photographic evidence of both species from the region. A solitary Dhole was recorded at two stations on three independent events in the lower subalpine zones. Spotted Linsangs were captured at four stations on 12 independent events in the sub-tropical and temperate zones. These findings highlight the importance of Barun Valley as a significant habitat for rare mammals and highlight the need for systematic surveys to understand their distribution, threats, and conservation needs.

Keywords: Asian Wild Dog, Barun Valley, camera trapping, eastern Himalaya, high-elevation biodiversity, Makalu Barun National Park, photographic evidence, rare mammals.

Nepali: वनकुकुर र सिलु बिरालो दक्षिण तथा दक्षिणपूर्वी एसियाका जंगलहरूमा पाइने दुर्लभ मांसाहारी स्तनधारी प्रजातिहरू हुन्। यिनीहरूको पारिस्थितिक भूमिका तथा संरक्षण महत्व भए पनि, विशेषतः नेपालमा यिनीहरू सम्बन्धी वैज्ञानिक अध्ययन न्यून रहेको छ। सन् २०१९ देखि २०२४ सम्म मकालु-वरुण राष्ट्रिय निकुञ्जको वरुण उपत्यकामा १० वटा क्यामेरा ट्र्याप प्रयोग गरी जैविक विविधता सर्वेक्षण गरिएको थियो, जसमा जम्मा ५,५०८ भन्दा बढी क्यामेरा-दिन संकलन गरिएको थियो। उक्त सर्वेक्षणमा प्राप्त वन कुकुर र सिलु बिरालोका तस्वीरहरू मकालु-वरुण राष्ट्रिय निकुञ्ज क्षेत्रबाट पहिलो पटक भेटिएको फोटोग्राफिक प्रमाण हुन्। वनकुकुर ठण्डा समशीतोष्ण जलवायु भएका मकालु-बरुण राष्ट्रिय निकुञ्ज क्षेत्रमा राखिएका दुई क्यामेरा ट्र्याप स्टेशनहरूमा तीनवटा स्वतन्त्र क्यामरा ट्र्याप फोटोहरूमा रेकर्ड गरियो। त्यसैगरी, सिलु बिरालो न्यानो तथा ठण्डा समशीतोष्ण क्षेत्रका राखिएका चारवटा ट्र्याप स्टेशनहरूमा जम्मा १२ वटा स्वतन्त्र क्यामरा ट्र्याप फोटोहरूमा रेकर्ड गरिएको थियो। यी नतिजाहरुले वरुण उपत्यका दुर्लभ मांसाहारी स्तनधारीहरूको महत्वपूर्ण बासस्थान भएको पुष्टि गर्छ। साथै, यस्ता प्रजातिहरूको वितरण, जोखिम कारकहरू र संरक्षणका आवश्यकताहरू बुझ्न दीर्घकालीन तथा व्यवस्थित अध्ययन आवश्यक रहेको स्पष्ट देखिन्छ।

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INTRODUCTION

The eastern Himalaya are known for their unique biodiversity and rich ecosystems. The region is home to many of the worlds' most iconic species, like Tiger *Panthera tigris*, Elephant *Elephas maximus*, Red Panda *Ailurus fulgens*, Snow Leopard *Panthera uncia*, Clouded Leopard *Neofelis nebulosa*, Dhole *Cuon alpinus* (WWF 2024). The Dhole, or Asiatic Wild Dog, is one of Asia's most widely distributed carnivores, found across southern and southeastern Asia. The Dhole has been classified as 'Endangered' on the IUCN Red List (IUCN 2015) and is severely limited in its range due to various threats, such as habitat destruction, and persecution (Kamler et al. 2015; Wolf & Ripple 2017). In Nepal, where the population is estimated to be fewer than 500 individuals (Jnawali et al. 2011), research on its status and ecology is scarce (Thapa et al. 2013). The Spotted Linsang *Prionodon pardicolor*, a nocturnal and arboreal carnivore, is one of Asia's least studied species (van Rompaey 1995). Recent records in Nepal, including photographic evidence from the Annapurna and Kanchenjunga conservation areas, highlight its elusive nature and rarity (Ghimirey et al. 2018; Lama 2018). This species is classified as 'Least Concern' globally (IUCN 2015), yet it is one of 27 protected priority mammal's species in Nepal and is considered nationally Endangered due to a small population of approximately 100 individuals (Jnawali et al. 2011). Despite its national importance, the Least Concern or non-flagship species receives limited attention and is often overlooked in research and conservation initiatives due to funding constraints in Nepal (Katuwal et al. 2017; Basnet & Rai 2020). Furthermore, research on both the Spotted Linsang and the Dhole in remote areas, like the Barun Valley of Makalu Barun National Park (MBNP), remains scarce, despite their conservation importance.

This study provides the first photographic evidence of Dhole and the Spotted Linsang in Makalu Barun National Park, extending their known ranges, and offering new insights into their distribution and ecological roles within this biodiversity hotspot. This study also assesses the implications of these findings for the conservation status of these species in Nepal. By addressing gaps in knowledge about their presence and ecology, this research provides valuable insights towards more focused, extensive surveys, and the need for targeted conservation efforts to protect these two species and their fragile alpine habitats.

MATERIALS AND METHODS

Makalu Barun National Park is located in eastern Nepal, east of the Everest region, and is renowned for its exceptional topographical, and ecological diversity. It is the world's only protected area with an elevation range exceeding 8,000 m, from 435 m at the base to 8,463 m at the summit of Mt. Makalu. The park's varied altitude, combined with heavy monsoon rains, creates a complex range of microhabitats that support rich biodiversity. MBNP is home to 3,128 species of flowering plants, 315 species of butterfly, 43 reptiles, 16 amphibians, 78 fish species, 440 bird species, and 88 mammal species (Jha 2003). This study was conducted along the Barun Valley, which extends from the Makalu Glacier to Barun Dovan, Arun and Barun confluence (Image 1). This area is part of the Barun Biomeridian Research Project (The East Foundation & Future Generation University 2021), which monitors the biodiversity along a transect around 27 km, encompasses nine distinct vegetation zones , ranging from lower subtropical to nival zones, running through the valley. Four main ecozones have been identified in the Barun Valley (Dobremez & Shakya 1975; Olson et al. 2004). These areas feature pristine, dense forests that provide ideal habitats for a variety of species, including those of conservation concern. The climate in the study area is characterized by a strong seasonality, with a wet monsoon period from June to September, which contributes to the high annual rainfall, and a dry winter season from October to March, with snowfall in the peak winter.

As part of a pilot project, ten camera traps (Browning Strike Force BTC-5HDP) were deployed at ten sampling locations between April 2019 and March 2024, covering an elevation range of 1,975–3,793 m. Sampling locations were selected along an elevation gradient to represent a range of habitats within the Barun Valley, ensuring that the study captured a broad spectrum of species across different ecozones. Camera trap locations were focused on areas where wildlife trails or corridors were prominent, as these locations were expected to maximize wildlife detections. The camera traps were mounted 45–60 cm above ground level to ensure optimal detection of terrestrial wildlife while minimizing the likelihood of damage from environmental factors. In alpine zones, the cameras were positioned higher, at 60–90 cm, to prevent snow accumulation, and potential trap malfunctions due to snowfall. The cameras were set to operate 24 h a day, with each trap taking a single photograph per trigger to conserve battery life, and maximize the duration of fieldwork. These traps were checked every three

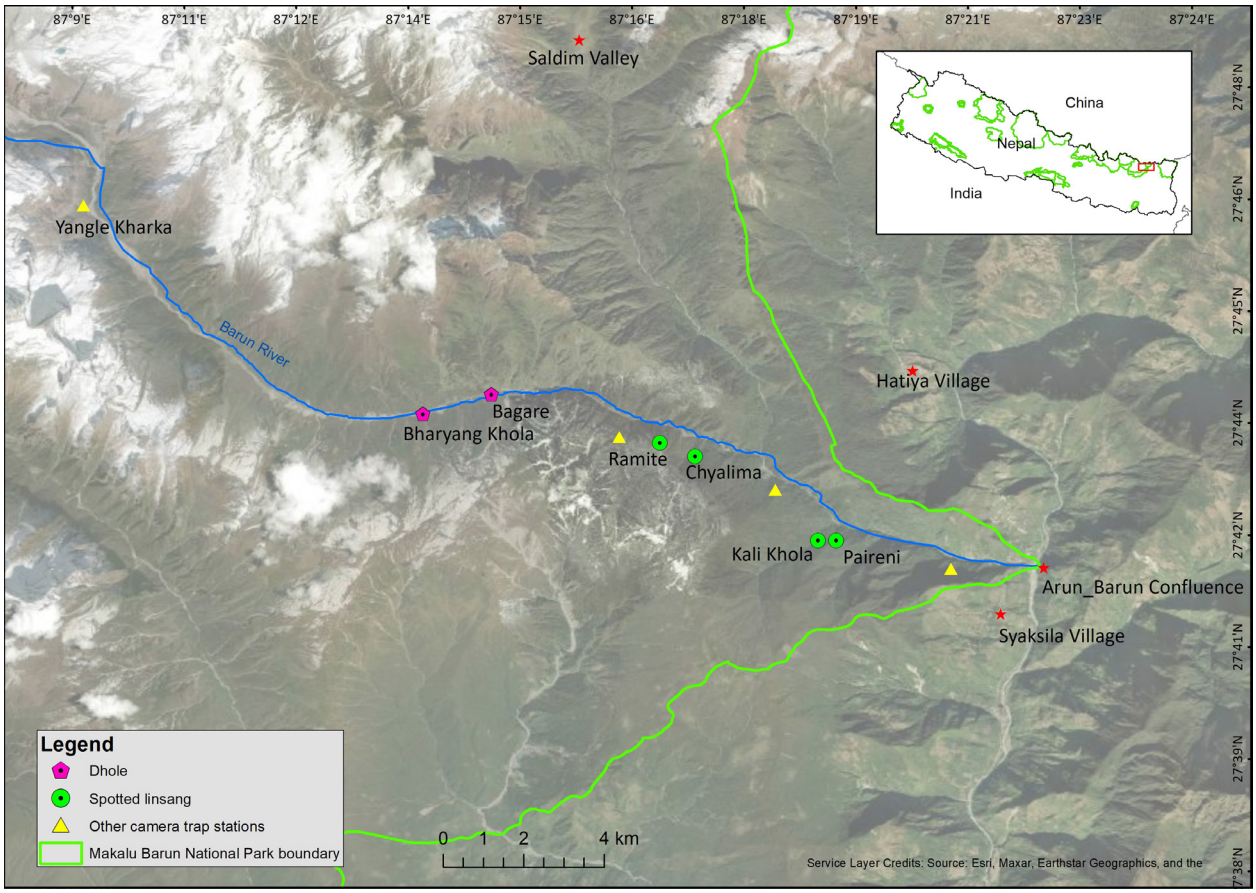

Image 1. The Barun Valley camera trap stations, where Dhole and Spotted Linsang were photographed within the Makalu Barun National Park area. The inset shows the location of the protected areas of Nepal (green boundaries).

months to replace memory cards and batteries. Species identification was conducted through photographic evidence, and any unidentified images were cross-checked with wildlife experts.

RESULTS

This study completed a total sampling effort of 5,508 camera-days, resulting in 38,075 photographs, capturing 30 mammal species. Among these, a solitary Dhole was photographed on three independent events at two stations: Bharyang Khola (3,064 m) and Bagare (2,910 m). The relative abundance of Dhole was 0.054 per 100 trap nights (Image 1, Table 1). The first photograph was taken in November 2021, followed by two additional captures in March 2022 and August 2022 (Image 2). Both stations, located approximately 30 m from the Barun River, are characterized by dense Rhododendron and bamboo forests. All Dhole photographs were captured during daylight hours, indicating diurnal activity in the area. In addition to the Dhole, 14 other mammal species were recorded at these two stations, including prey species and potential competitors of the Dhole (Table 1).

The Spotted Linsang was photographed by 12 independent events, at four stations, in the upper subtropical, and temperate zones: Kali Khola (2,043 m), Ramite Danda (2,867 m), Chyalima (2,428 m), and Paireni (2,071 m) (Image 1, Image 3). The relative abundance of Spotted Linsang was 0.21 per 100 trap nights. This species was recorded at Kali Khola in dense mixed forests dominated by *Acer* and *Quercus* species, while Acer, rhododendron, and malingo forests were prevalent at the Ramite Danda station (Image 3). Additionally, Chyalima station featured malingo-Acer forests, whereas Rhododendron and *Quercus lamellosa* were the dominant species at Paireni station. All stations had good ground cover, composed of fern species. Temporal patterns revealed that the Spotted Linsang is nocturnal, with all photographs taken between 1945 h and 0439 h, most frequently during the early morning hours (0000–0359 h). Seasonal variations in detection were observed,

Table 1. Dhole, Spotted Linsang and other mammalian species detected in camera trap locations. * indicates the date of unusual timestamp due to snowfall in the region.

Species	Dhole	Spotted Linsang
Stations	Bagare and Bharyang Khola	Ramite Danda, Chylima, Kali Khola, and Paireni Ukalo
No. of photos	3	24
Date and time	15.xi.2020 at 1432 h, March 2022 at mid-day*, 24.viii.2022 at 1547 h	06.ix.2018 at 0230 h, 09.v.2021 at 0327 h, 22.v.2021 at 0245 h, 14.vi.2021 at 2032 h, 10.vii.2021 at 0202 h, 10.vii.2021 at 1957 h, 31.iii.2022 at 0150 h, 23.iv.2022 at 2112 h, 01.v.2022 at 2351 h, 13.vii.2022 at 0325 h, 30.xii.2022 at 0439 h, and 30.i.2024 at 2148 h
Terrain	Steep slope	Steep slope
Activity pattern	Trotting	Stalking, Ambush hunting
Other mammals captured in at these stations	Himalayan Musk deer, Himalayan Black Bear, Leopard, Leopard Cat, Yellow-throated Marten, Red Panda, Nepal Gray Langur, Assamese Macaque, Mainland Serow, Himalayan Goral, Himalayan Tahr, squirrel species, bat species and rodent species.	Asian Golden Cat, Assamese Macaque, Clouded Leopard, Himalayan Black Bear, Himalayan Goral, Himalayan Tahr, Indian Hare, Leopard Cat, Mainland Serow, Masked Palm Civet, Nepal Gray Langur, Northern Red Muntjac, Orange-bellied Himalayan Squirrel, Particolored Flying Squirrel, Red Fox, Red Giant Flying Squirrel, Royle's Pika, Siberian Weasel, Wild Boar, Yellow-bellied Weasel, Yellow-throated Marten, Rodent spp. and Bat spp.

Image 2. Solitary Dhole photographed two locations at Barun Valley: 1—Bharyang Khola at 1547 h on 24 August 2022 and Bagare | 2–3—on March 2022 & 24 August 2022 at 1547 h. © Barun Bio-meridian Research Project/Future Generation University/Department of National Park and Wildlife Conservation.

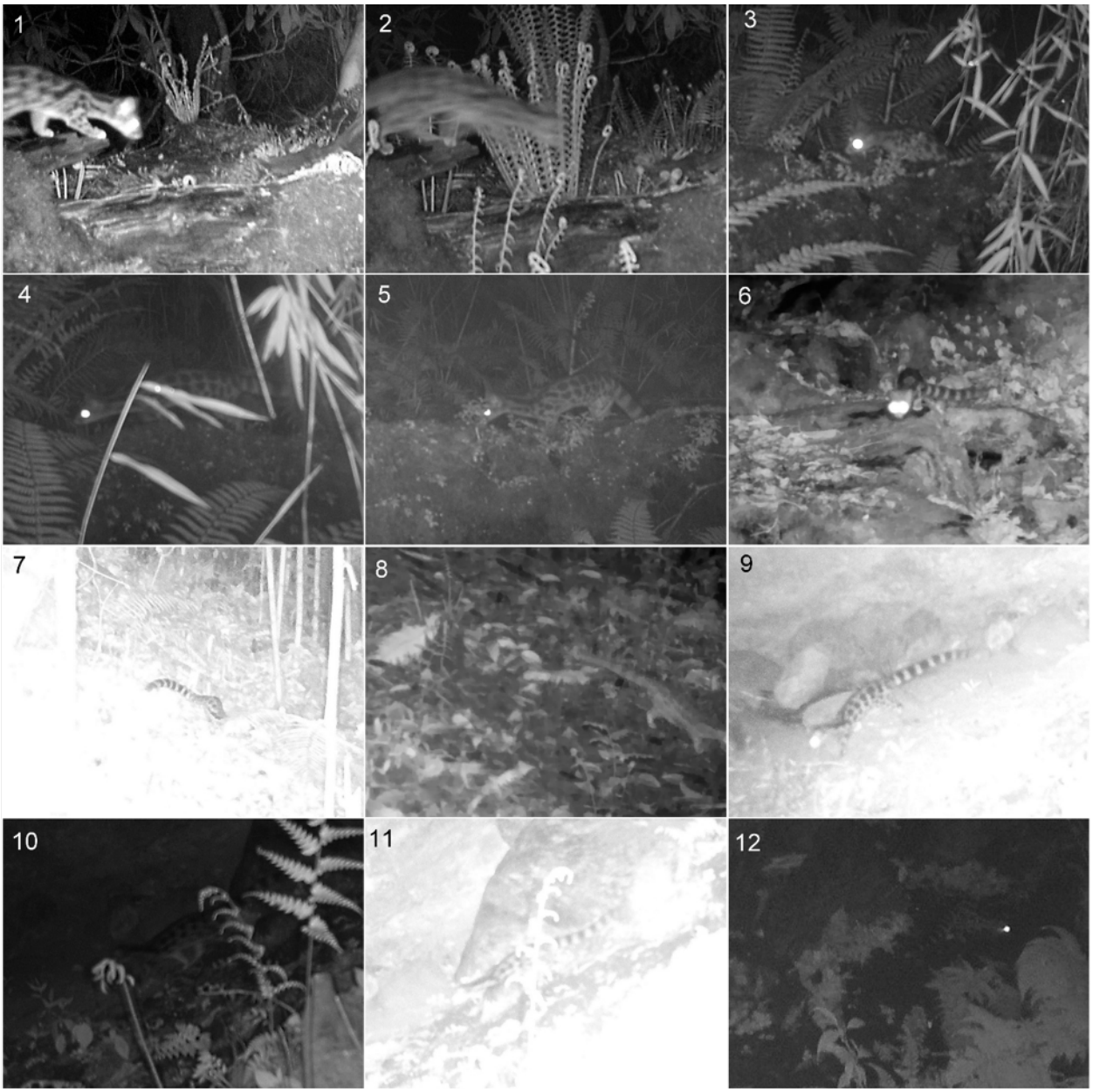

Image 3. Spotted Linsang photographed at various locations in Barun Valley: 1–5—Ramite Danda | 6—Paireni Ukalo | 7–8—Chyalima | 9–12—Kali Khola, Barun Valley. © Barun Bio-meridian Research Project/Future Generation University/ Department of National Park and Wildlife Conservation.

with three events in July, two in May, and one event each in other months, except for February, August, October, and November, when the species was not recorded.

DISCUSSION

This study provides the first photographic evidence of the Dhole in Makalu Barun National Park. Although Ghimirey et al. (2024) confirmed Dhole's presence at 12 sites across Nepal, including Makalu Barun National Park, their findings were based on Byers et al. (2014). Similarly, previous records, such as those by Jha (2003), relied on anecdotal evidence. Dholes, as apex predators, play a vital role in shaping ecosystems by regulating prey populations, and maintaining trophic balance (Beschta & Ripple 2009). They are considered a keystone species in Bhutan (Thinley et al. 2021), and their conservation is crucial in pristine habitats, such as Makalu Barun National Park. The park's subalpine forests, rich in Dhole's prey species, including Himalayan Serow *Capricornis sumatraensis*, Himalayan Tahr *Hemitragus jemlahicus*, Himalayan

Goral *Naemorhedus goral*, Assamese Macaque *Macaca assamensis*, and Nepal Grey Langur *Semnopithecus schistaceus*, provide an ideal habitat for Dholes. This abundance of prey aligns with findings from the eastern Himalaya, where Himalayan Serow, Himalayan Tahr, and Himalayan Goral were found to constitute 98.7% of the Dhole's diet (Bashir et al. 2013), further highlighting the suitability of Makalu Barun National Park for sustaining this apex predator. Furthermore, the valley's diverse carnivores and omnivores, including Leopard *Panthera pardus*, Clouded Leopard, Himalayan Black Bear *Ursus thibetanus*, Leopard Cat *Prionailurus bengalensis*, Asiatic Golden Cat *Catopuma temminckii*, Red Panda *Ailurus fulgens*, and Yellow-throated Marten *Martes flavigula*, further underscore the complex predator-prey dynamics within the park. Despite these favourable ecological conditions, Dholes face significant threats. Prey depletion and competition with other carnivores (Karanth et al. 2004; Andheria et al. 2007; Kamler et al. 2015) challenge their survival. While they are not heavily targeted by illegal wildlife trade (Velho et al. 2012), conflicts with locals due to over livestock predation often result in retaliatory killings, as observed in Bardia National Park, and Kanchenjunga Conservation Area (Khatiwada et al. 2011; Yadav et al. 2019). In the Barun Valley, local herders occasionally report cattle predation by Dholes, but sightings have become rare in recent years despite the species once being abundant (Dukpa Thikepa Bhote pers. comm. 23.xii.2023). This emphasizes the need for conservation efforts that prioritize mitigating human-wildlife negative interactions and creating safe habitats to support Dhole population recovery within the park.

This study provides the first photographic evidence of the Spotted Linsang in Makalu Barun National Park, marking only the third confirmed photographic record for Nepal in recent years. The three confirmed photographic records of the Spotted Linsang in Nepal in recent years were reported between 2018 and 2023, including the record from Makalu Barun National Park (2023), one from Annapurna Conservation Area (Ghimirey et al. 2018), and another from Kanchanjunga Conservation Area (Lama 2018). In Nepal, records of this species have relied entirely on non-invasive camera trapping surveys due to the difficulty of obtaining direct sightings or identifying it from indirect evidence (Duckworth et al. 2016).

The Spotted Linsang was found to be nocturnal, with all 24 photographs taken between 1945 h and 0439 h, consistent with previous records from other regions (Ghimirey et al. 2018; Lama 2018), which further complicates efforts to study the species. Our records of 12 independent events, obtained with a limited number of camera traps, indicates that Barun Valley is a key habitat for this elusive species. The study also provides new elevation data for the Spotted Linsang in Nepal. While previous records in Annapurna and Kanchanjunga Conservation Area ranged 2,392–2,745 m, the record at 2,867 m sets a new high-elevation record for Nepal, though still below the global limit of 3,308 m (Jennings & Veron 2015; Duckworth 2016). The habitat at Ramite Danda station resembles Annapurna Conservation Area, with ground cover dominated by ferns (Ghimirey et al. 2018). In contrast, lowland records from Chitwan National Park were in riverine forests, dense grasslands, and Sal *Shorea robusta* forests (Sunquist 1982), highlighting the species' habitat adaptability, although it appears to have a preference for evergreen forests (Jennings & Veron 2015). Information on the diet of the Spotted Linsang is limited, but its dental morphology suggests a preference for smaller prey (Jennings & Veron 2015). In Vietnam, stomach analyses of six individuals revealed remains of rodents, frogs, and snakes (Davis 1958). In the study area, rodents, shrews, and Orange-bellied Himalayan Squirrels were commonly observed at stations where Spotted Linsangs were recorded, indicating they may serve as potential prey species.

This study highlights the importance of Barun Valley as an important habitat for both the Dhole and the Spotted Linsang. Due to resource limitations and geographic challenges, only ten camera trap stations were established, with just two located in alpine areas, which are key habitats for these species. This limited sampling effort likely reduced the chances of capturing a broader range of species and encounters, particularly for more elusive carnivores. The study focused on overall biodiversity rather than targeting these two species specifically, which may have affected the depth of the findings. A more focused, extensive survey would likely yield more comprehensive information, improving the understanding of these species' distribution, behaviour, and ecological roles.

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