

New insights into the geographical distribution of brown bears *Ursus arctos* in Nepal

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Abstract In the current IUCN Red List assessment, the south-western distribution range of the brown bear *Ursus arctos* in Nepal ends in Upper Mustang, in the central Himalaya, and extends northwards into the Tibetan Autonomous Region of China. Although brown bears have been recorded further west of Upper Mustang, details of these findings have not been published previously. Using camera traps, we present new evidence of brown bears in Limi Valley, Upper Humla, north-western Nepal. Covering a study area of 336 km², we deployed 61 camera traps for 3,145 trap-nights during July–October 2021 and 10,748 trap-nights during June 2022–October 2023. In 2021 we recorded a single independent image of a brown bear, followed by 23 independent images during 2022–2023. The images were captured during spring and autumn but not in summer and winter. These new records increase the distribution range of the brown bear in Nepal, extending its global range south-westwards. Our results indicate the significance of Limi Valley as a stronghold for brown bears in Nepal and underscore the importance of formally protecting the currently unprotected wildlife habitats in Limi Valley. Our study emphasizes the need for further research into the ecology and population status of brown bears in Nepal.

Keywords Bear conservation, brown bear, camera trap, geographical range, Limi Valley, Nepal, *Ursus arctos*

The brown bear *Ursus arctos* is categorized as Least Concern on the IUCN Red List (McLellan et al., 2017). It is the most widespread bear species, with a geographical distribution ranging from north-western North America, across the Bering Strait to the Russian Far East,

across northern Asia, including Japan, to Fenno-Scandinavia, and extending southwards through the Tibetan Plateau to the Himalayas, south-western Iran, Turkey and western Europe (Hunter & Barrett, 2018). This terrestrial carnivore occurs in a variety of habitats, from dry Asian steppes to Arctic shrublands and temperate rain forests (McLellan et al., 2017), from sea level to 5,500 m (Nawaz et al., 2014). Its global population is estimated to exceed 200,000 individuals across c. 5,000,000 km² in north-western North America and 1,200,000 km² in Europe (excluding Russia) and significant portions of northern Asia (McLellan et al., 2017). The species faces various threats, including habitat loss, low acceptance by humans, poaching (particularly in Russia and China), collisions with vehicles, persecution, and small population sizes in certain countries in Europe and Central Asia (McLellan et al., 2017; Swenson et al., 2020). The brown bear is listed in Appendix I of CITES.

Within the Himalayan–Tibetan region, two subspecies of brown bear are known (Lan et al., 2017). The Himalayan brown bear *Ursus arctos isabellinus* inhabits the north-western Himalayan region (India and Pakistan), and the Tibetan brown bear *Ursus arctos pruinosus* can be found in the south-eastern Tibetan Plateau (China and parts of northern Nepal; Pocock, 1941; Servheen et al., 1999; Galbreath et al., 2007). Both subspecies are scarce and widely dispersed, with the Himalayan subspecies being particularly isolated (Swenson et al., 2020) and the Tibetan subspecies having sparse and poorly defined populations (McLellan et al., 2017).

The brown bear is a priority protected species in Nepal (Government of Nepal, 1973), but there has been limited research on the species within the country. It is categorized nationally as Critically Endangered, with the national population estimated to consist of < 20 mature individuals (Jnawali et al., 2011). To date, brown bear research in Nepal has been primarily focused on central Nepal (Gurung, 2004; Chetri, 2008, 2022; Aryal et al., 2010, 2012). There is limited information on the status of brown bears in western Nepal, although a few studies (Gurung, 2004; Aryal et al., 2012) have suggested that the species could be present west of Upper Mustang, in Dolpa. Local reports and observations of digging signs also suggest the presence of brown bears in Humla district, west of Dolpa (Kusi & Werhahn, 2016), but no previous scientific evidence has confirmed this.

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Here we present the first verified records of the brown bear in Humla, extending the species' global range south-westwards.

During 2021–2023, we carried out a camera-trap survey of the Himalayan wolf *Canis lupus chanco* in Limi Valley, in the northernmost part of Humla district in north-western Nepal. The study area is situated within the arid zones of the Himalayas, characterized by high-altitude Tibetan desert steppe and alpine grasslands with patches of shrubland (Miehe et al., 2016). The area shares a border with the Tibetan Autonomous Region of China to the north and is home to a variety of wild fauna including carnivores such as the Himalayan wolf, snow leopard *Panthera uncia*, Tibetan fox *Vulpes ferrilata*, red fox *Vulpes vulpes*, Altai weasel *Mustela altaica*, stone marten *Martes foina*, Eurasian lynx *Lynx lynx* and Pallas's cat *Otocolobus manul* (Werhahn et al., in press) and steppe polecat *Mustela eversmannii* (Gurung et al., 2022). It also supports a variety of ungulates, including the wild yak *Bos mutus*, kiang *Equus kiang*, naur *Pseudois nayaur*, Tibetan argali *Ovis ammon hodgsonii* and Tibetan gazelle *Procapra picticaudata*, and small mammals such as the Himalayan marmot *Marmota himalayana*, woolly hare *Lepus oiostolus*, plateau pika *Ochotona curzoniae*, Stoliczka's mountain vole *Alticola stoliczkanus* and Tibetan dwarf hamster *Urocrictus alticola*.

We conducted our camera-trap surveys across a 336 km² area during July–October 2021 and June 2022–October 2023. We laid a grid of 21 cells (each measuring 4 × 4 km) over a digitized map of the study area. In each grid cell we placed two camera traps randomly, in different locations (42 cameras in total). In addition, we deployed 19 camera traps

opportunistically at locations chosen to maximize the detection of large carnivores. The 61 camera traps (Cuddeback X-Change Colour Model 1279, Cuddeback, USA, and Reconyx Hyperfire HC600, Reconyx, USA) were deployed over altitudes of 4,500–5,200 m. We configured the cameras to capture only photographs, and selected the shortest possible delay and five images per trigger. We deployed the cameras for 3,145 trap-nights in 2021 and 10,748 trap-nights during 2022–2023.

We captured a single independent image of a brown bear in 2021 and 23 independent images during 2022–2023. We considered images to be independent when there was at least a 1-minute interval between consecutive images. The relative abundance index (calculated as the number of captures divided by the total trap-nights multiplied by 100) of brown bears in Limi Valley was 0.0318 in 2021 and 0.214 in 2022–2023. We obtained camera-trap images of brown bears from 10 locations (Fig. 1) during spring and autumn but no images were captured in summer and winter. We also observed an adult brown bear in a remote corner of the study area during mid October 2023 (Table 1).

The current global south-western distribution range of brown bears in Nepal ends in Upper Mustang (McLellan et al., 2017). Camera-trap images of brown bears were previously captured in Chiyol, Musi village of Dolpa district, in May 2020 (G. Khanal, pers. comm., 2021; Fig. 1), extending their geographical range westwards in Nepal. Our confirmation of brown bear presence in Limi Valley thus extends its range further west. These records have global significance because Chiyol and Limi Valley are connected to the Tibetan Plateau in western China where brown bears are rare (Harris, 2008).

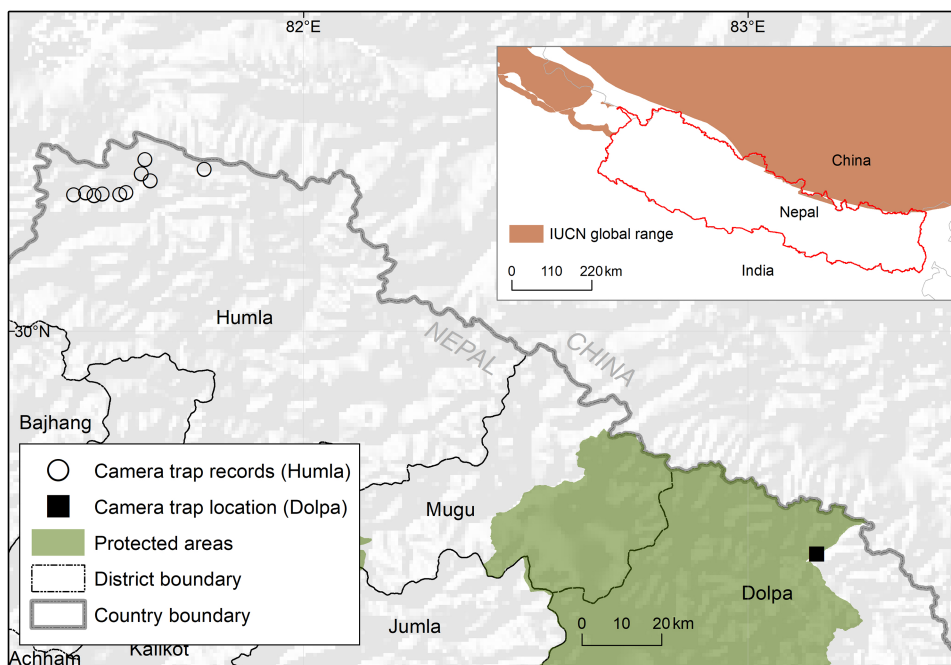


FIG. 1 Camera-trap records of the brown bear *Ursus arctos* in Limi Valley, Upper Humla, north-western Nepal (Table 1), and record of a brown bear photographed by a camera trap in Chiyol, Musi village, Upper Dolpa (G. Khanal, unpubl. data, 2020). The inset map indicates the species' known range according to the IUCN Red List (McLellan et al., 2017).

TABLE 1 Details of brown bear records from Limi Valley, Upper Humla, north-western Nepal (Fig. 1) during July–October 2021 and June 2022–October 2023.

Date	Elevation (m)	Habitat	Time	Location	Type of record
13 Sep. 2021	5,079	Grassland	20.17	Mergyu Valley	Camera-trap image
23 Aug. 2022	4,738	Shrubland	3.30	Sakya Valley	Camera-trap image
9 Sep. 2022	4,848	Grassland	23.10	Chyakpalung	Camera-trap image
21 Sep. 2022	4,935	Grassland	6.18	Sakya Valley	Camera-trap image
21 Sep. 2022	4,935	Grassland	20.29	Sakya Valley	Camera-trap image
17 Oct. 2022	4,814	Grassland	1.07	Sakya Valley	Camera-trap image
19 Oct. 2022	4,814	Grassland	17.26	Sakya Valley	Camera-trap image
20 Oct. 2022	4,769	Boulder field	21.24	Sakya Valley	Camera-trap image
24 Oct. 2022	5,079	Grassland	18.15	Mergyu Valley	Camera-trap image
19 Mar. 2023	4,888	Shrubland	8.10	Sakya Valley	Camera-trap image
25 Mar. 2023	4,888	Shrubland	13.29	Sakya Valley	Camera-trap image
28 Mar. 2023	4,810	Grassland	17.20	Gyau Valley	Camera-trap image
30 Mar. 2023	4,810	Grassland	16.52	Gyau Valley	Camera-trap image
7 Apr. 2023	4,888	Shrubland	23.57	Sakya Valley	Camera-trap image
16 Apr. 2023	4,814	Grassland	12.29	Sakya Valley	Camera-trap image
16 Apr. 2023	4,888	Shrubland	17.27	Sakya Valley	Camera-trap image
22 Apr. 2023	4,707	Grassland	15.19	Sakya Valley	Camera-trap image
11 May 2023	4,888	Shrubland	22.03	Sakya Valley	Camera-trap image
13 May 2023	4,707	Grassland	18.45	Sakya Valley	Camera-trap image
24 Aug. 2023	4,707	Grassland	19.26	Sakya Valley	Camera-trap image
28 Aug. 2023	4,935	Grassland	20.03	Sakya Valley	Camera-trap image
1 Sep. 2023	4,847	Shrubland	23.09	Sakya Valley	Camera-trap image
2 Sep. 2023	4,814	Grassland	21.22	Sakya Valley	Camera-trap image
3 Oct. 2023	4,769	Boulder field	4.02	Sakya Valley	Camera-trap image
20 Oct. 2023	4,796	Grassland	9.50	Sakya Valley	Sighting

PLATE 1 A brown bear *Ursus arctos* photographed by a camera trap in Limi Valley, Upper Humla, north-western Nepal, on 16 April 2023. Photo: Himalayan Wolves Project.

Brown bears in Limi Valley (Plate 1) display distinctive characteristics typical of the Tibetan brown bear *U. arctos pruinosus*, including dark fur, a white collar around the neck, a tan-coloured face and black ears (Pocock, 1941; Schaller, 2012). A previous genetic study identified all bear samples collected in the south-eastern Himalayas and Tibetan Plateau as *U. arctos pruinosus*, and all those from

the north-western to western Himalayas as *U. arctos isabellinus* (Lan et al., 2017). Our study area encompasses parts of the western end of the Tibetan Plateau, providing further support that the bears we recorded in Limi Valley are Tibetan brown bears. Considering the documented presence of Himalayan brown bears in Uttarakhand, India (Pal et al., 2016), immediately to the west of Limi Valley, it is possible that Limi valley is a contact zone between the Tibetan and Himalayan brown bears, but this requires genetic verification. The type locality of *U. arctos isabellinus* is specified as ‘mountains of Nepal’ (as *Ursus isabellinus*; Pasitschniak-Arts, 1993). This presents an avenue for further research into the evolutionary history of brown bears in the Himalayan–Tibetan region, where the possibility of an unclassified bear species has been suggested (Sykes et al., 2014).

We conducted several research expeditions in Limi Valley during 2014–2023, primarily in the summer. We consistently observed signs of brown bear digging activities but had no direct sightings. This could be because Tibetan brown bears have extensive home ranges ($> 7,000 \text{ km}^2$ for males and $2,200 \text{ km}^2$ for females) and low densities (McLellan et al., 2017), making sightings rare. It could also be because brown bears tend to be mostly crepuscular and nocturnal in human-dominated landscapes (Kaczensky et al., 2006; Seryodkin et al., 2013). This behaviour is reflected in our camera-trap records, with most brown bear

images captured during the night-time, early morning or late evening (Table 1). A single sighting in a remote corner of the study area in mid October 2023 supports the suggestion by Klinka & Reimchen (2002) that brown bears exhibit increased daytime activity in remote areas. Day-time images captured during March–April, when the valleys are devoid of people, also indicate increased diurnal activity in their absence. The absence of brown bear records during June–July, when herding activity is greatest, is probably further compounded by the mating period of these bears, which occurs during early May–July (Smith & Xie, 2013). The absence of camera-trap images during November–early March could indicate that the brown bears in Limi Valley initiate hibernation during late October, with their spring arousal taking place in mid March (Pasitschniak-Arts, 1993).

Currently, brown bears in Limi Valley do not appear to come into conflict with people as the area is remote and human activity is low and confined to the summer months. Nawaz (2007) noted that brown bears in Pakistan are less vilified compared to snow leopards and wolves because they are not aggressive and rarely attack people or prey on livestock. However, during a research expedition in 2016, local people reported to us the killing of a brown bear in Chuwa Khola, to the east of our study area within Humla district. Livestock herders killed the bear because they believed it to be a yeti and were afraid it might attack people and their livestock. Incidents such as this require attention and monitoring because the species is sometimes killed for its bile, which is traded for high prices in Asia (Sathyakumar, 2001). There are also reports of hunters targeting brown bears for their body parts, which are sold as delicacies in Tibet (Schaller, 2012).

Brown bear populations in the Himalayan–Tibetan region are reported to have declined by > 50% during the 20th century as a result of habitat loss and fragmentation, poaching and hunting (Servheen et al., 1999; Bellemain et al., 2007; Nawaz, 2008; Abbas et al., 2015). There are few suitable areas for brown bears in Nepal and habitat loss could lead to the local extirpation of the species in the country (Dai et al., 2021). Given the rarity of the brown bear in Nepal, Limi Valley is a promising area for further research into the ecology of the species in the country. We support the recommendation of Kusi et al. (2021) advocating for the protection of the currently unprotected wildlife habitats of Limi Valley, which harbour specialized high-altitude fauna and flora in Nepal.

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Author contributions Study design: NK, SG, GW; fieldwork: NK, SG, DTL, GW; data analysis: NK, GW; writing: all authors.

Conflicts of interest None.

Ethical standards This research involved a non-invasive camera-trap survey and otherwise abided by the *Oryx* guidelines on ethical standards. Any camera trap images of people in the data set are used only for quantifying human presence as a variable potentially impacting wildlife. None of the camera trap images of people have been or will be used for any other purpose.

Data availability The data supporting the findings of this study are available in Table 1.

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