First photographic record of the snow leopard *Panthera uncia* in Kishtwar High Altitude National Park, Jammu and Kashmir, India

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Abstract The snow leopard *Panthera uncia* is categorized as Vulnerable on the IUCN Red List. It is the least well-known of the large felids because of its shy and elusive nature and the inaccessible terrain it inhabits across the mountains of Central and South Asia. We report the first photographic record of the snow leopard in Kishtwar High Altitude National Park, India. During our camera-trapping surveys, conducted using a grid-based design, we obtained eight photographs of snow leopards, the first at 3,280 m altitude on 19 September 2022 and subsequent photographs over 3,004–3,878 m altitude. We identified at least four different individuals, establishing the species' occurrence in Kiyar, Nanth and Renai catchments, with a capture rate of 0.123 ± SE 0.072 captures/100 trap-nights. We also recorded the presence of snow leopard prey species, including the Siberian ibex *Capra sibirica*, Himalayan musk deer *Moschus leucogaster*, long-tailed marmot *Marmota caudata* and pika *Ochotona* sp., identifying the area as potential snow leopard habitat. Given the location of Kishtwar High Altitude National Park, this record is significant for the overall snow leopard conservation landscape in India. We recommend a comprehensive study across the Kishtwar landscape to assess the occupancy, abundance, demography and movement patterns of the snow leopard and its prey. In addition, interactions between the snow leopard and pastoral communities should be assessed to understand the challenges facing the conservation and management of this important high-altitude region.

Keywords Camera trapping, India, Kashmir Himalaya, Kishtwar, *Panthera uncia*, photographic record, snow leopard

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India contains c. 2% of the global snow leopard *Panthera uncia* range, with 400–700 individuals distributed along the sub-alpine, alpine and trans-Himalayan regions of Ladakh, Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh (McCarthy et al., 2017; Sharma & Singh, 2020). The snow leopard is an iconic species and an ideal flagship for the conservation of these high-altitude mountain ecosystems (McCarthy et al., 2017). The occupancy and abundance of the snow leopard is poorly known across its range in India (Suryawanshi et al., 2019; Sharma & Singh, 2020). Population surveys in the Western Himalayas have been limited to Ladakh, Himachal Pradesh and Uttarakhand (Ghoshal et al., 2019). In Kashmir the snow leopard has been reported from Gurez and Sonamarg (Ahmad et al., 2020), in the upper Baltal-Zojila region (Hussain, 2022), in the Kargil range (Maheshwari et al., 2012) and in the areas adjacent to the north-eastern and south-eastern boundary of Kishtwar that connect with the Zanskar range in the Union Territory of Ladakh (Snow Leopard Conservancy, 2018; Fig 1). However, its occurrence remains uncertain in the majority of Kashmir, including in protected areas. Here we report the first photographic records of snow leopards in Kishtwar High Altitude National Park, through camera trapping. Prior to this there were reports of snow leopard presence in the area based on signs (Hilaluddin & Naqash, 2013) and a sighting record (Zaheer et al., 2023), although neither of these reports included photographic evidence.

The 2,191 km² Kishtwar High Altitude National Park covers an altitude range of 1,800–6,000 m above the Chenab River and below the Nagin Sheer glacier, connected with Ladakh through the Zanskar range to the north-east and Himachal Pradesh to the south (Fig. 1). The Park is largely inaccessible above 4,300 m because of the rugged terrain and extreme weather. The Park has several vegetation types across its wide variation in elevation, aspect, slope and moisture regime (Sharma et al., 2018). The Semi-Arid Biogeographic Zone, which defines the north-eastern border of the study area, is a mosaic of biomes. This encourages the inward movement of several species of mammals, including the wolf *Canis lupus*, Siberian ibex *Capra sibirica*, Himalayan musk deer *Moschus leucogaster* and snow leopard. The National Park supports the livelihoods of thousands of nomadic livestock herders and also attracts pilgrims to several temples in the Kibber and Nanth catchments.

Using *ArcGIS 9.3* (Esri, USA), we divided the study area into a grid of 5 × 5 km cells and deployed 40 camera traps (Cuddeback Blue Series 1279 and 1248, Cuddeback, USA)
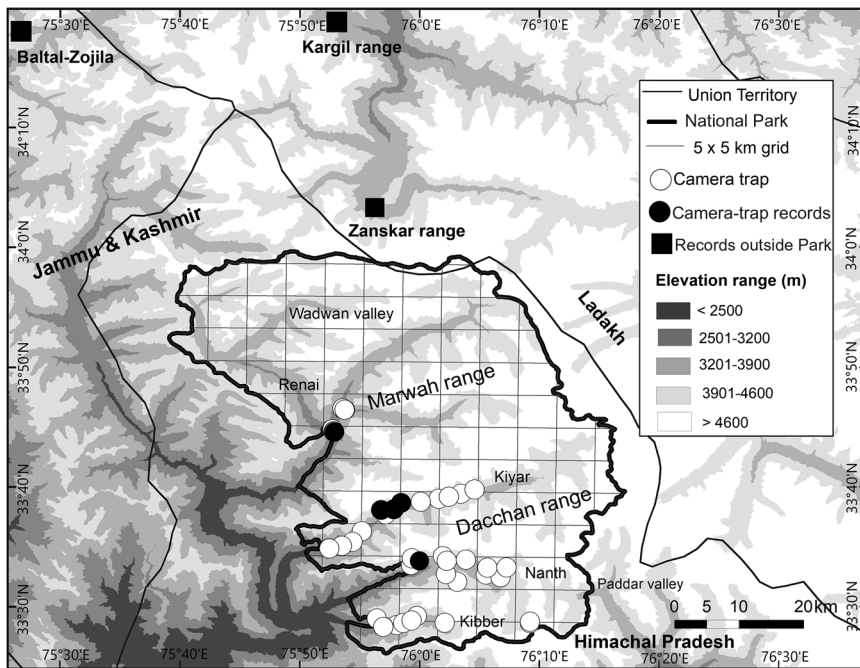
Fig. 1 The study area, showing the location of camera-trap stations and the new snow leopard *Panthera uncia* occurrence records in Kishtwar High Altitude National Park, Jammu and Kashmir, India, and three earlier records in the adjacent landscape (Maheshwari et. al., 2012; Snow Leopard Conservancy, 2018; Hussain, 2022).

at 57 locations in a total of 18 grid cells for 1 year (May 2022–June 2023). We deployed cameras on natural trails, trail junctions, ridge lines and locations of probable animal use, based on the occurrence of carnivore signs, to maximize the probability of detecting animals. We deployed 1–4 cameras in each grid cell, for a minimum duration of 1 month at each location, after which we moved cameras to new locations to ensure maximum coverage. We checked the cameras at least once per month (except during winter) to ensure they were functioning and to replace batteries and memory cards. As a large part of the National Park is glacier covered (including northern, north-eastern, eastern and south-eastern regions above 4,500 m) and thus mostly inaccessible, the positioning of our camera traps was limited to the southern, south-western and central areas of the Park. However, we are continuing our camera-trap surveys in the Park, with wider coverage.

During 6,623 trap-nights we obtained photographs of two individual snow leopards in a single frame on 19 September 2022 at 23.03 in the Kiyar catchment of the Dacchan range at 3,280 m. This was the first photographic evidence of the species in Kishtwar High Altitude National

Plate 1 Camera-trap photographic records of the snow leopard *Panthera uncia* in Kishtwar High Altitude National Park, Jammu and Kashmir, India; (a) is the first camera-trap record, on 19 September 2022, with two individuals.

TABLE 1 Relative abundance of mammalian species (encounter rate of sightings and signs of presence per km surveyed, and photo-capture rate per 100 camera-trap nights) and altitude range of detections in the Kishtwar High Altitude National Park, Jammu and Kashmir, India (Fig. 1).

Species	Encounter rate ± SE per km	Photo-capture rate ± SE per 100 camera-trap nights	Altitude (m)
Carnivores			
Snow leopard *Panthera uncia*	0.181 ± 0.084	0.123 ± 0.072	3,004–3,878
Himalayan brown bear *Ursus arctos*	0.137 ± 0.023	0.744 ± 0.338	3,408–4,098
Asian black bear *Ursus thibetanus*	0.054 ± 0.013	1.565 ± 0.809	2,622–3,630
Red fox *Vulpes vulpes*	0.118 ± 0.025	3.297 ± 0.978	2,300–3,700
Yellow-throated marten *Martes flavigula*	0.032 ± 0.009	0.518 ± 0.226	2,834–4,052
Leopard cat *Prionailurus bengalensis*		0.472 ± 0.275	2,622–2,729
Mountain weasel *Mustela altaica*	0.003 ± 0.002	0.017 ± 0.017	3,067–4,098
Potential snow leopard prey			
Siberian ibex *Capra sibirica*	0.017 ± 0.007	2.225 ± 1.048	3,036–4,042
Himalayan musk deer *Moschus leucogaster*		0.471 ± 0.428	3,044–3,661
Long-tailed marmot *Marmota caudata*	0.004 ± 0.003	0.710 ± 0.480	3,622–4,094
Pika *Ochotona* sp.	0.052 ± 0.008	0.816 ± 0.443	3,630–4,052

Park (Plate 1a). We obtained seven more photographs of snow leopards in three other grid cells, in the Kiyar and Nanth catchments of the Dacchan range and the Renai catchment of the Marwah range (Fig. 1). Of the eight captures, we recorded four during the day and four during the night, with an overall capture rate of 0.123 ± SE 0.072 captures/100 trap-nights. Based on their coat patterns, we identified at least four different individuals. The eight captures were at 3,004–3,878 m altitude. This is mostly an arid alpine region above the treeline, with steep and rugged terrain flanked by high-altitude pastures of junipers *Juniperus* spp., grasses and legumes on rolling hills.

During reconnaissance surveys, trail monitoring and camera trapping we also recorded the presence of ungulates such as the Siberian ibex and Himalayan musk deer, which have been reported previously in this area (Kichloo et al., 2023), and small mammals, including the long-tailed marmot *Marmota caudata* and pika *Ochotona* sp. These species are considered potential snow leopard prey (Lyngdoh et al., 2014). Of these, the highest camera-trap capture rate was of the Siberian ibex (Table 1). We also recorded other carnivore species with the camera traps (Himalayan brown bear *Ursus arctos*, Asian black bear *Ursus thibetanus*, red fox *Vulpes vulpes*, leopard cat *Prionailurus bengalensis*, yellow-throated

FIG. 2 The location of Kishtwar High Altitude National Park, and with respect to the global snow leopard distribution.

marten *Martes flavigula* and mountain weasel *Mustela altaica*), amongst which we recorded the highest photo capture rate for the red fox. The generally greater detection of carnivores compared to prey could be attributed to our survey design, which focused on trails, trail junctions and ridge lines used by carnivores.

We also documented significant anthropogenic pressure through livestock grazing at higher elevations in the Kibber, Kiyar, Nanth and Renai catchments. Nearly 3,000 graziers and nomadic herders visit the alpine pastures in the Marwah range each year, with c. 150,000 livestock (Hilaluddin & Naqash, 2006). Overstocking is therefore a threat to both the habitat and the wild ungulate prey of the snow leopard through competition for pasture. This could lead to human–wildlife conflict and drive the snow leopard and its prey into suboptimal areas, thus exposing them to other threats. Our camera-trapping results indicate an avoidance of livestock-grazing areas by snow leopards and wild ungulates during summer (May–August), with no detections of these species during these months. This could have significant conservation implications and requires further examination.

Our findings indicate that Kishtwar High Altitude National Park is potential snow leopard habitat. This region connects three Himalayan landscapes: the greater Himalayas of Jammu and Kashmir, the trans-Himalayas of Ladakh (through Zanskar) and the lesser Himalayas of Himachal Pradesh (Baba, 2003; Kichloo & Sharma, 2021). Given the geographical position of the Kishtwar landscape and its high-altitude passes that connect snow leopard populations in the Himalayan and trans-Himalayan regions (Snow Leopard Conservancy, 2018; Kothari, 2022) to the global snow leopard range (Fig 2), our findings are important for snow leopard conservation in India. We recommend that a comprehensive study is conducted over the entire Kishtwar landscape (including the Paddar and Wadwan valleys) to estimate the occupancy and abundance, and demography and movement patterns of snow leopards and their prey. In addition, evaluation of their interactions with pastoral communities and threats to the conservation and management of this important high-altitude region is needed.

Author contributions Conceptualization: TB, PC; data collection, field surveys: OS, MR; data analysis: OS; research design and interpretation: TB; writing: OS, TB; resources and supervision: TB, PC; research permission: PC; revision: OS, TB, PC.

Conflicts of interest None.

Ethical standards Our study is based on field data collected through non-invasive sampling. We conducted our camera-trap placement in a socially responsible manner that did not violate privacy or cause other unnecessary harm. Our research received the necessary approvals and permits from appropriate institutions and statutory authorities of Jammu and Kashmir. No ethical approval was required for this research, and it otherwise abides by the *Oryx* guidelines on ethical standards.

Data availability The data supporting our findings are available on request from the corresponding author.

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