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First verified evidence of Eurasian lynx and Pallas's cat in Humla, Nepal

We present novel evidence of Pallas's cat *Otocolobus manul* and Eurasian lynx *Lynx lynx* in Upper Humla, Nepal, through camera trap images. The IUCN distribution range for the two cat species indicates that both occur in northwestern Nepal, however no specific evidence for either species' presence in the region has been available to date. We covered a study area of 336 km² with 61 camera traps run for 3,145 camera trap nights from July to October 2021 and 61 camera traps run for 3,139 camera trap nights from May to August 2022. For the year 2021, this resulted in two independent captures for Pallas's cat (of which one captured two adults with a cub) and three independent captures for Eurasian lynx, and for the year 2022 in one independent capture of Eurasian lynx. These findings provide distribution updates for the Pallas's cat and Eurasian lynx in Nepal and indicate the need for more focused research into the population status and ecology of these cats in the country. The findings further underline the importance to rapidly implement gripping protection to the biodiverse and unique Upper Humla landscape in close collaboration with local communities.

The Eurasian lynx and Pallas's cat are two lesser cat species found at low density in the Greater Himalayas, the Transhimalayas, and across the Tibetan Plateau. The Eurasian lynx is a medium-sized wild felid found across Eurasia at varying densities. The Pallas's cat is a small cat adapted to the desert steppes of Central Asia. Both species are little studied in Asia; specifically in Nepal (Breitenmoser et al. 2015, Ross et al. 2020).

Eurasian lynx

The Eurasian lynx (hereafter lynx only) is a medium-sized cat found across Eurasia and is assessed as Least Concern by the IUCN Red List (Breitenmoser et al. 2015). For Central Asia the Red List proposes the subspecies as Turkestan lynx *L. l. isabellinus*, found in the countries of Turkmenistan, Afghanistan, Pakistan, Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, China, India, Nepal and Bhutan (Breitenmoser et al. 2015). While the population status of lynx in Europe is relatively well understood, the data around lynx populations in Asia is fewer (Breitenmoser et al. 2015). From most range states there is only sparse information available and data on population trend is mainly missing (Breitenmoser et al. 2015). The lynx is a Palearctic species adapted to cold arid habitats. It occurs throughout the rocky hills and mountains of the Central Asian desert regions, across the Tibetan Plateau, and along the northern slopes of the Himalayas (Nowell & Jackson 1996). In this region the lynx is especially found in open, thinly wooded areas, rocky areas and steppe habitats above the tree line but also thick scrub woodland (Breitenmoser et al 2015, Matyushkin & Vaisfeld 2003, Nowell & Jackson 1996). In China, the lynx is reported from the northwest and west including the provinces of Ningxia, Gansu, and Qinghai, Inner Mongolia, Xinjiang and Xizang, and the Tibetan Autonomous Region (Bao 2010). In Nepal, the lynx is believed to be decreasing and classified as Vulnerable but data for the species in the country is few (Jnawali et al. 2011, Kusi et al. 2018). Confirmed records of its presence in Nepal come from Shey-Phoksundo National Park, Dhorpatan Hunting Reserve, and Annapurna Conservation Area (Fox 1985, Kusi et al. 2018, Werhahn et al. 2018). Jnawali et al. (2011) in addition maps the distribution of lynx in Nepal in Rara National Park but without confirmed records. The low population size of lynx in Nepal may be problematic as there is a risk that the small populations are not connected (due to human disturbance) while also an ongoing population decline is assumed (Jnawali et al 2011).

Major threats for lynx in Asia are habitat fragmentation and loss (due to farming, infrastructure development, resource extraction and logging activities), poaching (retaliatory killing due to depredation or for the illegal wildlife trade), accidental mortality through trapping, dogs, and human disturbance (Bao 2010, Breitenmoser et al. 2015).

There is a need for more research in Asia on lynx ecology, distribution, population trends, conservation threats and genetic monitoring to understand the population status and trends but also the impact of habitat fragmentation on genetic diversity. These researches may then inform improved management (Bao 2010, Moqanaki et al. 2010).

Pallas's cat

The Pallas's cat, also called manul, is a small cat found in northern and central Asia inhabiting grasslands, semi deserts, and desert habitats with extreme continental climates. Kitchener et al. (2017) propose two subspecies for the Pallas's cat, the subspecies found in the Himalayas of Nepal is *O. m. nigripectus*. The species is one of the lesser known wild felids and merits more focused research into its ecology, behaviour, population status, and conservation as well as in-place monitoring (Dhendup et al. 2019, Shrestha et al. 2014). It is assessed as Least Concern in the IUCN Red List while previously from 2016 until 2022 the species was listed as Near Threatened (the change was caused by improved population size estimation methods and not due to an actual improvement for the species conservation status) (Barashkova et al. 2019, Dhendup et al. 2019, Moqanaki et al. 2019, Ross et al. 2020). The proposed distribution range of the Pallas's cat is extensive, but the species occurs at low densities, the populations are highly fragmented, often rare, and assumed to be likely declining across their range (Barashkova et al. 2019, Greenspan & Giordano 2021). Pallas's cats are elusive and rare to detect, they usually occur at low density and are reported to be very vulnerable to disturbances, habitat degradation and destruction (Ross et al. 2020). They are habitat specialists needing open landscapes with access to cover in form of rocky crevices or burrows made by other species, and are specialised to feed on different species of pika (*Ochotona* sp.), rodents, and small lagomorphs (Ross et al. 2010b, 2020). Greenspan & Giordano (2021) find that pika distribution is an important factor for global Pallas's cat distribution.

The distribution of Pallas's cat in the Himalayas is thought to be discontinuous and restricted to one or two locations in each country, which are likely isolated from each other (Dhendup et al. 2019). The Himalayan and Transhimalayan regions of India, Nepal, and Bhutan represent the southern limits

of the species' distribution (Dhendup et al. 2019).

In Nepal, the first evidence of Pallas's cat was obtained in 2012 from Thorkya Pass (4,200 m) and Aangumie Lapche (4,650 m) in the Marsyangdi valley of Manang district, located within the Annapurna Conservation Area ACA during a camera trapping survey of snow leopard *Panthera uncia* (Shrestha et al. 2014). A photograph of a Pallas's cat pelt from 1987 suggests the historical presence of the species in the region (Lama et al. 2016). In 2014–2015, the species was detected at six different locations within Manang at elevations ranging from 3,988 m to 5,073 m (Regmi et al. 2016). More recently the species has been documented also from Tinkyu village of Upper Dolpa, some 90 km northwest of Manang. A genetic sample was collected at 5,539 m marking it the highest elevation record for Pallas's cat to date (Werhahn et al. 2018). And recently Seimon et al. (2022) found genetic evidence for the presence of Pallas's cat in Sagarmatha National Park in eastern Nepal with samples collected at 5,110 and 5,190 m elevation.

Conservation threats to the Pallas's cat include predation by sympatric carnivores, herding dogs, and human offtake, but also habitat disturbance and fragmentation (Ross et al. 2020). In addition mineral exploitation and infrastructure developments are increasing throughout the species' range and the cat continues to be at risk from a declining prey base, mostly that of pika (*Ochotona* spp.) in relation to rodent control programmes as applied through vast landscapes of their range (Ross et al. 2010b, 2020).

The Pallas's cat is not a fast runner and relies on its camouflage and taking cover in cavities such as burrows (e.g. of marmots), or in rock crevices for protection. The cats also need cavities as dens for their daily use and for rearing their young (Ross et al. 2010a).

Hence open areas without suitable cover are avoided and habitats with cover such as ravines, rocky areas, shrub-steppe, and hillslopes are selected (Ross 2009, Ross et al. 2010a).

As a result, Pallas's cats use only a small fraction of the habitats within their steppe ecosystems and this habitat selection and specialisation is thought to be the explanation for their low densities (Ross et al. 2020).

Here, we report the documentation of Eurasian lynx and Pallas's cat in Upper Humla, northwestern Nepal, providing solid evidence for the two species in this Transhimalayan region of the country. These records add detail to the IUCN range maps at the southern distribution edges for the two species and add insights into their habitat breadth in a high-altitude Transhimalayan grassland and steppe environment with low temperatures and intense winds.

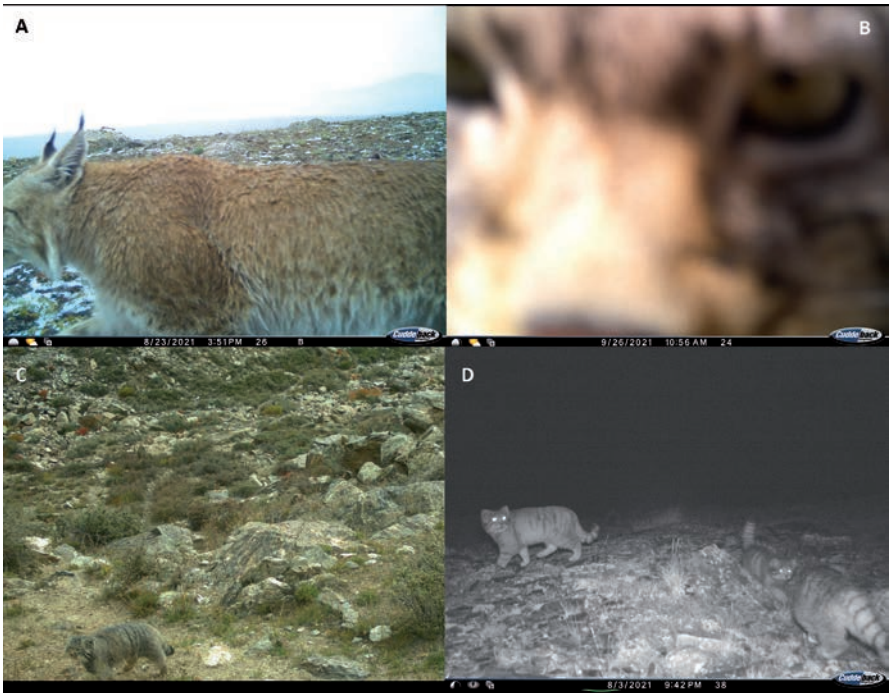

Fig. 1. Camera trap captures of Eurasian lynx (A and B) and Pallas's cat (C and D) in Upper Humla during August-September 2021 (Photos Himalayan Wolves Project).

Methods

We conducted a systematic camera trapping survey with 61 cameras covering a study area of 336 km^2 with two cameras placed in two different locations within a grid of 4 km x 4 km. The cameras were deployed for a total of 3,145 camera trap nights between 12 July 2021 and 6 October 2021 and for a total of 3,139 camera trap nights between 28 May 2022 and 30 August 2022.

Study site

The habitat comprises alpine steppes and grasslands of the Transhimalayas which are continuous with the Tibetan Plateau landscape and is seasonally used for yak herding. Local people belong to the Buddhist ethnic group. Small mammals found in the area include Himalayan marmot *Marmota himalayana*, woolly hare *Lepus oiostolus*, plateau pika *Ochotona curzoniae*, Stoliczka's mountain vole A*lticola stoliczkanus* and the Tibetan dwarf hamster *Cricetulus alticola*. Larger ungulates include the wild yak *Bos mutus*, Kiang *Equus kiang*, Naur *Pseudois nayaur*, Tibetan argali *Ovis ammon hodgsonii*, and Tibetan gazelle *Procapra picticaudata*. Other carnivores present are the Himalayan wolf *Canis lupus chanco*, Tibetan fox *Vulpes ferrilata*, red fox *V. vulpes*, Altai weasel *Mustela altaica* and steppe polecat *M. eversmanii* (Gurung et al. 2022).

Results

Lynx

In 2021, we captured three independent camera trap pictures of lynx of one individual in each case (Fig. 1 A & B). This results in a relative abundance of 3/3145*100 = 0.095 for 2021. Two captures were at location 30°24'28.8"N/81°37'26.4"E at 4,980 m elevation on 23 August 2021 at 15:21 h and 26 September 2021 at 10:56 h. And the third capture was at location 30°21'43.2"N/81°37'12.0"E at 4,968 m elevation on 29 July 2021 at 19:27 h. Both locations were within gently rolling hillslopes (Fig. 2). For the year 2022 we only caught one lynx on camera at the same location as the two captures in the previous years at location 30°24'28.8"N/81°37'26.4"E at 4,980 m elevation on the 1 August 2022 at 19:44 h. This results in a relative abundance of 1/3139*100 = 0.032 for 2022.

Pallas's cat

We captured two independent images of Pallas's cat in 2021 resulting in a relative abundance of 2/3145*100 = 0.064. One capture was of two adults with a cub at location 30°19'26.4" N / 81°36'32.4" E at 5,127 m elevation on 3 August 2021 at 21:42 h (Fig.1 D). And

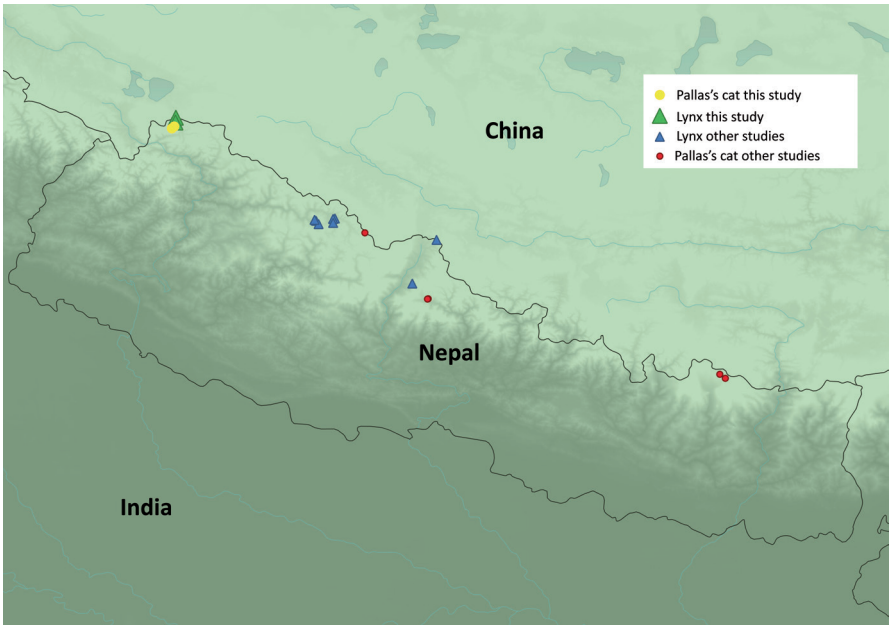

Fig. 2. Camera trap capture locations of Pallas's cat and Eurasian lynx in this study and other recent studies from Nepal (Kusi et al. 2018, Seimon et al. 2022, Shrestha et al. 2014, Werhahn et al. 2018; for other Pallas's cat studies from the region see also: Fox & Dorji 2007, Mahar et al. 2017, Pal et al. 2019, Thinley 2013, Wangchuk et al 2004).

another capture of one adult at 30°18'25.2" N / 81°35'09.6" E at 4,771 m elevation on 16 September 2021 at 09:59 h (Fig.1 C). The first location was on top of a steep ridgeline with a boulder field hillslope (talus slope) on one side and a gentle rolling hillslope on the other side, while the second location was within a broken rocky boulder field (Fig. 2).

Discussion

These findings of lynx and Pallas's cat in Upper Humla, northwestern Nepal represent first verified evidence for the presence of the two cat species in the region. Elderly local people had told us that lynx were present in the region in the past but were not aware of the species' current presence in the area. And they were not aware of the presence of Pallas's cat; most people with exception of a few very elderly did not recognise the Pallas's cat when shown photographs. This seems remarkable given that herders spent extensive time periods in the pasturelands in the summer season where these records were made and may be an indication of the elusiveness of the Pallas's cat and its possibly low density.

Lynx

The closest records of lynx comes from Upper Dolpa (Werhahn et al. 2018) around 180 km east from the current location in Upper Humla. Kusi et al. (2018) provides an overview of historical and recent lynx records in Nepal and finds that the species may be sparsely distributed and is little studied in the country. The relative abundance for lynx in Upper Humla (0.095) is slightly higher than what Kusi et al. (2018) found in Upper Mustang (0.06).

Werhahn et al. (2018) found Eurasian lynx scats in alpine shrub lands at elevations from 4,738–4,818 m in Upper Dolpa. Their dietary analysis based on six Eurasian lynx scats revealed 56% woolly hare, 17.7% pika and rodent *Alticola* sp., 9.7% Himalayan marmot, 7% vegetation and 3.3% domestic goat C*apra aegagrus hircus* in the scats. All these small wild mammals are also abundant in the habitat where the current findings were made in Upper Humla. Herders usually keep yaks in these pasturelands; goats and sheep are also brought higher up for herding during summer, but they usually remain at lower elevations than where these records were made.

We want to emphasise the importance of the claims by Kusi et al. (2018) that the government of Nepal shall amend the wildlife damage relief guidelines (GoN 2015) and include the Eurasian lynx as eligible for depredation compensation. A reliable mechanism should be put into action for the successful implementation of these legal guidelines from local to regional scale.

Pallas's cat

The closest record (published) of Pallas's cat comes from Shey-Phoksundo National Park in Upper Dolpa (Werhahn et al. 2018) around 230 km east from the present location in Upper Humla. Another unpublished record was made in the Langu section of Shey-Phoksundo National Park (Gopal Khanal personal communication 2021) and more recently in sano Koike of Mugu village within Mugu district (Tashi Topgyal Lama personal communication 2022). The habitat north of Limi valley in Upper Humla is favourable for Pallas's cat as it comprises alpine steppe habitats with rolling hillslopes and extensive boulder fields interspersed with lakes. Prey species present for Pallas's cat in the area include Plateau Pika, Royle's Pika *O. roylei*, woolly hare, Tibetan dwarf hamster, Himalayan marmots, and several species of rodents.

Our team has conducted ecological and social research in the Humla region since 2013 and we had repeatedly shown images of Pallas's cat to local people, but we never encountered evidence for the species' presence during the earlier research. While few of the elderly locals may have recognised the animal from the photo (they referred to it by the local name 'Thumba gyalpo'), they did not report its current presence in the area; this may indicate that the species has been present historically in the area or that older aged locals remember the species from their herding times in the past further north on the Tibetan Plateau in the Tibetan Autonomous region. The elusive nature of the species makes it difficult to detect it in the landscape without a targeted approach. Further, the density may likely be low in the Humla region. The documentation of a cub is a positive sign.

In Mongolia and Russia there are reports of the fat and organs of Pallas's cats being used as traditional medicine (Barashkova et al. 2019, Ross et al. 2020). But local people in Humla do not report any use of the animal (while many other animals do find a use in their culture).

Conclusion

Conservation actions for Eurasian lynx and Pallas's cat in Asia remain very limited but are highly recommended (Breitenmoser et al. 2015, Dhendup et al. 2019, Moqanaki et al. 2019, Ross et al. 2020). Pallas's cats and lynx are two very elusive wild felids. The Pallas's cat inhabits only a small percentage of the landscape suitable for their needs and is often found at low densities (Ross et al. 2020). Similarly, the lynx in high Asia is very elusive and often only present at low densities (Breitenmoser et al. 2015). Hence, large areas of intact habitat are required to con-

serve viable populations of Eurasian lynx and Pallas's cat (Ross et al. 2020).

The habitats of Upper Humla are a prime habitat for both species, as well as many other characteristic high-altitude species such as snow leopard, Himalayan wolf, wild yak, Tibetan argali, Tibetan gazelle, and Kiang in the Himalayas (Kusi & Werhahn 2016a, b). These findings underline the need to implement gripping protection to the Upper Humla landscape. More research into the population status and ecology of Pallas's cat and lynx in this region are strongly recommended.

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