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Cover: Iberian Lynx kitten in Zocueca, Spain. © Sergio Marijuán.

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EDITORIAL

Foreword to the second special issue on small wild cats

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We are delighted to present the second special issue on small wild cats that covers seven species with important updates on their distribution, tenacity and adaptability. Obtaining such information is now possible because of camera trapping becoming affordable and popular. The enthusiasm of the authors who contributed to this issue will hopefully inspire you.

Two contributions focus on the Iberian Lynx *Lynx pardalis*, one of the most endangered wild cat species in the world (Simón 2011). One accounts of a population that benefits from a long-term conservation program in southern Spain, where reintroduced Iberian Lynx have been settling in agricultural land since 2011. The other contribution sheds light on the trophic niche of an isolated population in central Spain. It shows that molecular methods are gaining prominence when studying cryptic taxa.

The European Wildcat *Felis silvestris* is the only Wildcat population living on a volcanic island (Anile et al. 2009). In 2009, camera traps set up around Mount Etna in Sicily detected an individual that was again photographed in 2018 at the very same spot!

The Jungle Cat *Felis chaus*, however, was recorded for the first time in a landscape where nobody would have expected it: in a remote valley above 3,000m in the Annapurna Himalaya. On the other hand, in northern Pakistan, it was detected amidst factory buildings.

The Asiatic Golden Cat *Catopuma temminckii* was first reported in 1831 to inhabit the Himalayan foothills in Nepal (Hodgson 1831). In 176 years, it was photographed only twice in Nepal, viz, in May 2009 by Ghimirey & Pal (2009) and in November 2017 by Rai et al. (2019) in the country's eastern part. Farther west, it remained elusive until a team of researchers ventured into the central Himalaya. It was also photographed in far eastern Bhutan – an account that again reveals its many costumes.

The Flat-headed Cat *Prionailurus planiceps* is perhaps the most cryptic small wild cat, as it lives in almost impenetrable landscapes. Incidental observations in peat swamp forests in northern Borneo provide insight into its secretive lifestyle.

The Pampas Cat *Leopardus colocolo* is widely distributed in South America but was recorded in northwestern Peru only in 2016 (Garcia-Olaechea & Hurtado 2016). Both authors have been working in this area ever since and now share their findings about the Pampas Cat and another little known carnivore.

The Andean Cat *Leopardus jacobita* is endemic to the highlands of the Andes, where a skin turned up in an unexpected location in northwestern Argentina. This finding bridges a gap between two evolutionarily significant units of this little known species.

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WILD CAT NETWORK SACON

The authors of the first and second special issues covered work on 16 small wild cats living in 15 countries. These special issues are a good platform for sharing information that is crucial for planning conservation measures.

We thank the following people for reviewing the submitted manuscripts for this special issue: Pedro Monterroso, Aitor Gastón, Carl Traeholt, Andrew Hearn, Azlan Mohamed, Jennifer McCarthy, Tashi Dhendup, Jimmy Borah, André da Pinto Silva, Sriyanie Miththapala, Zaheer Khan, Flavia Tirelli, Susan Walker, Matthias Waltert, Jorge Lozano, Galo Zapata-Ríos, Claudia Kanda, Juan Ignacio Reppucci, Arash Ghoddousi, Carlos Fernandes, Tawqir Bashir, Wyatt Petersen, Priya Singh, Babu Ram Lamicchane, and Yadav Ghimirey.

We look forward to your experiences and endeavors in the world of small wild cats. Stay fascinated !!

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COMMUNICATION

Breaking barriers: Iberian Lynx *Lynx pardinus* Temminck, 1827 (Mammalia: Carnivora: Felidae) colonizing Olive groves

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Abstract: In recent years, the Andújar-Cardeña Iberian Lynx *Lynx pardinus* population has grown both in number and in occupied surface area. This feline has spread into areas surrounding existing population nuclei and occupied new habitats including human-dominated areas and tree crops. Here we describe this colonization process and the evolution of the Iberian Lynx populations in the Olive *Olea europaea* groves that surround typical Lynx scrub habitats in Andújar-Cardeña. Our findings were obtained through radio-tracking, camera trapping and European Rabbit *Oryctolagus cuniculus* monitoring. Two colonized areas—Zocueca and Marmolejo-Montoro—were identified in which Olive cultivation is predominant. Since 2011, a total of 45 and 50 different individuals have been detected in Zocueca and Marmolejo-Montoro, respectively. At present, 19 individuals are known to live in Zocueca and 29 in Marmolejo-Montoro. The main cause of mortality is road-kills. Our results suggest that the Iberian Lynx is capable of colonizing human-modified areas such as agricultural land provided that they can support high-density Rabbit populations and the causes of non-natural mortality are minimized.

Keywords: Agricultural land, camera trapping, human-dominated habitat, radio telemetry, Sierra Morena.

Resumen: En los últimos años, la población de lince ibérico de Andújar-Cardeña ha crecido tanto en número como en superficie ocupada. Este felino se ha extendido a áreas que rodean los núcleos de población existentes y ha ocupado nuevos hábitats, incluyendo áreas dominadas por humanos y cultivos arbóreos. En este trabajo se describe este proceso de colonización y la evolución de las poblaciones de lince ibérico en los olivares Olea europaea que rodean sus hábitats típicos de matorral mediterráneo en Andújar-Cardeña. Nuestros hallazgos se obtuvieron mediante radioseguimiento, fototrampeo y seguimiento de la población de conejos. Se identificaron dos áreas colonizadas, Zocueca y Marmolejo-Montoro, en las que predomina el cultivo del olivo. Desde 2011, se han detectado un total de 45 y 50 individuos diferentes en Zocueca y Marmolejo-Montoro, respectivamente. En la actualidad, se sabe que 19 individuos viven en Zocueca y 29 en Marmolejo-Montoro. La principal causa de mortalidad son los atropellos. Nuestros resultados sugieren que el lince ibérico es capaz de colonizar áreas modificadas por humanos, como tierras agrícolas, siempre que existan poblaciones de conejos de alta densidad y se minimicen las causas de la mortalidad no natural.

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Author details: Dr. Germán Garrote has been working in research and conservation of the Iberian Lynx since 2000. José Francisco Bueno, Manuel Ruiz, Santiago de Lillo, José Manuel Martin and Manuel Moral are field assistants of the Iberian Lynx conservation program of the Agencia de Medio Ambiente y Agua de Andalucía, Spain. Miguel Ángel Simón was the director of this program for 20 years and is now retired.

Author contribution: Germán Garrote designed the study, conducted the field surveys, compiled the data and wrote this manuscript. Bueno, Ruiz, Lillo, Martin and Moral conducted the field surveys. M.A.SImon wrote this manuscript.

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INTRODUCTION

The global expansion of human activities has had profound consequences for wildlife (Gaynor et al. 2018). Human-induced habitat degradation and loss, prey depletion and poaching are widely recognized as the main threats to carnivores (Karanth et al. 2004; Groenendijk et al. 2015; Wolf & Ripple 2016), causing widespread declines in their populations (Carter & Rosas 1997; Lodé et al. 2001; Ripple et al. 2014). Nevertheless, in recent decades a certain stabilization or even increase in the abundance of some carnivore populations has taken place owing foremost to protective legislation, greater public concern and a variety of policies that encourage co-existence between humans and carnivores (Recharte & Bodmer 2010; Chapron et al. 2014). Some carnivore species can now settle in and use human-altered landscapes if there are no human activities that act as impediments (Dellinger et al. 2013; Garrote et al. 2013). Thus, understanding and then managing carnivore responses to landscape heterogeneity and to the human-driven changes occurring therein are now two main priorities in ecological research and applied conservation techniques (Fahrig et al. 2011).

The Iberian Lynx *Lynx pardinus* is an Iberian endemic specialist predator whose staple prey is the European Rabbit *Oryctolagus cuniculus* (Fedriani et al. 1999; Gil-Sánchez et al. 2006). Its populations dropped dramatically in the 20th century (Gil-Sánchez & McCain 2011) to the point that at the beginning of the 21st century, less than 100 Lynx were estimated to remain in just two isolated populations in eastern Sierra Morena and Doñana (Simón et al. 2012; Guzmán et al. 2004). This decline was attributed to the combined effects of habitat destruction and fragmentation, declines in European Rabbit abundance, and hunting and/or poaching (Guzman et al. 2004; Rodríguez & Delibes 2004). As a result, the species was listed as Critically Endangered in 2002 (Cat Specialist Group 2002). Since then, the Iberian Lynx population increased significantly in size due to measures carried out as part of conservation projects (Simón et al. 2012) designed to increase the carrying capacity of occupied habitats by enhancing European Rabbit populations, reducing known causes of mortality, and creating new populations through reintroductions (Simón et al. 2012). These actions succeeded in population recovery, so that the Iberian Lynx was downlisted to Endangered in 2015 (Rodríguez & Calzada 2015). By 2017, the minimun number of Iberian Lynx detected in the wild was estimated at 589 individuals (Simón 2018). Specifically, the population in Andújar-Cardeña rose from 79 individuals in an area of 153km^2 in 2004 to 195 individuals detected in 520km^2 in 2017. During the period of 13 years, the Lynx has spread to areas surrounding its main remnant population nuclei that contain apparently suboptimal habitats such as humanized areas and tree crops (Garrote et al. 2013, 2016).

On the southeastern edge of the range of the Andújar-Cardeña Lynx population, the Mediterranean scrubland borders vast swathes of intensively cultivated Olive *Olea europaea* groves. The first Lynx to establish territories here were detected in 2012, and the first breeding attempt in this type of habitat was recorded in 2013 (Garrote et al. 2015). Thereafter, more Lynx began to occupy this area and a new Lynx subpopulation was established 8km to the south of the main population in an area dominated by Olive groves. Below, we describe the colonization process and evolution of the Iberian Lynx populations that now thrive in these new habitats.

STUDY AREAS

Andújar-Cardeña in eastern Spain's Sierra Morena (Figure 1) is an area with low mountains covered by well-preserved Mediterranean forests and scrublands where most of the land is occupied by large hunting reserves. It is located between Guadalmellato (25km to the west) and Guarrizas (30km to the east), where Iberian Lynx were reintroduced since 2010. By 2017, the minimum number of individuals detected in Guadalmellato and Guarrizas were 82 and 85 individuals, respectively (Simón 2018). On the southern to southeastern edge of Andujar-Cardeña, the Mediterranean scrubland borders two large areas of intensive Olive cultivation consisting of old trees set in parallel lines, Marmolejo-Montoro and Zocueca. Due to the intensive management of these groves, few patches of shrubs or meadows still exist, the only exceptions to this uniformity being small rocky outcrops that cannot be managed, scattered stands of Mastic Tree *Pistacia lentiscus* and Holly Oak *Quercus coccifera*, and narrow (< 2m) gullies lined with Giant Cane *Arundo donax* and young White Poplar *Populus alba*. To the south of both areas flows the Guadalquivir River, which is surrounded by a gallery forest consisting mainly of White Poplar.

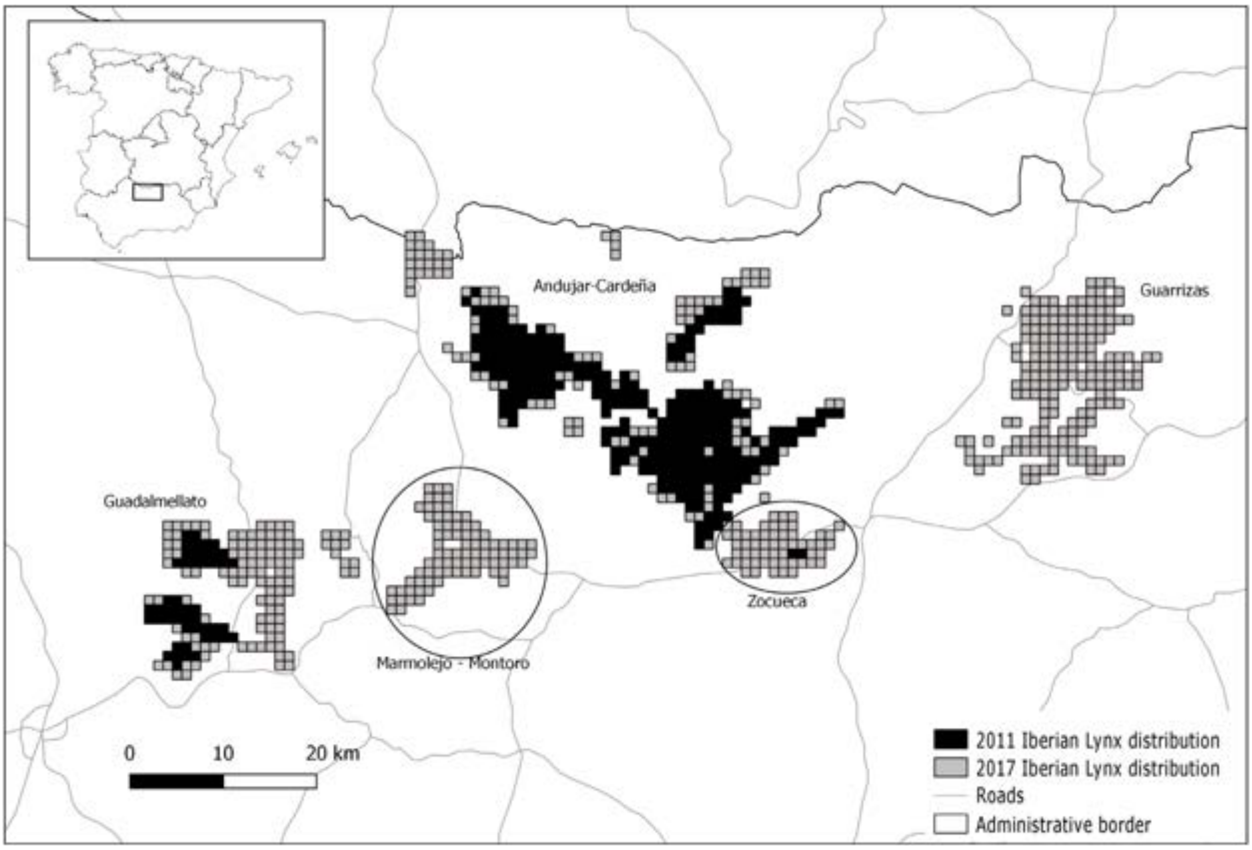

Figure 1. Iberian Lynx distribution in Sierra Morena, Andalucía. Guarrizas and Guadalmellato populations, created by reintroduction, are included. The study areas of Marmolejo-Montoro and Zocueca are shown by an ellipse.

MATERIALS AND METHODS

Our findings were obtained as part of the Iberian Lynx population-monitoring program carried out within the framework of the Iberian Lynx Life Project (see Simón 2012; Simón et al. 2012). This monitoring program employs radio-tracking, camera trapping and Rabbit population monitoring. Radio-tagged Lynxes were captured using double-entrance, electro-welded mesh box traps (2×0.5×0.5 m) baited with Rabbits where Lynx were trapped and then fitted with VHF radio collars (Wagener Collar, Brenaerham, Germany). The VHF radio-tracking routine consisted of obtaining 1–5 locations by triangulation each week. We used the Locate extension of the QGIS 2.2.0 (QGIS Development Team, 2014) program to obtain locations from the field data. Camera traps were deployed across the entire Iberian Lynx distribution area (Gil-Sánchez et al. 2011). During the year, signs of Lynx presence like tracks and excrements were searched for in the known distribution area and in its periphery. When such signs were detected in a new area, camera traps were installed to confirm the species' presence and to attempt to identify the individuals present. In this way, we were able to identify the areas into which the species was expanding, which were then incorporated into the annual population-monitoring program. We designed a camera trapping grid system each year, with a mean distance between cameras of 1.36±1.03 km. Surveys lasted from June to July until October to November to maximize detection of kittens. The camera stations were kept active for a period of two to five months, depending on efficiency and redundancy of captures. Cameras were baited with Lynx urine or with live bait, either Rabbits or Rock Pigeons *Columba livia* in wire cages inaccessible by Lynxes. Each camera trap was visited once a week allowing to download pictures, to replenish urine or batteries and to care for live bait. Due to high levels of human frequentation and unrestricted access, only Lynx urine was used as bait in the Olive groves to avoid camera theft. Two camera trap models were used in this study: Moultrie M880 and Covert II Assasin. Lynxes were individually identified on the basis of their spot pattern (Garrote et al. 2011). Fecundity was assessed yearly by camera trapping through counting the number of kittens that accompanied each adult female after the breeding season. Therefore, our measure of fecundity is in regards to the number of kittens per territorial female detected during the period of post-weaning dependence (Monterroso et al. 2016). We identified a Lynx as territorial if the individual had breeding status, determined through detection of kittens, and/or if the camera trapping results or radiotracking data supported a non-overlapping surface (Gil-Sánchez et al. 2011). The information obtained from the camera traps and radio-tracking enabled us to delimit the species' annual area of presence in a grid of 1x1 km^2.

European Rabbit populations were monitored using latrine counts (> 20 pellets in a circle with an area > 30cm^2) along transects. Latrine counts are an indirect method that is frequently used to estimate relative Rabbit abundance over large areas (Virgós et al. 2003), which is calculated as a kilometric abundance index (KAI) of latrines. The complete Iberian Lynx distribution area was divided into 2.5×2.5 km^2 squares. Latrine counts were carried out along 4.5–7 km transects in each square. Sampling was conducted once a year in June and July at the end of the Rabbits' breeding season (June–July) when the populations reached their greatest density (Beltrán 1991).

RESULTS

Two areas dominated by Olive cultivation were identified as having been colonised by Iberian Lynx. The first, Zocueca, is located on the southeastern edge of the main population (Figure 1). A total of 56 camera traps were installed in this area from 2011 to 2017, yielding a sampling effort of 2,017 trap nights. A total of 46 different individuals were identified throughout the study period. The first Lynx was detected in 2011. In 2017, a minimum of 19 individuals were detected in an area of 53km^2 (Table 1).

The second area, Marmolejo-Montoro, lies 8km to the south-west of the main Andújar-Cardeña Lynx population. The first two Lynx were sighted and radio-detected here in 2013; one was a radio-collared individual from the main Andújar-Cardeña population (Table 1). A total of 58 camera traps were installed in this area from 2013 to 2017, yielding a sampling effort of 7,474 trap nights. A total of 50 different individuals were identified throughout the study period. In 2017, a minimum of 29 individuals had been detected in an area of 82km^2.

Nine Lynx with radio-collars were monitored in Zocueca and seven in Marmolejo-Montoro. Of these 16 individuals, seven were captured and radio-marked in

Image 1. Iberian Lynx in an Olive grove in Sierra Morena, Spain.

Table 1. Results of the Iberian Lynx population-monitoring in our study area.

	2011	2012	2013	2014	2015	2016	2017
ZOCUECA							
Individuals	1	4	12	11	10	14	19
Breeding females	0	0	2	3	3	4	4
Breeding events	0	0	1	2	1	3	4
Kittens	0	0	2	5	2	6	10
Kittens/breeding females	0	0	1	1.7	0.7	1.5	2.5
Surface	2	12	27	47	44	54	53
Rabbit abundance	-	-	22.5	18.8	18.9	26.2	19.5
Radio-tagged individuals	0	1	2	3	5	4	5
Camera-trap stations (trap nights)	2 (62)	2 (175)	5 (225)	5 (246)	20 (433)	11 (446)	11 (430)
MARMOLEJO-MONTORO							
Individuals			2	9	24	28	29
Breeding females			0	2	5	5	6
Breeding events			0	1	5	3	4
Kittens			0	2	13	9	8
Kittens/breeding females			0	1.0	2.6	1.8	1
Dead			0	0	0	3	2
Surface			8	19	73	85	82
Rabbit abundance			-	9.1	29.6	25.4	23.2
Radio-tagged individuals			1	1	1	6	6
Camera-trap stations (trap nights)			-	11 (1068)	14 (1146)	16 (2289)	17 (2971)

Olive groves in the study area; 10 were individuals that had been marked in other areas and had dispersed into the study area. These Lynx originated from the Andújar-Cardeña population (n=4), and from the individuals reintroduced into Guarrizas (n=3) and Guadalmellato (n=3) (Figure 1). One of the Lynx radio-marked in Marmolejo-Montoro established itself in Zocueca.

Rabbit abundances in the two areas are similar, with an annual average of 20.92+-3.59 latrines/km in Zocueca (years 2013–2017) and 21.84+-8.90 latrines/km in Marmolejo-Montoro (years 2014–2017).

A total of 11 Lynx breeding attempts were detected in Zocueca and 13 in Marmolejo-Montoro. Average fecundity was 1.46±0.70 and 1.68±0.69 kittens/year/territorial female in Zocueca and Marmolejo-Montoro, respectively.

In all, 22 Lynx deaths were reported (Table 2), with road accidents being the most frequent cause of death in both populations (63%). Disease was the second commonest cause of death (18%): of the four known cases, one was a five-year-old territorial female that died of tuberculosis; and the other three were old animals that had lost their territories and had wandered into this area.

Table 2. Cause-specific mortality detected in the Zocueca and Marmolejo-Montoro Iberian Lynx populations in the period 2011–2017.

	Zocueca	Marmolejo-Montoro
Road-kill	10	4
Poaching	1	0
Disease	4	0
Fight	2	0
Total	17	5

DISCUSSION

Our results show that the Iberian Lynx has colonized the Olive groves that border the Mediterranean scrub habitats in the mountains of Andújar and Cardeña. When the Lynx's range was at its smallest and restricted to just Doñana and Andújar, the research showed that its preferred habitat was found to be Mediterranean shrublands (Palomares et al. 2000; Fernández et al. 2006). Specifically, Lynx showed a preference for areas with shrub cover of over 35%, rocky outcrops and high densities of European Rabbits (Palomares et al. 2000;

Image 2. Iberian Lynx in Zocueca, Spain.

Image 3. Iberian Lynx (kitten) in Zocueca, Spain.

Palomares 2001; Fernández et al. 2006), whereas arable areas and woody crops were identified as unsuitable habitats (Palomares 2001; Fernández et al. 2006). Nevertheless, our findings suggest that the ecology of the Iberian Lynx is more plastic than originally thought, and that it is able to use habitats including agricultural areas that were deemed unsuitable (Palomares et al. 2000). Although some patches of scrub must be present in the chosen agricultural areas, research shows that the Iberian Lynx can establish territories and even reproduce in areas with only 2% shrub cover as long as suitable Rabbit densities exist (Garrote et al. 2016).

The presence of this feline is dependent on Rabbit abundance, which directly affects its demography and, above all, its breeding rates (Monterroso et al. 2016). The appearance in 2011 of a new variant of the Rabbit Haemorrhagic Disease Virus (RHDV2), also known as *Lagovirus europaeus* GI.2 (hereafter GI.2; Le Pendu et al. 2017) in European Rabbit populations led to a decline of 60–70% in Rabbit populations in Andújar-Cardeña, which was followed by a fall of 45.5% in Lynx breeding rates from 1.36±0.12 kittens/year/territorial female before GI.2 to 0.13±0.07 (2011–2013; Monterroso et al. 2016). Emergency management actions implemented to alleviate the effects of GI.2 (i.e., Rabbit restocking operations and the setting up of supplementary feeding stations) prompted a significant increase in Lynx fecundity (2012–2017: 0.82±0.19 kittens/year/territorial female, unpublished data). Pre-GI.2 fecundity values, however, have not yet been restored. In the Olive groves where Rabbit abundance was three times higher than in Andújar-Cardeña (07.13±0.62 latrines/km; unpublished data), Lynx fecundity reached 1.46±0.70 and 1.68±0.69 kittens/year/territorial female in Zocueca and Marmolejo-Montoro, respectively. These values are higher than the fecundity detected in the Andújar-Cardeña Lynx population during the same period and similar to values during the pre-GI.2 period. Evidently, Lynx breeding rates are not impeded by the use of Olive grove habitat.

The recovery of the Iberian Lynx population in Andújar-Cardeña was due to two main factors: (i) the carrying capacity of the habitat was increased by improving Rabbit populations and (ii) non-natural mortality was reduced (Simón et al. 2012; López et al. 2014). In the most remote areas where the impact of human presence is minimal, the main strategy employed was the reinforcement of Rabbit populations. In more peripheral areas, where Rabbit populations are strong enough to sustain the territorial Lynx's, the emphasis was put on reducing non-natural mortality via an anti-poaching program, the identification of road black-spots and educational activities. As a consequence of these conservation efforts, Lynx mortality (compared to figures from the 1980s and 1990s) has decreased significantly, not only in Andújar-Cardeña but throughout its whole range (Simón et al. 2012; Lopez et al. 2014). The highest abundance (n = 202 individuals) and density (0.72 individuals/km^2) of the Lynx population in Andujar-Cardeña was reached between 2010 and 2011. This coincides with the completion of the conservation efforts to increase the carrying capacity of the Lynx. It was also during this time that the first Lynx was detected in the Olive groves. Almost simultaneously, the appearance of the aforementioned GI.2 caused a significant decline in Rabbit populations in areas of historical presence, reaching minimum densities in 2013 (Monterroso et al. 2016). Therefore, the process of colonization of Olive groves by the Lynx could be due to the search for new territories due to intraspecific competition, conditioned by demographic pressure, and subsequently exacerbated by the reduction in the carrying capacity of the medium due to the drastic decline of food. It is after the settlement of the first Lynx native to Andujar-Cardeña, when dispersing Lynx of the neighboring Guarrizas and Guadalmellato populations were detected.

It has become obvious that the Iberian Lynx can colonize areas such as Olive groves that have been altered by human activities, provided that good Rabbit populations exist and that mortality rates are kept to acceptable levels (López-Parra et al. 2012; Garrote et al. 2013; López et al. 2014). The colonization of these areas improved connectivity between Lynx populations in Andújar-Cardeña, Guarrizas and Guadalmellato, and stimulated a continuous exchange of individuals. Today, these populations can be considered a single metapopulation. The vast areas of agricultural land surrounding traditional Lynx habitats were always regarded as unsuitable and obstructing the species' expansion. Nevertheless, the historical absence of the Lynx in these areas could in fact be more closely tied to human-induced mortality than to any lack of habitat resources (Corsi et al. 1999; Gastón et al. 2016). Given the scarcity of European Rabbits in most Iberian habitats (Delibes-Mateos et al. 2014), agricultural areas with small patches of scrub could become the most Rabbit-rich habitat in the Lynx's range (Calvete et al. 2004). Therefore, management should be orientated towards allowing small shrubby patches to be conserved in Olive groves and other agricultural areas. Likewise, vigorous actions must be implemented to reduce non-natural mortality, which would notably increase the useful surface available for Iberian Lynx.

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COMMUNICATION

Iberian Lynx *Lynx pardinus* Temminck, 1827 (Mammalia: Carnivora: Felidae) in central Spain: trophic niche of an isolated population

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Abstract: Understanding predator-prey relationships is fundamental to develop effective conservation plans. Between 2015 and 2018, we combed 21 transects, each 7km long, searching for Iberian Lynx *Lynx pardinus* scat within the province of Madrid in central Spain. In order to minimise inherent subjectivity of visual identification as much as possible, we performed a double specific nested polymerase chain reaction (PCR) followed by a primer extension assay addressed to two Iberian Lynx diagnostic single nucleotide polymorphisms. Forty-six scat samples were positively identified as belonging to Iberian Lynx through genetic analysis. From these, we extracted remains of consumed prey, which we determined to the lowest possible taxonomic level, mainly through hair identification. Identified prey was divided into four types: lagomorphs, small mammals, birds, and ungulates. The species' diet composition was described based on the frequency of occurrence (FO) of each prey and niche breadth, and also compared with prior knowledge of the species using four prior studies as a comparative reference through the calculation of the niche overlap value. The FO of lagomorphs (39%) was the lowest, while the FO of small mammals (54%) was the highest recorded to date. The niche breath (0.36) was higher than recorded in prior studies, but still showing the specialist character of the Iberian Lynx. Niche overlap was low (C = 0.49), showing differences in trophic niche between the population in our study area and the one studied in southern Spain. This indicates that the Iberian Lynx is adept at switching its main prey, an ability that has previously been firmly rejected. It is, however, capable of adapting to alternative prey more often than recorded to date, which could be a behavioural response to the patchy distribution of European Rabbit *Oryctolagus cuniculus* in the study area.

Keywords: Diet, lagomorphs, niche breadth, niche overlap, single nucleotide polymorphism.

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Author contribution: PA made the bibliographic review, statistical analysis, wrote the manuscript and participated in scat collection. AI designed and carried out the identification of scat samples content. GA provides support and experience in field work, identification of scat content and also reviewed the manuscript.

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UNIVERSIDAD COMPLUTENSE MADRID

INTRODUCTION

The Iberian Lynx *Lynx pardinus* is endemic to the Iberian peninsula (Rodríguez & Delibes 1992), and is regarded as a trophic super specialist (Ferrer & Negro 2004). Since the 1950s, the Iberian Lynx population has declined continuously (Valverde 1963; Cabezas-Díaz et al. 2009). Only 93 individuals were recorded in 2002 (Guzmán et al. 2004). Following conservation measures such as reintroductions of captive-bred Iberian Lynxes in southern Spain, this population experienced a constant growth (Simón et al. 2011; Rodríguez & Calzada 2015), reaching 589 individuals in 2017 (Simón 2018). Furthermore, Cruz et al. (2019) confirmed the presence of Iberian Lynxes outside the currently known range of the species in the southern Iberian peninsula, suggesting the continued existence of a stable population in central Spain within the province of Madrid.

The diet of a species is a fundamental aspect of its ecology that depends mainly on the abundance and availability of prey types (Terraube & Arroyo 2011), but also on learning and experience of individuals (Shipley et al. 2009). A widespread phenomenon in many vertebrate and invertebrate taxa (Bolnick et al. 2003) is the so-called 'niche variation hypothesis'. This occurs when some co-occurring individuals of a species actively select different prey types in their shared environment (Araujo et al. 2011). The niche variation could be a response to two main factors: (i) change in environmental conditions that affects prey availability and prompts all individuals of a population to use a larger spectrum of resources, or (ii) each individual continues to use a narrow range of resources that diverges from conspecifics, thus minimizing the interspecific competition (Costa et al. 2008).

Understanding predator-prey relationships is fundamental to identify conservation priorities, prior to the design of conservation programmes for vulnerable or endangered species (Popp et al. 2018). Lacking information on these relationships could result in ill-informed conservation strategies that lead to a failure of reaching conservation goals and at the same time to a gross waste of resources, as occurred in the Doñana National Park with the restocking of European Rabbits *Oryctolagus cuniculus* (Carro et al. 2019).

The knowledge about diet plasticity of a species is a keystone to assess the transferability of results obtained in a certain area to another, and for assessing whether an alternative management will provide similar results (Terraube & Arroyo 2011). A relevant descriptor of niche is breadth, which is a function of the proportion of each resource used with regard to total consumed resources (Smith 1982). Therefore, a species that uses a wide range of trophic resources in a similar proportion will show a high niche breadth and, consequently, will be regarded as a generalist for studied resources (Symondson et al. 2002). On the contrary, a species that uses a high proportion of a narrow range of resources will be regarded as a specialist (Shipley et al. 2009).

Rodríguez & Delibes (1992) were the last authors who reported an Iberian Lynx population in the province of Madrid before Cruz et al. (2019). The territorial and solitary behaviour of the Iberian Lynx (San Miguel 2006; Calzada et al. 2007; Martín et al. 2007) results in a low-density spatial organization that makes it extremely difficult to find and track (Alfaya et al. 2019). The central Spanish population was already small in the early 1990s (Rodríguez & Delibes 1992), remained elusive and was not considered in conservation programs initiated in 2002 (Rodríguez & Calzada 2015) that lead to the recovery of the population in southern Spain (Simón 2018).

Different studies carried out in Doñana National Park and in Sierra Morena showed that the European Rabbit is its main prey, being present in 70–99% of analysed samples (Delibes 1980; Beltrán & Delibes 1991; Palomares et al. 2001; Gil-Sánchez et al. 2006). The Iberian Lynx, however, also consumes other prey species in lower proportions, but their relative importance increases when the availability of Rabbits decreases (Beltrán et al. 1985; Beltrán & Delibes 1991). Therefore, Iberian Lynxes also prey on small mammals, e.g., Wood Mouse *Apodemus sylvaticus* and Garden Dormouse *Eliomys quercinus* (Aymerich 1982; Gil-Sánchez et al. 2006), wild ungulates like Red Deer *Cervus elaphus*, Fallow Deer *Dama dama* (Delibes 1980; Beltrán et al. 1985; Beltrán & Delibes 1991; Gil-Sánchez et al. 2006), European Mouflon *Ovis orientalis musimon* (Gil-Sánchez et al. 2006), and birds such as Red-legged Partridge *Alectoris rufa*, Mallard *Anas platyrhynchos* and Eurasian Magpie *Pica pica* (Delibes 1980; Aymerich 1982; Beltrán & Delibes 1991; Gil-Sánchez et al. 2006).

In this article, we report the diet composition of Iberian Lynx, based on analysis of scat collected in a study area in central Spain. We discuss the trophic niche breadth of this population in the light of research conducted on the species' diet in southern Spain.

STUDY AREA

The research was performed in the western region of the province of Madrid (Figure 1), which is delimited by boundaries with the community of Castilla–León in the north and northwest, the community of Castilla–La Mancha in the south, and the Manzanares River basin in the east. The study area ranges in elevation from 440 to 2,320 m. It represents three main landscape regions: (i) the Guadarrama Mountains, a mountainous granitic zone, (ii) the foothills with a gradient of siliceous sand and soft slopes, and (iii) the depression, a terrain characterised by interfluvial hills (Rivas-Martínez 1982; Zabía & del Olmo 2007).

The meso-Mediterranean zone is the dominant bioclimatic belt within the study area, but the oro- and supra-Mediterranean zones are also present in the Guadarrama Mountains (Rivas-Martínez 1982). The main climatic features of the study area are the seasonal variation in temperature between -8°C and 44°C, summer drought and irregular precipitation ranging from 400 to 2,000 mm per year (Zabía & del Olmo 2007).

The landscape in the study area is a mosaic of pastures with scrub and Holm Oak *Quercus ilex* groves interspersed with villages and patches of agricultural land (Schmitz et al. 2007; Image 1). Local people use pastures traditionally during the summer for grazing transhumant cattle, periodically perform selective logging in the forests and clean the understorey (Arnaiz-Schmitz et al. 2018).

MATERIAL AND METHODS

Sample collection

Evidence of the presence of Iberian Lynxes within the study area was collected between January 2015 and May 2018. We designed 21 transects of 7km each that were combed by at least two researchers. We searched for scat on foot along pathways and firebreaks, since both Iberian Lynx and European Wildcat *Felis silvestris* usually move along such linear structures (Lozano et al. 2013; Garrote et al. 2014). Sometimes, we also combed other less regular landscape features such as the bases of large rocks, around Rabbit holes and near rivers, where scat was more likely to be found (Martín et al. 2007). Along these transects, we searched for scat that

Image 1. Landscape in the study area in the province of Madrid.

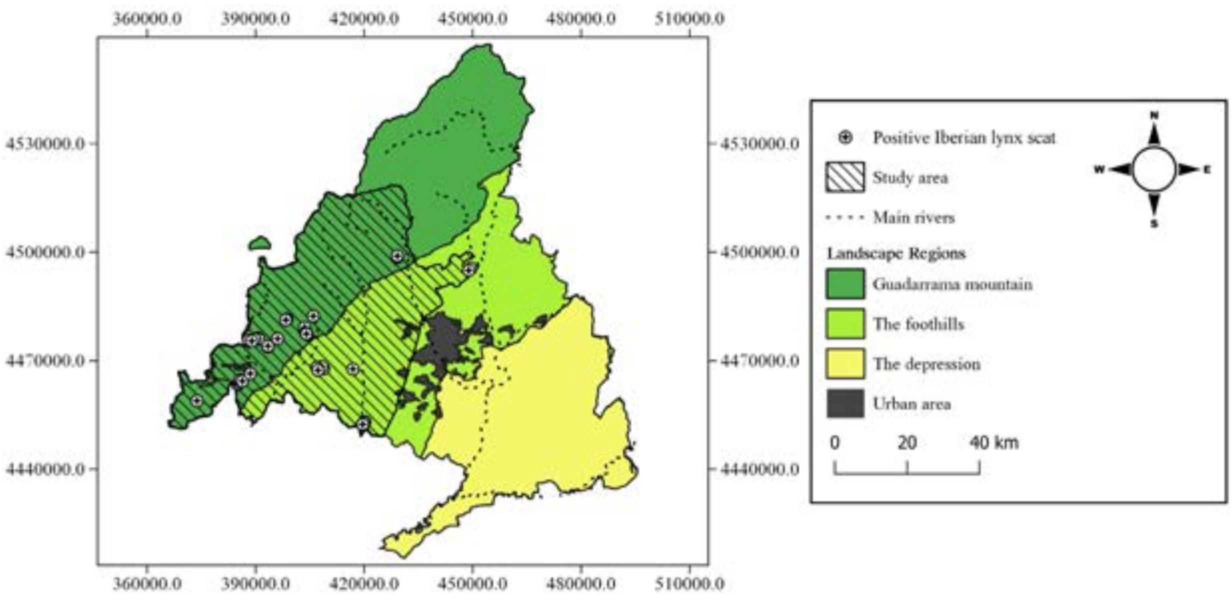

Figure 1. Study area within the province of Madrid with main rivers, landscape regions and locations, where scat of Iberian Lynx was found.

is morphologically compatible with scat of the Iberian Lynx. This ranges in length from 5cm to 9cm and in width from 1.5cm to 2cm, and is divided into several fragments (Rodríguez 1993). It ranges in colour from ash-grey to dark-brown, and is entirely covered by a mucous patina when fresh (Iglesias & España 2010).

The probability of an erroneous identification of the scat of Iberian Lynx, however, is high (Boshoff & Kerley 2010, Molinari-Jobin et al. 2012; Garrote & de Ayala 2015). It has been often misidentified due to its similarity with the scat of European Wildcat and Red Fox *Vulpes vulpes* (Palomares et al. 2002). To reduce this probability as much as possible, we performed a specific genetic identification analysis designed by Cruz et al. (2019). This genetic analysis consists of a double specific nested PCR followed by a primer extension assay addressed to two Iberian Lynx diagnostic single nucleotide polymorphisms (SNPs). The product of the double nested PCR is already specific for the Iberian Lynx since we used the primer DL7F [5'-CTT AAT CGT GCA TTA TAC CTTGT-3'] developed by Palomares et al. (2002), which was aligned to sequences of orthologue carnivores including Eurasian Lynx *Lynx lynx*, Canada Lynx *L. canadensis*, European Wildcat, and Domestic Cat *Felis catus* in order to select diagnostic positions. Then we identified two SNPs specific of the Iberian Lynx. These SNPs were marked with fluorescence and detected through a capillary electrophoresis. This method of analysis provides an increase of sensitivity and straightforward verification of the belonging species through the diagnostic SNPs, being strongly protected against false positive results. For further details see Cruz et al. (2019).

Content analysis

Subsequent to positive genetic identification of scat samples as belonging to the Iberian Lynx, we analysed the contents of these samples. We used a stereomicroscope to identify and remove remains of consumed prey like broken bones, teeth, feathers, and hair. Teeth and bone remains were identified with a stereomicroscope, while feathers and hair required the use of a 40x microscope. We washed hairs, first with distilled water and detergent, and then with 70% alcohol as described in Teerink (1991). After drying hairs, we poured a thin layer of transparent nail varnish over a slide and let it dry for 30 seconds. Then we put each hair on the slide for 30 minutes and covered it with a cover glass. That way, we obtained a hair cuticle mould with a scale pattern showing a certain, although limited, taxonomic value (Short 1978).

Removed remains were identified up to the family level, except those belonging to Wild Boar *Sus scrofa*, because of their easy identification. We identified hair using Teerink (1991) and Valente et al. (2015), teeth using Dueñas et al. (1985), and feathers using Dove & Koch (2011).

Diet composition

Hutchinson (1957) defined the niche as an n-dimensional hypervolume where distribution of environmental variables and/or factors would allow a certain species to exist indefinitely. This approach provides a quantitative perspective of the niche concept and, therefore, established the conceptual basis for the performance of studies in many different fields of ecology (Smith 1982). We defined the trophic niche as the n-dimensional hypervolume, n being the number of prey types consumed by the target species, constrained by used trophic resources that would allow the species to exist indefinitely.

For diet description we grouped consumed prey into four categories: birds, lagomorphs, small mammals and ungulates. We calculated the frequency of occurrence (FO) for each category regarding total analysed scat samples, and also the niche breadth using Levins Index (Levins 1968):

$$B = 1/(\sum [p_i^2])$$

where p_i is the proportion of occurrence of the prey category i, regarding the total consumed prey. To compare this with other populations, we used the standardisation suggested by Colwell & Futuyma (1971),

$$B_{stand} = (B-1)/ (n-1)$$

where n is the number of prey categories consumed. This index shows the degree of specialisation of a certain species; a value close to 0 is indicative of a specialist predator, while a generalist predator shows values close to 1 (Colwell & Futuyma 1971).

Both FO and B_{stand} calculated from analysed scat samples were compared with prior knowledge of the trophic ecology of the Iberian Lynx. For that, we selected four relevant studies as a comparative reference (Table 1), and regrouped their results to our four prey types. This was not possible in regard to the study by Fedriani et al. (1999) who used a broad classification of prey items, e.g., other vertebrates, referring to all non-lagomorph vertebrates. Therefore, we calculated the FO of each prey category and B_{stand} for all four reference studies, and compared results with those obtained in our study area.

We compared the trophic niche of the Iberian Lynx population in the province of Madrid (M) with that described in prior studies (A). For the latter, we

Table 1. Previous studies used as comparative references, with authors, sample size (n), sample periods (years), studied population and niche breadth (B_{stand}) of respective populations.

Authors	n	Years	Population	B_{stand}
Delibes 1980	1573	1973–1976	Doñana-Aljarafe	0.060
Beltrán & Delibes 1991	209	1983–1984	Doñana-Aljarafe	0.279
Palomares 2001	1171	1993–1996	Doñana-Aljarafe	0.005
Gil-Sánchez et al. 2006	360	2001–2002	Andújar-Cardeña	0.035

calculated the average FO of each prey category in the reference studies. Then we used the index formulated by Schoener (1970) for calculating the niche overlap between both populations, M and A:

$$C = 1- ½ \sum | p_{iM} – p_{iA} |$$

where p_{iM} is the proportion of occurrence of the category i within population M, and p_{iA} is the same but within population A. C takes a minimum value of 0 when there is no overlap, and a maximum of 1 when the proportions of consumed resources are the same in both populations.

Lastly, we compared FO and B_{stand} obtained in the province of Madrid between the two periods when samples were collected, i.e., spring–summer and autumn–winter. We used Fisher's exact test, which is suitable for small sampling sizes.

RESULTS

Between January 2015 and May 2018, we collected 98 scat samples along 21 transects that were each combed twice, once in spring–summer from May to July and once in autumn–winter from October to February. Through genetic analysis we identified 46 of these samples positively as belonging to Iberian Lynx, with 31 collected in the spring–summer season and 15 collected in the autumn–winter season. As our genetic method allows only for identifying scat of Iberian Lynx, we did not attempt to identify the remaining 52 scat samples to other species.

The content analysis of the 46 scat samples revealed an overall niche breadth B_{stand} of 0.36, with small mammals constituting the majority of prey categories. Fisher's exact test shows the existence of marginally non-significant ($p = 0.07$) differences in diet composition between both seasons of the year considered (Figure 2). Details are provided in Table 2.

DISCUSSION

The B_{stand} (0.36) calculated for the population in our study area shows the specialist character of the Iberian Lynx. However, this value is higher than those obtained for comparative reference studies in Table 1. Furthermore, the obtained C value of 0.49 shows the trophic niche shift of this population, with regard to that known so far. Figure 3 shows that the trophic niche of the Iberian Lynxes within the study area is directed towards predation on small mammals.

The Iberian Lynx is regarded as a trophic specialist, strictly dependent of the European Rabbit (Delibes 1980; Aymerich 1982; Beltrán et al. 1985; Beltrán & Delibes 1991; Calzada & Palomares 1996; Palomares

Table 2. Frequency of occurrence (FO) of prey categories in scat samples of Iberian Lynx (n=46) collected in the study area between January 2015 and May 2018.

Prey category	FO in spring–summer	FO in autumn–winter	Total FO
Small mammals	50%	40%	54%
Lagomorphs	26.31%	53.33%	39%
Birds	21.05%	0%	17%
Ungulates	2.63%	6.67%	4%

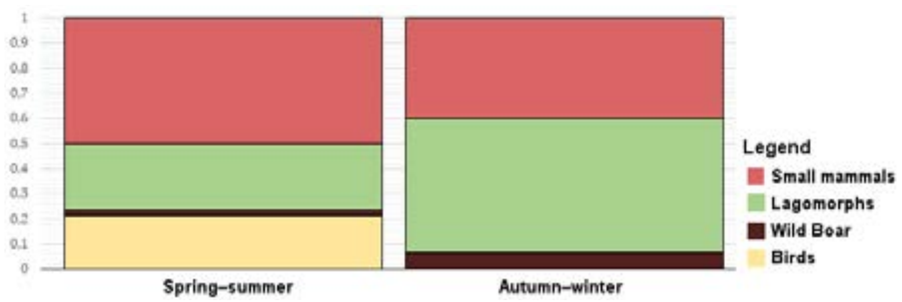

Figure 2. Bar graph showing the frequency of occurrence (FO) of each prey category within analysed scat samples collected in the two seasons.

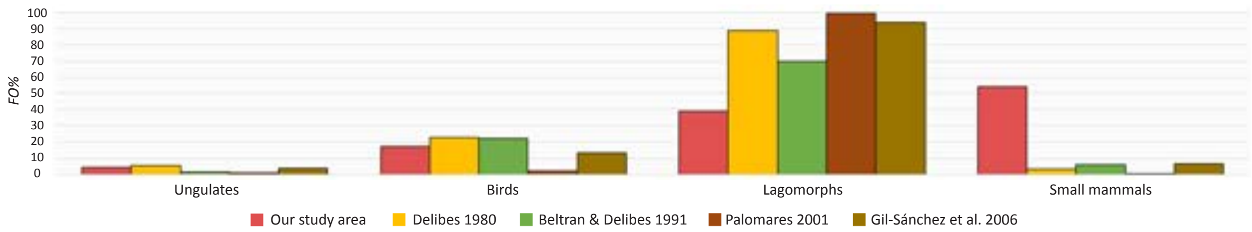

Figure 3. Diet compositions of the Iberian Lynx: comparison between results obtained within the province of Madrid and in reference studies conducted in southern Spain.

et al. 2001; Ferrer & Negro 2004; Gil-Sánchez et al. 2006). There are such strong links between these two species that the collapse of Rabbit populations can even inhibit the reproductive capability of the Iberian Lynx which has been interpreted as its 'inability' to switch its main prey (Ferreras et al. 2011). In this research, we compared niche breadth and overlap between a potential population in the central Iberian peninsula and prior knowledge obtained from southern populations. Our results show differences in comparison with those obtained from the four studies used as a comparative reference (Fig. 3). Therefore, our study is the first record in which lagomorphs are not the main prey, showing a 30% lower FO than in the lowest record so far (70%, Beltrán & Delibes 1991). On the contrary, the FO of small mammals is clearly over-represented (47.5% higher) in comparison with prior studies.

A similar pattern than the one observed here was already recorded in Delibes et al. (1975). In this study carried out in the provinces of Cáceres and Salamanca (closer to our study area than to southern populations), the recorded FO for Rabbits was 56.5% while the small mammals and birds occur in the 27% and 12% of samples, respectively. These results, although still different to ours, show a pattern of Iberian Lynxes farther inland feeding on alternative prey other than Rabbits more frequently.

Rabbit distribution within our study area shows clear differences between main landscape regions. The population in the north is naturally fragmented, most likely because of the patchy distribution of suitable habitat (Virgós et al. 2003). In the south, Rabbits are widespread (Blanco & Villafuerte 1993) due to the existence of a high density of boundaries between croplands and scrublands (Calvete et al. 2004) where they find a suitable combination of trophic resources and shelter (Tapia et al. 2014). As far as we know there is no more actualized information about new population trends, but the described spatial arrangement coincides with our field observations throughout the sampling period.

The observed pattern in our study area could be a response to: (i) Iberian Lynx adaptation that shows a different trophic behaviour in different environments. Note that 65% of the Iberian Lynx scat samples analysed were collected in the landscape region of the Guadarrama Mountains, where Rabbit distribution is patchy. This could lead to the exploration of different trophic niches in areas where Rabbit abundance is lower. A similar pattern was obtained by Sáez-Gómez et al. (2018) and Nájera et al. (2019), who recorded Iberian Lynxes preying on Red-necked Nightjar *Caprimulgus ruficollis* eggs and Domestic Cats, respectively, as a response to the decline of Rabbit abundance; (ii) an uncertain proportion of our Iberian Lynx scat samples could come from juvenile individuals, whose habitat requirements are less restrictive than those of resident individuals (Gastón et al. 2016). Therefore, trophic plasticity could be wider too, which would add some noise to our results; and (iii) overestimations of the FO of small species might have been obtained (Torres et al. 2015). These have more hair and other indigestible matter per unit of body mass, which can cause their occurrence in a higher number of scat samples per unit of consumed mass (Floyd et al. 1978). Despite this, earlier studies on the trophic ecology of the Iberian Lynx did not suggest evidence of overrepresentation of small prey (Delibes 1980; Aymerich 1982; Beltrán et al. 1985; Beltrán & Delibes 1991; Calzada & Palomares 1996; Palomares et al. 2001; Ferrer & Negro 2004; Gil-Sánchez et al. 2006). Therefore results are still comparable.

The observed seasonal variation in the diet of the Iberian Lynx in our study area corroborates results of previous studies on the species (Delibes 1977; Beltrán & Delibes 1991; Gil-Sánchez et al. 2006) as well as on the Eurasian Lynx (Krofel et al. 2011). Lagomorph predation resulted in a 27% lower value during the spring–summer period, while small mammals consumed showed a 10% increase in comparison with the autumn–winter period. Bird predation was only recorded in spring–summer (FO = 21%). B_{stand} also shows differences between both seasons, being higher in spring–summer (0.58) than in autumn–winter (0.41). Therefore, during the cold season of the year, the Iberian Lynx consumes a lower variety of trophic resources, whilst this pattern changes in the warm season.

This could be motivated by two facts that are likely to produce a synergic effect: (i) during autumn–winter, when high precipitation and low temperature occur, the daily activity of prey is reduced, being less available for Iberian Lynxes (Beltrán & Delibes 1994). On the other hand, during the spring–summer season, climatic conditions are less adverse, which allows for an increase in daily activity and, therefore, higher availability of different prey species; (ii) the Rabbit reproduction period begins in October–November and can last until June–July, depending on environmental conditions. This produces a maximum peak of abundance just before summer. Then Rabbits become the most abundant prey and, as a consequence, predators apply the highest pressure to a single trophic resource. Moreover, Rabbits do not reproduce during summer (Soriguer & Palacios 1994). Therefore, a quick and deep decrease of Rabbits occurs, forcing Iberian Lynxes to prey on alternative trophic resources (Delibes 1980) for the rest of the summer.

Our results reinforce the key role that lagomorphs play in the diet of the Iberian Lynx. This category is the most frequent prey when diversity of available prey is lower. Here, however, we provide evidence for a lower trophic dependence of the Iberian Lynx on lagomorphs than in the areas of Doñana-Aljarafe and Andújar-Cardeña. In our study area, the Iberian Lynx shows its adaptive capacity, adopting a relatively generalist strategy when trophic diversity is high, and a more specialist strategy when diversity is low. Despite this, the low number of samples collected in autumn–winter season (n=15) must be taken into account and, therefore, the pattern showed here may change with a larger dataset.

Knowledge of predator-prey relationships is fundamental for the adequate design and implementation of species conservation plans (Popp et al. 2018). Therefore, the results of our research provides base line information for designing conservation actions for the Iberian Lynx in central Spain. We show that the Iberian Lynx is capable to adapt to a wider prey spectrum than previously assumed by Ferrer & Negro (2004) and Ferreras et al. (2011). Based on the described pattern, we think that Iberian Lynxes can profit from an increase in prey diversity provided in enrichment programmes carried out at captive breeding centres (Rivas et al. 2016). Familiarising them with a broader prey diversity may enhance the ability of reintroduced individuals to colonise and survive in new territories.

Future research efforts on the trophic ecology of the Iberian Lynx should focus on increasing the number of scat samples for analysis of diet composition, but also on prey availability and the estimation of 'real' proportion each prey species contributes to the diet by means of correction factors, as suggested by Wachter et al. (2012) and Klare et al. (2011). This will provide more reliable information about the trophic needs of the Iberian Lynx.

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COMMUNICATION

New records of the Flat-headed Cat *Prionailurus planiceps* (Vigors & Horsfield, 1827) (Mammalia: Carnivora: Felidae) in western Sarawak, Malaysia

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Abstract: The Endangered Flat-headed Cat is threatened due to loss of lowland and wetland habitats. Its elusive nature and low density occurrence make field sampling difficult. Compilation of records from both camera trapping and direct observation can provide important updates to its current distribution in Sarawak. In western Sarawak, the Flat-headed Cat was recorded in Maludam National Park, in Ulu Sebuyau National Park and at Sarawak River, which are the first confirmed records. The Flat-headed Cat appears to inhabit swamp forest in pristine protected areas as well as near human settlements. The conservation of peat swamp forests is crucial for its long-term persistence.

Keywords: Borneo, camera trap, conservation, national park, peat swamp forest.

Abstrak: Kucing Hutan hidup terancam berikutan hilangnya kawasan dataran rendah dan habitat tanah paya. Menyendiri dan sukar difahami serta kepadatan penghunian yang rendah mengakibatkan persampelan lapangan sukar. Pengumpulan rekod-rekod dari perangkap kamera dan pemerhatian secara langsung dapat memberikan maklumat yang penting mengenai penyebaran semasa di dalam Sarawak. Dalam Sarawak barat, Kucing Hutan telah direkodkan di dalam Taman Negara Maludam, di dalam Taman Negara Ulu Sebuyau dan di Sungai Sarawak, yang merupakan rekod buat pertama kalinya. Kucing Hutan dilihat mendiami hutan paya di dalam kawasan terlindung sepenuhnya serta berdekatan dengan penempatan manusia. Pemuliharaan hutan paya gambut amat penting bagi kesejahteraan dan kesinambungannya untuk jangka masa yang panjang.

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Competing interests: The authors declare no competing interests.

Author details: Mohd-Azlan Jayasilan has been conducting research and advocacy activities in the field of biodiversity conservation in Sarawak for over a decade. Current work complements the study on the distribution and ecology of carnivores in Sarawak. Thaqifah Syaza Jailan undertook master's degree specifically in researching carnivores within totally protected areas in Sarawak, Malaysia.

Author contribution: MAJ and TSJ conceived and designed the study. MAJ and TSJ collected the data, analysed and wrote the manuscript. Both authors read and approved the final manuscript.

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INTRODUCTION

The Flat-headed Cat *Prionailurus planiceps* is one of the smallest felids in the world and the least studied of the five cat species in Borneo (Wadey et al. 2014; Wilting et al. 2016). In Malaysia, it was recorded in the lowlands of peninsular Malaysia, and of Sabah and Sarawak on Borneo (Wadey et al. 2014, 2017). It can be considered as a habitat specialist as it has been recorded mostly in lowlands associated with aquatic habitat such as peat swamp forest and riverine forest (Wilting et al. 2015; Phillipps & Phillipps 2016). Sarawak accounts for over 64% of the total peat swamp area in Malaysia, but is faced with the highest level of threat (Hon & Mohd-Azlan 2016). Major threats to the Flat-headed Cat include degradation and destruction of wetlands and lowland forests (Wilting et al. 2015). Hunting Flat-headed Cats for the pet or fur trade has not been recorded in Sarawak.

Limited distribution along with persistent loss of habitat have pushed this species into the IUCN Endangered category and Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Wilting et al. 2015). The paucity of scientific information on its natural history and occurrence in the wild encouraged predictive modelling and predictive studies in Borneo (Wilting et al. 2010, 2016). Nevertheless, a record in a mangrove forest at close proximity to a settlement in Sarawak suggests this species may be able to co-exist with humans in sustainably managed areas (Tisen & Azad 2013).

Previous observations of this species in Sarawak were in two protected areas, namely Loagan Bunut National Park and Maludam National Park (Gumal et al. 2010). A captive individual at Kampung Buntal in North Kuching District was infected with feline pan-leukopenia virus (Tisen & Azad 2013).

Here, we report new observations of the Flat-headed Cat during opportunistic surveys along the Sarawak River near Kota Samarahan, in Maludam National Park and from a camera trapping survey in Ulu Sebuyau National Park.

STUDY AREAS

Ulu Sebuyau National Park (USNP) was gazetted in 2010 with a total size of 182.87km^2 consisting primarily of peat swamp forest. Adjacent small patches of degraded isolated mangroves and Nipa Palm *Nypa fruticans* forests are heavily utilized by local people for aquaculture, fishing and crabbing. They practise traditional fishing methods, including the use of baited crab pods targeting Mud Crab *Scylla serrata*. Adjacent to the Batang Lupar River, USNP's many streams host a large population of Saltwater Crocodile *Crocodylus porosus*. USNP is currently not open to the public as it has no infrastructure and is far from human settlements.

The Maludam peat swamp forest encompasses one of the largest peat domes in northern Borneo. Due to the occurrence of species of conservation importance such as Proboscis Monkey *Nasalis larvatus*, Sarawak Surili *Presbytis chrysomelas* and hornbills *Anthracoceros albirostris*, *A. malayanus* and *Buceros rhinoceros*, this area was declared a national park by the Sarawak State Government in 2000. The 431.47km^2 park is divided by a 28-km stretch of the Maludam River that cuts across the park in the southeast-northwest direction. The waters of the Maludam River in the slow-moving, upstream stretches are clear and black in appearance due to tannin, whereas the flow downstream is influenced by tide. The dominant plant species along the riverbanks comprise *Pandanus andersonni*, several *Syzygium* species, *Hanguana malayana*, and the fan palm *Licuala petiolulata* (Nyanti et al. 2016). Sarawak River comprises a vast network of river branches with complex connections that are often more than 100km apart. The delta is at the South China Sea and experiences saltwater intrusion. The Sarawak River's upstream tributary comprises peat swamp and small patches of riverine forest. Most areas along the river are cultivated, and villages lie scattered along its banks.

MATERIAL AND METHODS

Camera trapping in USNP was carried out between October 2015 and March 2017 using 19 passive infrared camera trap units (Bushnell® Trophy Cam). They were deployed at 19 locations near animal trails at least 500m apart along major rivers and hill ridges both within USNP and in the vicinity of park boundaries (Figure 1). They were mounted 20–30 cm above ground in order to increase the probability of detecting small- to medium-sized mammals. Seven camera traps were mounted very close to streams and in areas with high possibility of flood, indicated by watermarks on tree trunks, 50–115cm above ground to prevent them from flooding and subsequent malfunction. During the sampling period, camera traps were repositioned twice. The time delay between photographs was set to one minute. All cameras were operational 24 hours a day continuously throughout the survey period, except in instances of

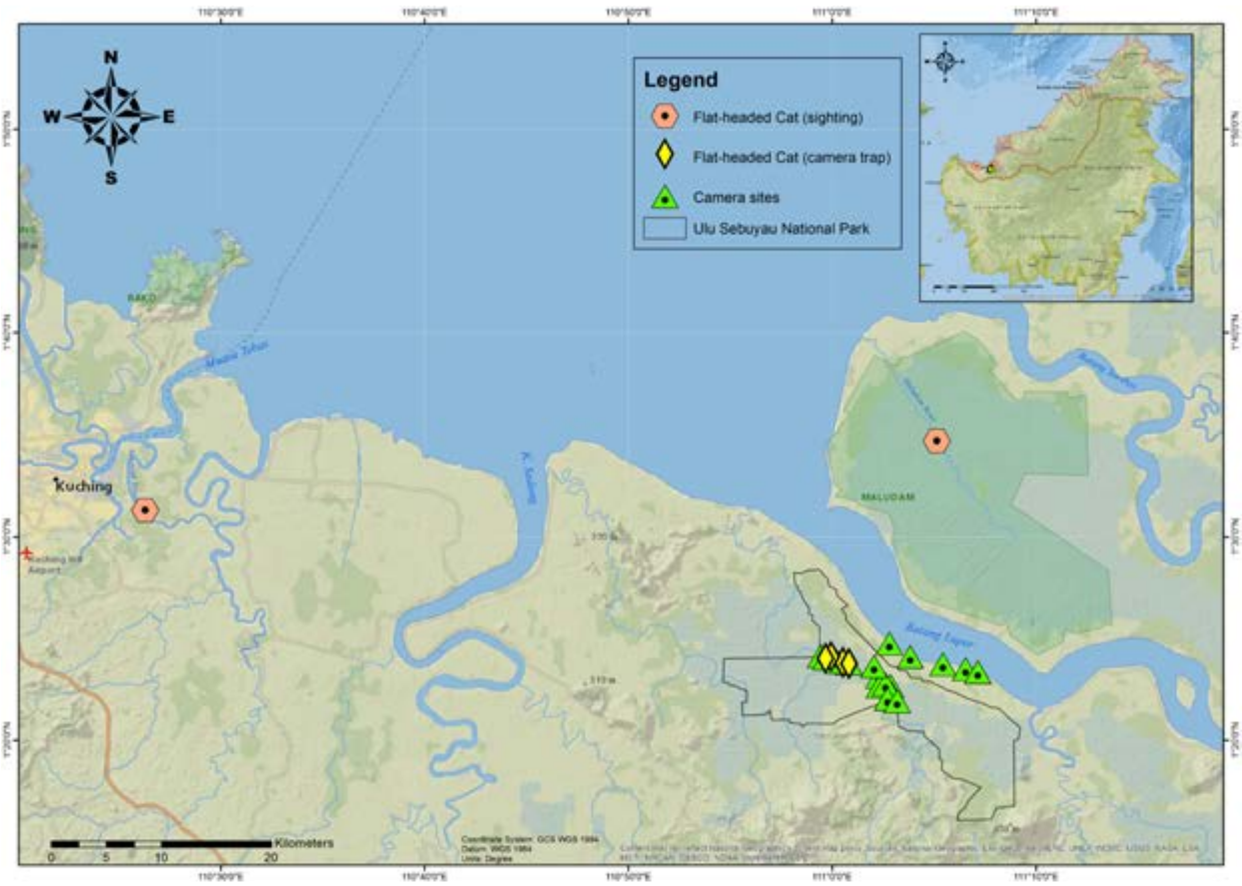

Figure 1. Camera trapping sites in Ulu Sebuyau National Park with locations where Flat-headed Cats were detected.

malfunction. Time and date were recorded for each exposure except during camera malfunction or excessive moisture due to high humidity and condensation. Only active camera trap days were used to calculate the number of camera trap days:

Total camera trap days (TCD) = Σcd_i

where c is the active camera operating within a site, and d is the number of days.

The overgrowth of water plants and abandoned logs in the river makes boat travel through several parts of the river difficult (Image 1). Consequently, the planned deployment of camera traps in several areas was not possible.

We used a Garmin GPSMAP 64S unit to determine coordinates (datum WGS84) and elevation of camera trap locations, which ranged from -1m to 13m elevation. The images were sorted by species, camera trap location and independent image. A notionally independent image was defined as the consecutive photographs of different species or the consecutive photographs of individuals of the same species taken an hour apart.

Boat surveys in the Maludam National Park (MNP) river were carried out in October 2013, and on the Sarawak River in February 2018. During these surveys, photographs were taken with a digital single-lens reflex camera (Canon EOS Rebel T1i).

RESULTS

Camera trapping in USNP resulted in a total of 2,808 days of survey effort with 1,883 independent images obtained in 38 locations. The Flat-headed Cat was recorded at four locations in USNP with a total of seven independent images recorded at -1–13 m above sea level, representing approximately 0.37% of all independent images. All camera traps that photographed a Flat-headed Cat were situated less than 80m from USNP's main river (Image 2). The first Flat-headed Cat was recorded on day 16 and the last on day 198 of the total survey effort. After the camera traps were relocated further inside the forest, the Flat-headed Cat was not photographed again.

During night-time boat surveys, we covered 78km in

Image 1. The overgrowth of water plants and abandoned logs in the main river of Ulu Sebuyau National Park obstruct water transportation. © Thaqifah Syaza Jailan & Mohd-Azlan Jayasilan.

Image 2. Flat-headed Cat photographed at (a) Sarawak River, (b) Maludam National Park. © Anthony Pine.

48 hours in MNP and 15km in 16 hours on the Sarawak River. In MNP, a Flat-headed Cat was observed on 3 October 2013 at 06.25h, and at the Sarawak River near Loba Batu Blat on 15 February 2018 at 23.08h (Image 3). At both sites, the cats crouched quietly on the riverbanks, not bothered by the passing boat, thus providing opportunity to photograph them.

Details of records in surveyed sites are provided in Table 1.

DISCUSSION

This study provides the first conclusive evidence that the Flat-headed Cat is present in USNP and MNP, confirming earlier predictive modelling results by Wilting et al. (2010). In addition, the observation of a Flat-headed Cat in the protected peat swamp landscapes asserts the importance of these habitats for the long-term survival of the species. The discovery of the Flat-headed Cat in USNP is a new addition to the species list in this park.

Our records indicate that the Flat-headed Cat is active both by night and day. This corroborates records obtained after sunset in Sumatra, Borneo, and peninsular Malaysia (Bezuijen 2000, 2003; Meijaard et al. 2005; Yasuda et al. 2007; Cheyne et al. 2009; Gumal

Table 1. Records of Flat-headed Cat in Ulu Sebuyau National Park (USNP), Maludam National Park (MNP), and Sarawak River (SR) in Sarawak, Malaysia from 2013 to 2018.

Date and time of records	Coordinates and elevation	Location	Remarks
03.x.2013, 06.25h	1.580^{0}N, 111.084^{0}E; 1m	MNP	Resting on the riverbank
01.xi.2015, 22.07h	1.400^{0}N, 110.994^{0}E; -1m	USNP; *75m	Passing through
30.xi.2015, 19.08h	1.397^{0}N, 111.009^{0}E; 13m	USNP; *37m	Passing through
11.xii.2015, 06.25h	1.402^{0}N, 110.999^{0}E; 3m	USNP; *23m	Passing through
17.iii.2016, 00.36h	1.397^{0}N, 111.009^{0}E; 13m	USNP; *37m	Passing through
23.iv.2016, 02.35h	1.396° N, 111.013° E; 9m	USNP; *40m	Passing through
23.iv.2016, 15.17h	1.397^{0}N, 111.009^{0}E; 13m	USNP; *37m	Passing through
15.ii.2018, 23.08h	1.521^{0}N, 110.438^{0}E; -4m	SR	Resting on the riverbank

*Approximate distance of camera traps from Ulu Sebuyau River.

Image 3. Camera trap records of Flat-headed Cat in Ulu Sebuyau National Park. © Thaqifah Syaza Jailan & Mohd-Azlan Jayasilan.

et al. 2010; Hearn et al. 2010), and by day in Borneo and peninsular Malaysia (Traeholt & Idris 2011; Gardner et al. 2014; Wadey et al. 2014; Baker & Chua 2016). Cheyne et al. (2009) recorded a Flat-headed Cat at approximately 2.5km from the Sabangau River after 622 camera trap nights in the Sabangau peat swamp forest. In our study it took less than 200 days to obtain photographs of the Flat-headed Cat at locations closer to the river. Flat-headed Cats were also observed near waterbodies such as riverbanks, small streams, ponds and lakesides by Yasuda et al. (2007), Mohamed et al. (2009), and Hearn et al. (2010). The observation of the Flat-headed Cat crouching near the river edge suggests that this species maybe adept at hunting aquatic prey species during the low tide when they are easily accessible.

The Fishing Cat *Prionailurus viverrinus* is the only other cat in Asia that has also been observed sitting on the banks of watercourses, apparently lying in wait for aquatic prey (Mukherjee 1989; Malla & Sivakumar 2014; Taylor et al. 2016; Naing Lin & Platt 2019). Detectability may be increased, if camera traps in future surveys are placed closer to such potential hunting grounds of the Flat-headed Cat instead of placing them on forest roads or trails.

The widespread degradation, fragmentation and loss of suitable habitat for the species raise concerns about the long-term persistence of the Flat-headed Cat in Sarawak. The remaining Flat-headed Cat population in Sarawak is probably small, fragmented and most likely inhabiting areas near increasingly polluted, turgid watercourses (Mohd-Azlan & Das 2016). While its presence in the Sarawak River area is promising news, this area is heavily affected by anthropogenic activities like plantation and infrastructure development. There is a high risk of localised extinction in the short term as a consequence of such anthropogenic pressures and rapid landscape changes. Nonetheless, there is no evidence of widespread hunting of the Flat-headed Cat in Sarawak. If the remaining peat swamp forest of Sarawak are, however, managed sustainably, the long-term viability of Flat-headed Cat populations can possibly be sustained.

The usage of camera trapping in documenting Flat-headed Cat is challenging in peat swamp forests and mangroves. Often, cameras need to be set at sharp angles higher up in trees to avoid inundation in tidal areas or during the monsoon season. This setting may have affected the detection probability because only larger mammals can be detected from such a camera position. Direct observation using a boat survey can be considered as an alternative method in studying the Flat-headed Cat especially in peat swamp forests. Sightings during boat surveys will, however, only be possible near riverbanks. The new records of Flat-headed Cat reported here further supports the conclusion of earlier authors that the conservation of peat swamp forests is crucial for the survival of this cryptic species. More camera trapping surveys and boat surveys in peat swamp forest patches can shed important light on the importance of preserving small fragmented forest patches in a rapidly changing landscape.

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COMMUNICATION

Temporal overlap between two sympatric carnivores in northwestern Peru and southwestern Ecuador

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Abstract: The coexistence of sympatric species is determined by differences in their ecological niche. Thus, for taxonomically and ecologically similar species to coexist, they must segregate in at least one of the three most important dimensions of the ecological niche: space, time or diet. The Pampas Cat *Leopardus colocola* and the Sechuran Fox *Lycalopex sechurae* are sympatric species; and they are the most common medium-sized carnivores in the Sechura Desert and in the lowland seasonally dry tropical forest of Peru and Ecuador. We evaluated the activity pattern of both mesocarnivores using camera trapping and temporal overlap analysis in both arid ecosystems. We found a high degree of activity overlap and no statistically significant difference in the activity pattern of both species ($\Delta = 0.85$ with 95% CI = 0.81 – 0.94; W = 0.531, SD = 2, P = 0.767), both being cathemeral. There is, however, a contrasting pattern in the daytime activity of these species in the dry forest. These results suggest that the different diet composition may be the main dimension that is facilitating the coexistence of both mesocarnivores in the arid ecosystems of northern Peru and southern Ecuador.

Keywords: Activity pattern, dry forest, mesocarnivores, Pampas Cat, Sechura Desert, Sechuran Fox.

Resumen: La coexistencia de especies simpátricas es determinada por las diferencias en su nicho ecológico. Por la tanto, para que especies taxonómica y ecológicamente similares coexistan, deben de segregarse en por lo menos una de las tres principales dimensiones del nicho ecológico: espacio, tiempo o dieta. El Gato del Pajonal Leopardus colocola y el Zorro de Sechura Lycalopex sechurae son especies taxonómica y ecológicamente similares que viven en simpatría, siendo los carnívoros de mediano tamaño más comunes del Desierto de Sechura y de las partes bajas del Bosque Tropical Estacionalmente Seco de Perú y Ecuador. Debido a esto, evaluamos los patrones de actividad de ambos mesocarnívoros usando cámaras trampas y análisis de actividad temporal en ambos ecosistemas áridos. Encontramos un alto nivel de superposición de actividad temporal y ninguna diferencia significativa en los patrones de actividad de ambas especies (Δ = 0.85 con 95% CI = 0.81–0.94; W = 0.531, DE = 2, p = 0.7668), siendo las dos especies catemerales. Sin embargo, hay un patrón contrastante en la actividad diurna de estas especies en el bosque seco. Estos resultados sugieren que la diferente dieta de ambas especies puede ser el principal factor que está facilitando la coexistencia de ambos mesocarnívoros en los ecosistemas áridos del norte de Perú y sur de Ecuador.

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INTRODUCTION

The coexistence of sympatric species is determined by their ecological niche. To facilitate coexistence in the same space, taxonomically similar species need to distinguish themselves by having different diets, habitat use or temporal patterns (Schoener 1974). The temporal pattern is determined by behavioural responses of the species to abiotic pressures and biotic interactions (Beltran & Delibes 1994; Weller & Bennett 2001). Abiotic pressures such as intense temperatures and moonlight, can influence the diel activity of a species. Similarly, activity patterns can be determined by biotic interactions such as predator species synchronizing their activity with their most profitable prey (Monterroso et al. 2013; Marinho et al. 2017), or competing species having a different activity pattern to avoid direct encounters with dominant species (Di Bitetti et al. 2009).

Generally, sympatric mesocarnivores (i.e., mammalian carnivore species situated at an intermediary trophic level that could weigh up to 15kg) are considered competing species. This is because of their similar morphology, body size, and ecosystem function as controllers of prey species (Davies et al. 2007; Prugh et al. 2009). We studied two sympatric mesocarnivores that inhabit the arid ecosystems of Peru and Ecuador, the Pampas Cat *Leopardus colocola* and the Sechuran Fox *Lycalopex sechurae.*

The Pampas Cat is a small wild felid (2–5kg), widely distributed from northern Ecuador to southern Argentina. It occurs at elevations from sea level to 5,704m in a great variety of habitats, such as desert, dry forest, wetlands, savannas, cerrado, and Andean ecosystems like paramo and puna (Silveira 1992; Bagno et al. 2004; Cossíos et al. 2007; García-Olaechea & Hurtado 2018). It is an obligate carnivore, mainly feeding on rodents and birds (Napolitano et al. 2008; Fajardo et al. 2014). In the Cerrado, it is mainly a diurnal species, while in the Andes it is mainly nocturnal and cathemeral (Silveira et al. 2005; Lucherini et al. 2009; Huaranca et al. 2019). The Sechuran Fox is a medium-sized canid (2.5–5kg), distributed only from southern Ecuador to central Peru. It occurs from sea level to 1,800m in the Sechura Desert and the seasonally dry tropical forest of the Tumbesian Region and Marañon Valley (Cossíos 2007; Figueroa et al. 2013). It is an omnivorous species, feeding on different small vertebrates, arthropods, and fruits; and is considered mainly nocturnal (Cossíos 2007).

Given the wide distribution of the Pampas Cat and its variation in temporal activity across different ecosystems, our main objective was to quantify the temporal overlap of the Pampas Cat and a potential competing species, the Sechuran Fox, in the Sechura Desert and seasonally dry tropical forest of northwestern Peru and southwestern Ecuador. These two species are the only carnivores of similar size in the Sechura Desert, and the two most common carnivores in the lowland dry forest (Chávez-Villavicencio et al. 2015; García-Olaechea & Hurtado 2018).

STUDY AREAS

This project was conducted along the southern Ecuadorian and northern Peruvian coastline ecosystems: the Sechura Desert (SD; limited to Peru) and the seasonally dry tropical forest (SDTF; Brack-Egg 1986). Both arid ecosystems are among the Global 200 priority ecoregions for global conservation; the SD is categorized as Vulnerable while the SDTF is considered Critically Endangered (Olson & Dinerstein 2002). We surveyed three SD localities: (a) San Pedro de Vice Mangrove (5.524^{0}S, 80.886^{0}W), (b) Ñapique Lake (5.503^{0}S, 80.704^{0}W), (c) Illescas Reserve Zone (6.079^{0}S, 81.055^{0}W); and three SDTF localities: (d) El Virrey (5.511^{0}S, 79.951^{0}W), (e) Cerros de Amotape National Park (3.963^{0}S, 80.517^{0}W), and (f) La Ceiba Natural Reserve (4.167^{0}S, 80.261^{0}W) (Figure 1). The SD extends from the coast 20–100 km inland to the adjacent dry forest. It is an arid ecoregion almost devoid of vegetation, except for certain riverine areas (Brack-Egg 1986). The annual average temperature varies between 16°C and 24°C, and the average precipitation is lower than 100mm per year (Richer & Ise 2005).

The SDTF stretches over 100–150 km on the western slopes of the Andes and meets the coast of the Pacific Ocean in northern Peru. The climate is hot and dry with an annual average temperature of approximately 24°C, with highs of 40°C during the summer, receiving <200mm of rain per year (Brack-Egg 1986). It has some patches of forest that grows green during the rainy season and is adapted to arid conditions in the dry season (Linares-Palomino et al. 2010).

MATERIALS AND METHODS

Data collection

Between April 2015 and February 2016, we surveyed each locality with 32 camera traps (12 Illuminator Covert DLC and 20 Bushnell Trophy Cam) separated by at least 300m. Each camera trap was positioned on a mammal

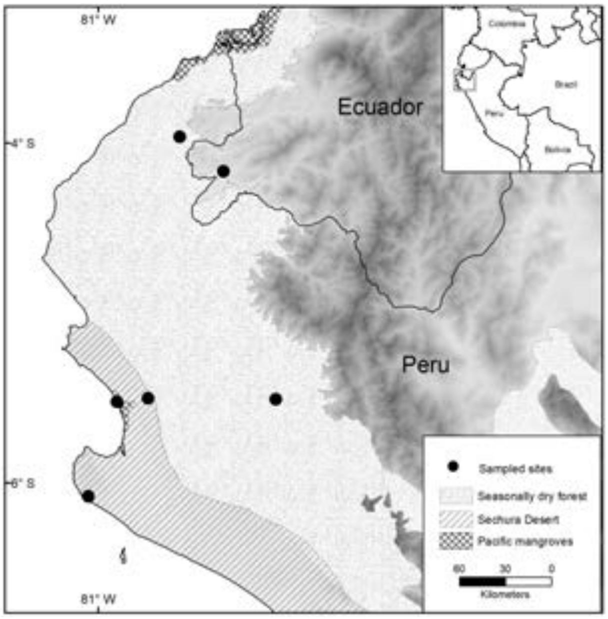

Figure 1. Studied localities in northwestern Peru and southwestern Ecuador, highlighting the Sechura Desert and the seasonally dry tropical forest.

trail or near a water source approximately 30cm above the ground, and set to take three photos per second after each detection. To increase the capture rate, we placed shiny CDs in front of the cameras as a visual attractant (Cove et al. 2014). The sampling effort at each locality varied from 50 to 340 camera trap days.

Data analyses

We consider an independent event when the same species was recorded by the same camera trap within one hour (Marinho et al. 2017). The independent events were classified into three categories: diurnal events recorded between 1h after sunrise and 1h before sunset, nocturnal events between 1h after sunset and 1h before sunrise, and crepuscular events from 1h before to 1h after sunrise and sunset (Lucherini et al. 2009; Foster et al. 2013). We determined the time of sunset and sunrise using the software Moonrise 3.5 (Sidell 2002). We followed Gómez et al. (2005) in classifying both species into five possible categories: diurnal with <10% of independent events at night, nocturnal with >90% of independent events at night, mostly diurnal with 10–30 % of independent events at night, mostly nocturnal with 70–90 % of independent event at night, and cathemeral with 30–70 % of activity during day or night.

To statistically compare the activity patterns of the Pampas Cat and the Sechuran Fox in each ecosystem, we used the non-parametric Mardia-Watson-Wheeler test (Batschelet 1981). Additionally, we used the same test and found no significant differences in the activity patterns of each species in both ecosystems, i.e., the activity pattern of Pampas Cat was the same in the SD and the SDTF (Appendix 1). Thus, we pooled the data from both ecosystems, for an overall activity pattern comparison between the two species.

To estimate the temporal overlap between the Pampas Cat and the Sechuran Fox, we estimated the diel activity pattern using the kernel density analysis with a smoothing parameter of 1.00 (Ridout & Linkie 2009). First, we calculated the overlap estimator of the pooled data, followed by the overlap in each ecosystem. The overlap coefficient (Δ) ranges from 0 (no overlap) to 1 (complete overlap) and uses four estimators, from which two estimators, Δ1 and Δ4, are recommended (Ridout & Linkie 2009). The first one is recommended for small samples sizes of <50 events, while the second one is best for large sample sizes of >50 events (Meredith & Ridout 2017). We used the Δ1 for the overlap in each ecosystem, and the Δ4 for the pooled overlap for both ecosystems. The precision of the estimators was obtained through 95% confidence intervals from 10,000 bootstrap samples. We followed Monterroso et al. (2014) in defining a low overlap when the Δ was <0.5, moderate when the Δ was between 0.5 and 0.75, and high overlap when the Δ was >0.75. The analyses were done with the Overlap (Meredith & Ridout 2017) and Circular packages (Agostinelli & Lund 2017) in the R software (R Core Team 2015).

RESULTS

We obtained 58 independent events of Pampas Cat (58.6% in the SD and 41.4% in the SDTF) and 373 of Sechuran Fox (78.8% in the SD and 21.2% in the SDTF) in 1,783 camera trap days (Image 1). We also registered seven events of Ocelot *Leopardus pardalis* and two events of Margay *Leopardus wiedii* in Cerros de Amotape National Park of the SDTF. These last two taxonomically and ecologically similar species, however, were not included in the analyses because of the low number of records.

The activity pattern of the Pampas Cat and the Sechuran Fox were both categorized as cathemeral, but with more activity at night than during the day and the crepuscule. Although not significant, the Pampas Cat showed less diurnal activity in the SD than in the SDTF (17.6% vs 41.8%), while for the Sechuran Fox the diurnal activity was similar across both ecosystems (21.4% vs 21.5%) (Figure 2).

Image 1. A Pampas Cat *Leopardus colocola* and a Sechuran Fox *Lycalopex sechurae* in the Sechura Desert. © Peruvian Desert Cat Project.

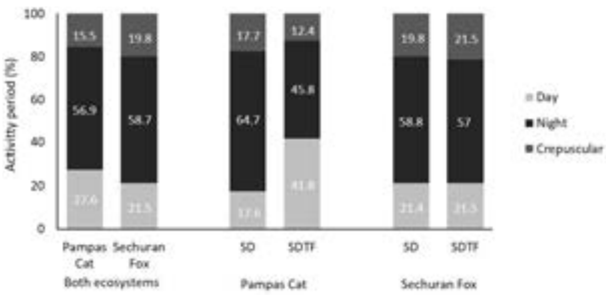

Figure 2. Activity patterns of Pampas Cat and Sechuran Fox in both arid ecosystem of northwestern Peru and southwestern Ecuador: the Sechura Desert (SD) and the seasonally dry tropical forest (SDTF).

The temporal overlap between the activity pattern of the Pampas Cat and the Sechuran Fox in both arid ecosystems was high (Δ = 0.85 with 95% CI = 0.81–0.94) and not statistically different (W = 0.531, SD = 2, P = 0.767). Similarly, the overlap in the Sechura Desert was also high (Δ = 0.81 with 95% CI = 0.76–0.92) and not statistically different (W = 0.481, SD = 2, P = 0.787). Finally, the temporal overlap between both species in the dry forest was moderate (Δ = 0.69 with 95% CI = 0.53–0.75), but not statistically different (W = 4.592, SD = 2, P = 0.101) (Figure 3).

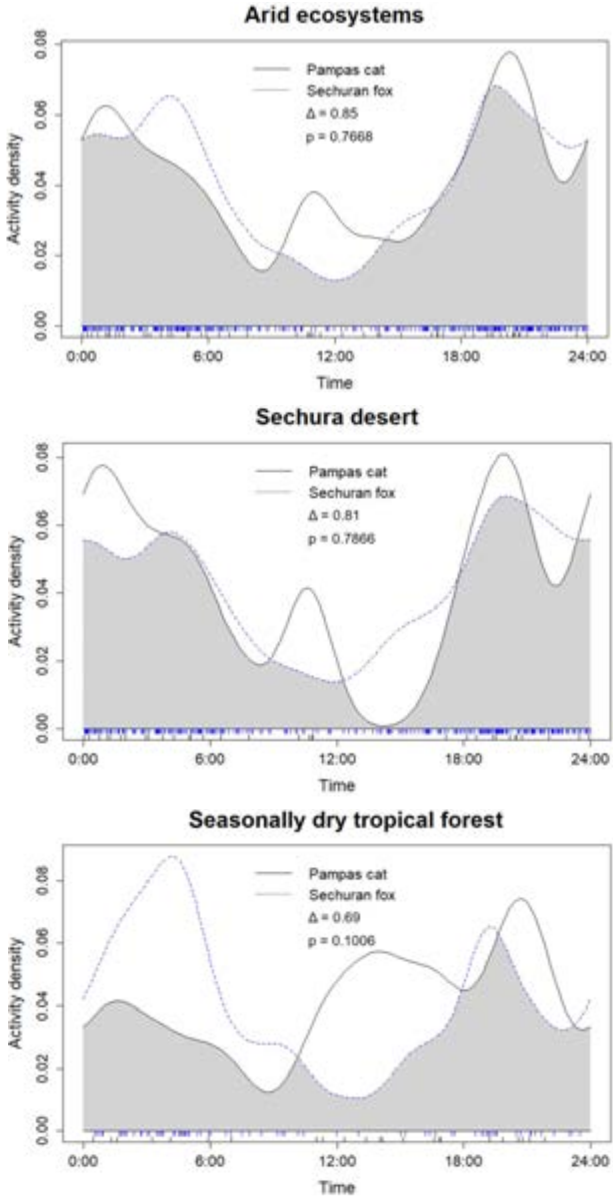

Figure 3. Overlap of diel activity patterns of Pampas Cat *Leopardus colocola* (solid black lines) and Sechuran Fox *Lycalopex sechurae* (dashed blue lines) in a) both arid ecosytems, b) in the Sechura Desert, and c) in the seasonally dry tropical forest. Gray area represents the estimate overlap of both activity patterns (Δ), and p values show the significance.

DISCUSSION

Our results are partially consistent with the available literature for both carnivores in other regions of South America. The Pampas Cat in the Brazilian Cerrado is mainly a diurnal species, with some crepuscular and occasional nocturnal activity (Silveira et al. 2005). In three countries in the Andes, however, it is mainly nocturnal (Lucherini et al. 2009), while a recent study in the Bolivian Andes determined that it is cathemeral (Huaranca et al. 2019). Latter study results are consistent with our results, which also found most of the events at night (50%). This overall flexibility of the Pampas Cat's activity pattern can be explained by the different environmental conditions of the studied ecosystems, and because of the different carnivore communities that exerted different coexistence adaptations.

Information about the Sechuran Fox is scarce, as it is an endemic and under-studied species. Asa & Wallace (1990) suggested that in the Sechura Desert it is mostly nocturnal. We found, however, that it is cathemeral in both ecosystems. This discrepancy could be due to different methodologies used. While Asa & Wallace (1990) radio-tracked four individuals (three of them were possibly a family) for five weeks in just one locality (Bayovar, close to Illescas Reserve Zone), we used camera traps for 14 weeks in six different localities. These differences in survey period, area, and equipment allowed us to cover a larger area and record more individuals, thus obtaining a larger data set for a more representative estimate of the population's activity. Additionally, the Sechuran Fox family that showed a more nocturnal activity may have used a different foraging strategy when accompanied by juveniles, or where the density of intraguild conspecifics like the Pampas Cat was low.

The activity overlap of the Pampas Cat and the Sechuran Fox in both arid ecosystems was high, which represents a lack of temporal segregation between these sympatric species. If we focus on the SDTF populations, however, we see a trend of temporal avoidance, and potentially with other carnivores as well. This trend was observed mainly during daytime when the Pampas Cat is more active than the Sechuran Fox. The Pampas Cat's higher activity during the day in the SDTF compared to the SD, may be a consequence of the higher vegetation cover and thus lower temperatures in the SDTF compared to the SD. The greater continuous forest cover facilitates movement to capture prey and hide from predators while avoiding exposure to the intense heat of the desert. Another potential reason for this discrepancy in the activity pattern in the SDTF compared to the SD may be to avoid direct encounters with other potential nocturnal competitor species, e.g., Ocelot and Margay also occur in one of the survey localities of the SDTF (Hurtado & Pacheco 2015).

As the theory of the niche partitioning proposes, a high degree of overlap in one dimension should be associated with a low degree of overlap in at least one other dimension (Macarthur & Levins 1967). We assume that the coexistence of Pampas Cat and Sechuran Fox is facilitated to a higher degree by their different diet compositions than by temporal segregation. While the Pampas Cat is an obligate carnivore, feeding on small vertebrates such as rodents and birds (Napolitano et al. 2008; Fajardo et al. 2014), the Sechuran Fox is an omnivorous species, feeding on fruits like *Prosopis pallida*, *Cordia lutea*, *Ficus*, and *Cocoloba ruiziana,* and on rodents, ground birds, and lizards (Cossíos 2007; Escribano-Avila 2019). Furthermore, the Sechuran Fox prefers feeding on plants over vertebrate sources (Asa & Wallace 1990; Cossíos 2005). This pattern of coexistence was also found between other feline and canine species in South America, the Geoffroy's Cat *Leopardus geoffroyi* and the Culpeo Fox *Lycalopex culpaeus* (Gantchoff & Belant 2016). Latter authors concluded that the different diet compositions have stronger evidence of segregation than activity patterns and occupancy.

Most of the available information on Pampas Cat is from the Andes, where its interaction with the Andean Cat *Leopardus jacobita* and other high-altitude carnivores has been studied (Walker et al. 2007; Napolitano et al. 2008; Lucherini et al. 2009; Reppucci et al. 2011; Villalba et al. 2012; Huaranca et al. 2019). This is the first time that Pampas Cat ecology has been studied in different arid ecosystems, bringing insights about its coexistence with the endemic Sechuran Fox. Activity patterns of Pampas Cats have neither been studied before in the SD nor in the SDTF, and there is only one publication about the activity patterns of radio-tracked Sechuran Foxes in the SD (Asa & Wallace 1990). Studies of the biology of the carnivore community in the Sechura Desert and in the seasonally dry tropical forests will help understand the needs of these species and serve to develop species-specific conservation plans.

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Appendix 1. Mardia-Watson-Wheeler tests between the Sechura Desert and the seasonally dry tropical forests for both species. W is the static of the test, and large W values indicate greater differences between species distributions. d.f are the degrees of freedom, and the statistically difference for P< 0.05.

Species	W	d.f	P
Pampas Cat	2.8953	2	0.2351
Sechuran Fox	4.1528	2	0.1254

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Author contribution: AGO and CMH designed the study, and collected and analyzed the data. AGO wrote the article and CMH provided relevant comments and revisions.

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SHORT COMMUNICATION

First photographic record of Jungle Cat *Felis chaus* Schreber, 1777 (Mammalia: Carnivora: Felidae) in Haripur District, Pakistan

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Abstract: The Jungle Cat *Felis chaus* was recorded in Pakistan's Haripur District during a camera trapping survey in March to April 2019. This is the first photographic evidence of its presence outside a protected area in northern Pakistan.

Keywords: camera trapping, Khyber Pakhtunkhwa Province, small wild cat.

Little is known about the status and conservation needs of the Jungle Cat *Felis chaus* in Pakistan (Sheikh & Molur 2004). Roberts (1977) considered it ''the most widely distributed and adaptable smaller cat'' in the country that is ''well able to hold its own in areas of human settlement''. It is thought to favour riverine thickets and irrigated plantations (Roberts 1977). In 1979 and 1980, about 169,000 Jungle Cat skins were imported to the United States, most of which originated in Pakistan and India (McMahan 1986). In the Indian subcontinent, it is threatened by habitat loss due to industrialisation and urbanisation of scrubland and low intensity agricultural areas (Gray et al. 2016). In Pakistan, its natural habitat was assessed in 2004 to be declining by <10% within 10 years due to changes in land use (Sheikh & Molur 2004). Since this assessment, a few authors announced its presence in several protected areas in the country (Ali et al. 2003; Nawaz 2008; Khan & Siddiqui 2009; Laghari 2011a, Rais et al. 2011; Khan et al. 2012, 2015; Begum et al. 2013). They only referred to sightings and indirect observations without providing photographic evidence. To date, a comprehensive view of the cat's contemporary distribution in Pakistan is lacking.

Here we report the first photographic record of the Jungle Cat in northern Pakistan, obtained during a brief camera trapping survey in a human-dominated area.

Study area

This survey was conducted in the frame of a program to document the wildlife in a rural landscape in Haripur District. This district is located in Pakistan's Khyber Pakhtunkhwa Province north of Islamabad and known in particular for production of *Citrus* and other fruits (Shah et al. 2010; Ali et al. 2013). Legumes and cereals such as Maize *Zea mays,* Wheat *Triticum aestivum* and Barley *Hordeum vulgare* are also cultivated (Fazal et al. 2010). Native wild flora includes *Dalbergia, Morus* and *Acacia* (Fazal et al. 2010).

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Competing interests: The authors declare no competing interests.

Author contribution: A. Anjum conducted fieldwork; A. Appel & M. Kabir wrote the article.

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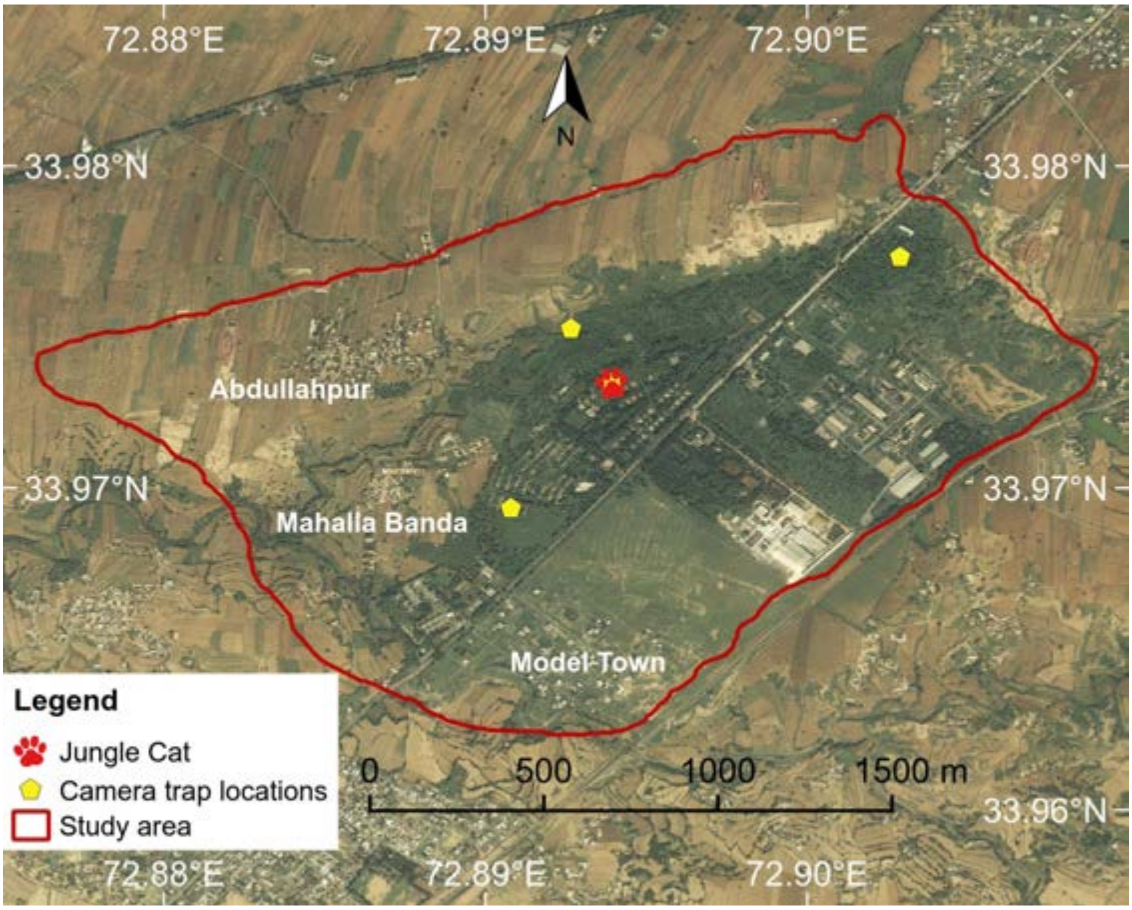

Figure 1. A satellite view of the study area in Haripur District, Pakistan.

The 3.5km^2 large study area encompasses three villages and an industrial estate (Figure 1). The agricultural fields surrounding residential areas are interspersed with grazing ground for small livestock, patches of natural bushland and small orchards (Image 1). Elevation ranges from 493m to 513m.

December and January are the coldest months in the area (Fazal et al. 2010), with temperatures dropping to 3°C and 4°C and a precipitation of 48mm and 74mm per month, respectively (Weather Atlas 2019). June and July are the hottest months (Fazal et al. 2010), with temperatures of 39°C and 37°C, respectively, and a maximum rainfall of 246mm (Weather Atlas 2019).

Image 1. Orchard around a camera trap location within the study area. This location is surrounded by residential buildings.

Material and Methods

Two Bushnell Trophy HD camera traps (model Essential 119736 with infrared flash) were deployed with a distance of 500–900 m between locations. They were mounted at four locations at a height of 40–50 cm above ground. They were set to be active for 24hr and to take three consecutive photographs at an interval of one second. A scent lure for attracting furbearers (Kaatz Bros. Beaver Lure) was spread on stones and on wood in front of the camera traps.

Sunset and sunrise times were obtained using the database of the Astronomical Applications Department of the United States Naval Observatory (2019).

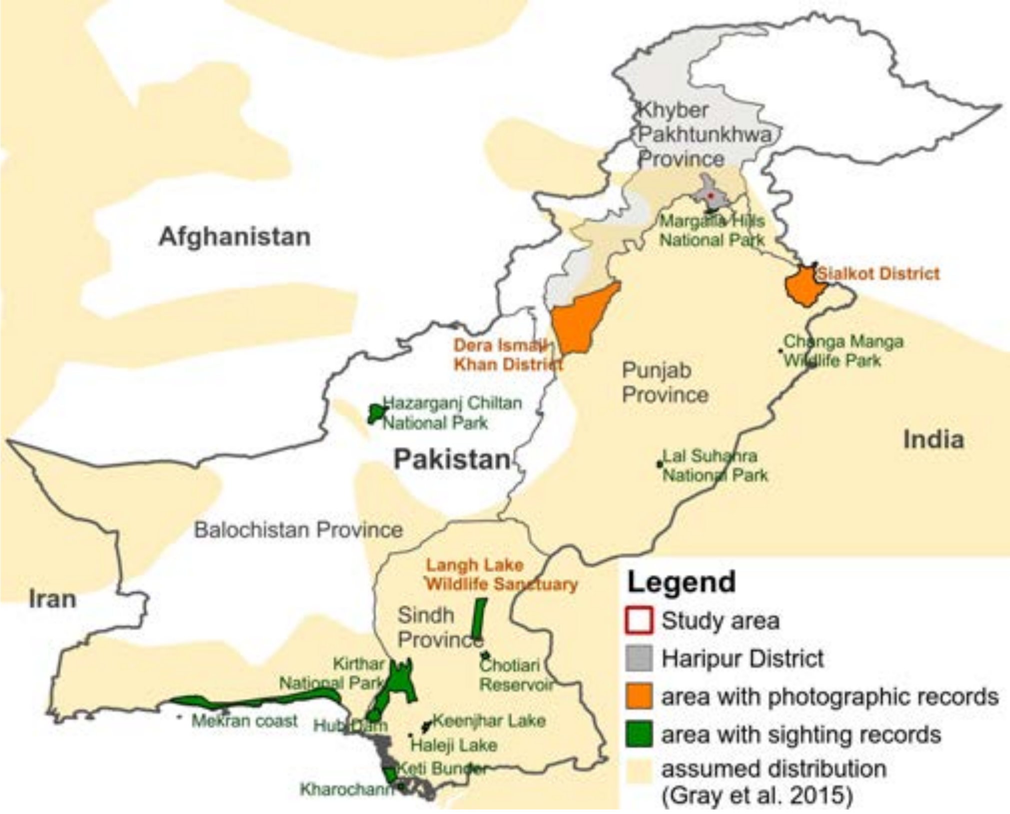

Figure 2. The Jungle Cat in Pakistan: areas with records and assumed distribution in the 21st century.

Results

Camera trapping was carried out from 2 March to 28 April 2019, with a total survey effort of 56 camera trap days. A Jungle Cat was recorded at an elevation of 510m; it repeatedly entered a residential area in the night of 14 to 15 March between 23.11h and 01.18h (Image 2).

Other wildlife species recorded by the camera traps comprise Golden Jackal *Canis aureus* and Wild Boar *Sus scrofa*. Red Fox *Vulpes vulpes*, Indian Grey Mongoose *Herpestes edwardsi*, Cape Hare *Lepus capensis*, Indian Crested Porcupine *Hystrix indica*, and Indian Flying Fox *Pteropus giganteus* were sighted.

Discussion

Our record appears to be among the northernmost records of the Jungle Cat in Pakistan (Figure 2). Roberts (1977) considered it to be less common in this part of the country than farther south, based on hunting records available at the time. It is thought to be present in Margalla Hills National Park in Islamabad Capital Territory, and in Punjab Province in Changa Manga Wildlife Park and Lal Suhanra National Park (Sheikh & Molur 2004). In Balochistan Province, it was sighted in Hazarganj Chiltan National Park (Khan & Siddiqui 2009) and Mekran coastal wetlands (Ali et al. 2003). In Sindh Province, it was sighted in wetlands surrounding the Nara canal (Laghari 2011a), and by local people in the Chotiari Reservoir area, a wetland located in eastern Sindh Province (Rais et al. 2011). Farther south, it was sighted around Keenjar and Haleji Lakes (Khan et al. 2012), in Kirthar National Park (Khan et al. 2013), Hub Dam area (Begum et al. 2013) and in coastal wetlands (Nawaz 2008; Laghari 2011b). Its alleged presence in the Thar Desert based on tracks found in sand (Khan et al. 2015) needs to be authenticated. To date, photographic evidence does not exist from any of the above-mentioned areas.

Our record corroborates the often expressed notion that the Jungle Cat inhabits agricultural lands and frequents human settlements in their vicinities (Roberts 1977; Nowell & Jackson 1996; Sunquist & Sunquist 2002; Baker et al. 2003; Ogurlu et al. 2010). Also in neighbouring Iran, it was frequently sighted outside protected areas close to agricultural lands, poultry farms and fish ponds (Sanei et al. 2016).

Jungle Cats were photographed by day in Dera Ismail Khan District in southern Khyber Pakhtunkhwa Province (Muhammad Ali, pers. comm. December 2018), in Sialkot

Image 2. Jungle Cat recorded in a residential area in the night of 14 to 15 March 2019.

Image 3. Jungle Cat photographed in Sialkot District.

Image 4. Jungle Cat photographed in Langh Lake Wildlife Sanctuary.

District in Punjab Province (Image 3), and in Langh Lake Wildlife Sanctuary in Sindh Province (Image 4). Records in India and Iran indicate that it is active both by day and after dark (Mukherjee 1989; Majumder et al. 2011; Kalle et al. 2013; Kumara et al. 2014; Sanei et al. 2016).

The detection of only two other wildlife species may be due to the limitations of this survey, both in time and available equipment. The scent lure used in front of camera traps might have scared off smaller mammals.

Further effort is needed to obtain a comprehensive view of the Jungle Cat's current distribution and ecology in Pakistan. To widen the knowledge on the species, we suggest to create an online database and encourage wildlife photographers and citizen scientists to share their records. This would facilitate to model its distribution and habitat use.

In Pakistan, camera traps were first used in wildlife research targeting Snow Leopard *Panthera uncia* in May 2006 (McCarthy et al. 2007). Wildlife scientists targeting smaller carnivores mostly relied on sign surveys and binoculars, e.g., Rais et al. (2009), Khan & Siddiqui (2009), Khan et al. (2013, 2015), Begum et al. (2013), and Zehra et al. (2014). Only in 2011 were camera traps used for documenting the presence of a small wild cat in Pakistan, i.e., Eurasian Lynx *Lynx lynx* in the Hindu Kush mountains (Din et al. 2013). To date, only scanty information is available about other small wild cats in the country (Sheikh & Molur 2004). With this article, we hope to inspire fellow Pakistani wildlife scientists to initiate camera trap surveys as well. Surveys targeting Jungle Cat, Caracal *Caracal caracal*, Fishing Cat *Prionailurus viverrinus*, Leopard Cat *P. bengalensis*, Pallas's Cat *Otocolobus manul*, and Asian Wildcat *Felis lybica ornata* are urgently needed to acquire baseline data on their status and conservation needs in Pakistan.

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PLATINUM OPEN ACCESS

SHORT COMMUNICATION

New record on Asiatic Golden Cat *Catopuma temminckii* Vigors & Horsfield, 1827 (Mammalia: Carnivora: Felidae): photographic evidence of its westernmost distribution in Gaurishankar Conservation Area, Nepal

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Abstract: The Asiatic Golden Cat *Catopuma temminckii* is poorly known in Nepal and was previously recorded only twice in the eastern part of the country. We conducted a camera trap survey in the Lapchi Valley ($32km^2$) of Gaurishankar Conservation Area (GCA), a protected area in north-central Nepal, from October 2018 to April 2019. Eleven cameras were deployed to record mammalian diversity in a 2×2 km^2 grid across Lapchi block of GCA. During the study period, four photos and three videos (each of 10 seconds length) of Asiatic Golden Cats were recorded at an elevation of 2,540m at a single camera trap station. This is the first photographic record of Asiatic Golden Cat in this region of Nepal extending the distribution of the species further west in the Himalaya. A more detailed study on its distribution, population size and behaviour is warranted in the near future to implement appropriate conservation measures.

Keywords: Camera trap survey, capture rate, Himalaya, Lapchi Valley, small wild cats, threatened species.

The Asiatic Golden Cat *Catopuma temminckii* is one of the 12 wild felid species recorded in Nepal (Lamichhane et al. 2016), where it is the least studied species and listed as Data Deficient in the National Red List (Jnawali et al. 2011). It is a shy and elusive mammal with characteristic markings such as two distinctive mustache-like white facial stripes, longitudinal markings on the forehead, two white stripes lining the inner rims of the eyes and a white underside on the tail (Jnawali et al. 2011). Its global population has been assessed as Near Threatened and it is thought to be decreasing due to extensive habitat loss and poaching across its range (McCarthy et al. 2015). It is listed on Appendix I

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of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (McCarthy et al. 2015). To date, the cat is known to occur in the foothills of the Himalaya (Ghimirey & Pal 2009; Bashir et al. 2011; Rai et al. 2019), China (Jutzeler et al. 2010), and southeastern Asia (Grassman et al. 2005; Johnson et al. 2009; Than Zaw et al. 2014; Pusparini et al. 2014) (Figure 1). According to the IUCN Red List, the distribution of the Asiatic Golden Cat is limited up to Makalu Barun National Park in eastern Nepal (McCarthy et al. 2015).

Recent camera trap studies provided important records of the species' occurrence in eastern Nepal (Rai et al. 2019), in Bhutan (Tempa et al. 2013; Dhendup 2016; Dhendup et al. 2016), and in northeastern India (Choudhury 2007; Lyngdoh et al. 2011; Gouda et al. 2016; Nadig et al. 2016; Chatterjee et al. 2018; Mukherjee et al. 2019; Ghose et al. 2019; Nijhawan et al. 2019). Currently, there is a lack of research and conservation action as a result of which very little is known about the species in Nepal (Jnawali et al. 2011). The results of this study contribute important new information about its occurrence in the Himalaya of central Nepal.

Study area

The present study was conducted to assess the distribution and activity patterns of wildlife in Lapchi Valley of Gaurishankar Conservation Area (GCA) as part of a biodiversity monitoring program funded by National Trust for Nature Conservation (NTNC) in the frame of GCA project. GCA was declared as conservation area in January 2010. It comprises sub-tropical to nival bio-climatic zones with 16 major vegetation types and a faunal diversity of 235 bird, 34 mammal, 16 fish, 14 snake, 10 amphibian, and eight lizard species (NTNC 2013). Musk Deer *Moschus leucogaster*, Assam Macaque *Macaca assamensis*, Snow Leopard *Panthera uncia*, and Leopard Cat *Prionailurus bengalensis* are some of the nationally threatened species living in GCA (NTNC 2013). Major precipitation in the area includes rain during the summer monsoon from June to August and snow in winter from January to March (NTNC 2013).

GCA is divided into six blocks, namely Gumba, Lambagar/Lapchi, Rolwaling, Bigu/Kalinchowk, Marbu-Khare, and Gumdel/Marbu (NTNC 2013). The study area in Lambagar/Lapchi Block extends across Bigu Rural Municipality of Dolakha District and is surrounded by China in the west, north, and east (Figure 2). The Lapchi

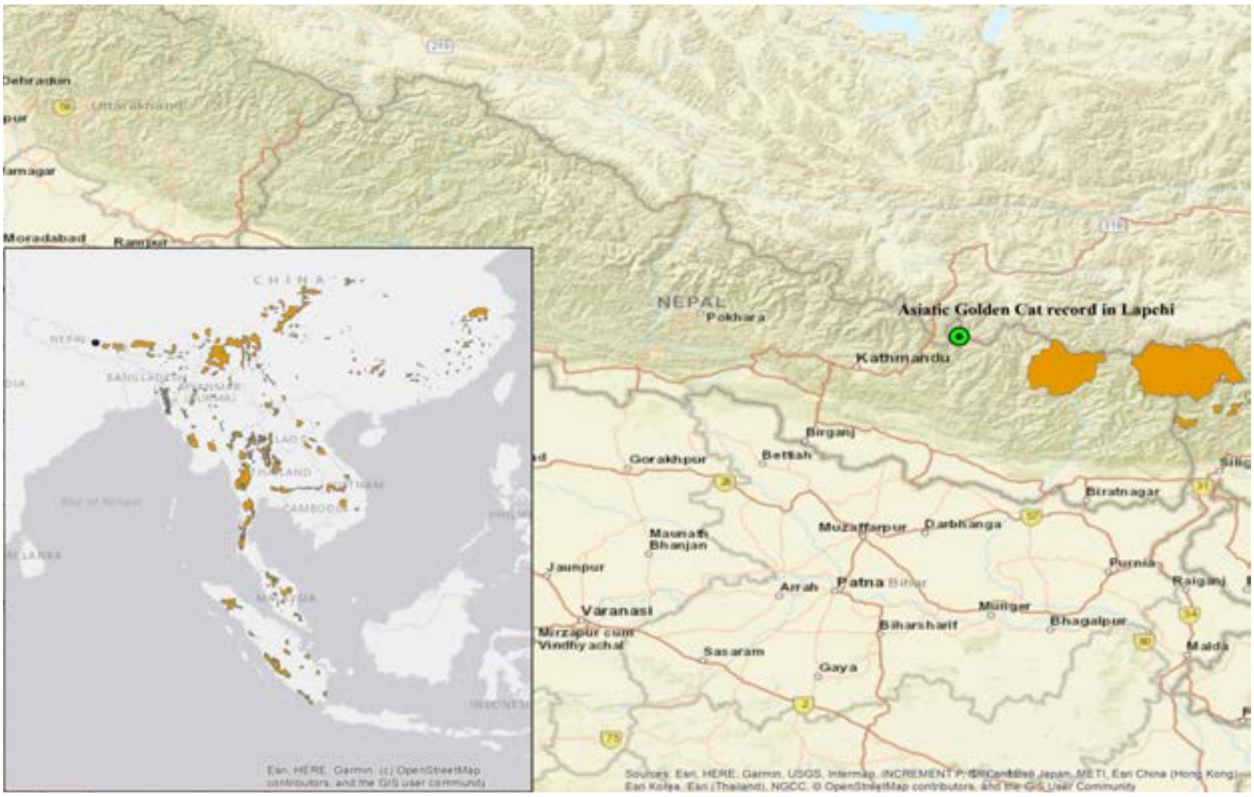

Figure 1. Asiatic Golden Cat recorded in Lapchi Valley of Gaurishankar Conservation Area (green circle with black dot) and the current global distribution of Asiatic Golden Cat (in orange, map modified from McCarthy et al. 2015).

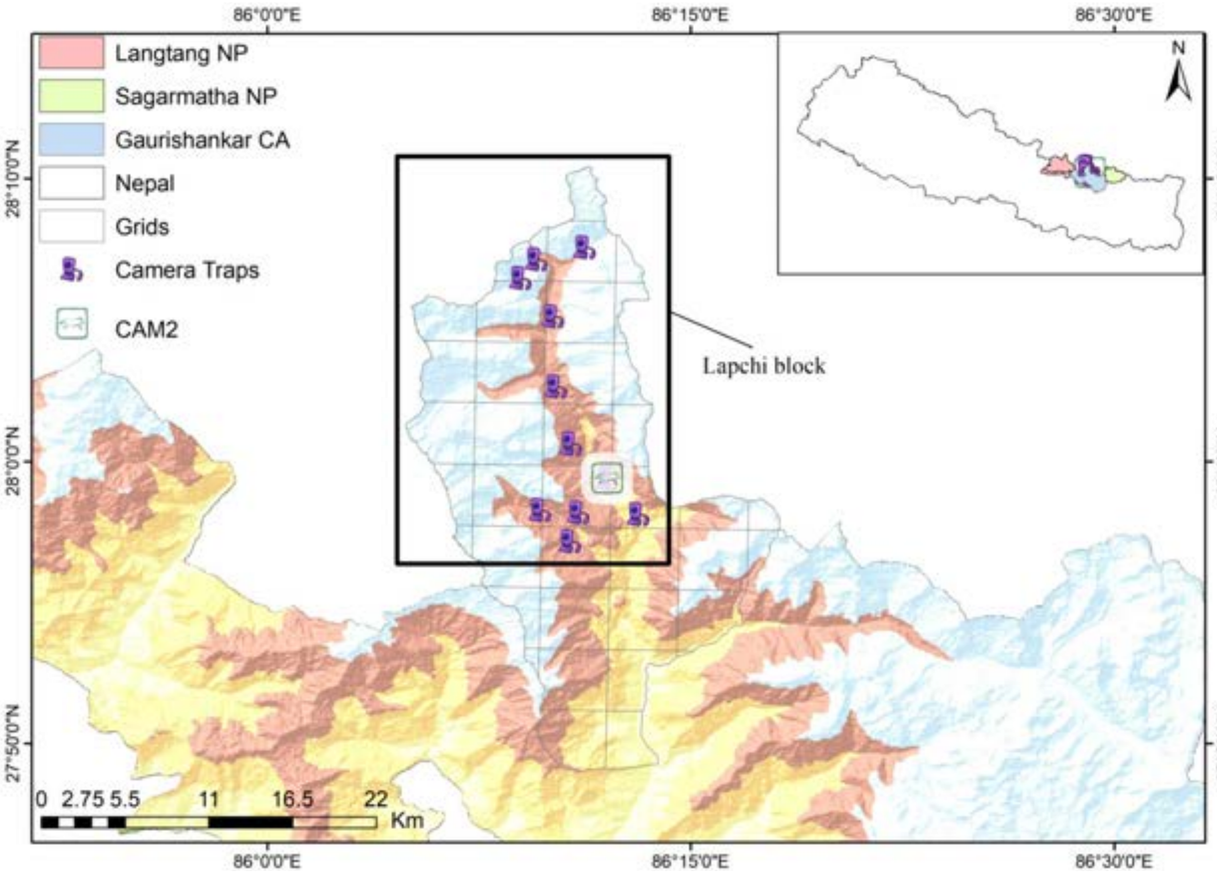

Figure 2. Study area in Lapchi block of GCA with camera trap locations, geo-processed between 2,100m and 4,100m elevation (in pink). The location where the Asiatic Golden Cat was recorded is indicated by the CAM2 icon.

Block consists of four vegetation types, namely, *Betula utilis* forest, mixed forest of *Abies spectabilis*, *Betula utilis*, *Rhododendron campanulatum*, and *Juniperus indica*, Rhododendron forest dominated by *R. campanulatum*, and alpine scrub dominated by Rhododendron shrubs (NTNC 2013). Sherpa people are the main residents of this area. They rear domestic Yak *Bos grunniens* as their livelihood and implement a shifting grazing system (NTNC 2013).

Materials and Methods

During October 2018, a total of 11 camera traps (Bushnell Trophy Model #119537C and Model #119405C) were deployed at elevations of 2,200–4,200 m across the Lapchi Block. The block was divided into a grid of 2×2km^2 cells, and camera traps were deployed on the basis of accessibility and resource availability with a distance of at least 2km from each other. The infrared cameras are motion and heat sensitive at a range up to 15m. During the study period, two cameras were lost and one malfunctioned, leaving a total of eight cameras functioning for the duration of the study. Indirect signs such as faecal droppings, fur remains, latrine, and tracks of mammals were considered for selecting suitable sites for camera trap placement.

Camera model #119537C was set to take photographs, and model #119405C was set to hybrid mode for taking both photographs and videos simultaneously. All camera traps were active for 24 hours and set to take three images at an interval of one second between consecutive images and one minute between triggers. The camera traps were placed at a height of 30–40 cm above ground. Consecutive images of individuals of the same species at an interval of 30 minutes between triggering events, different individuals of same or different species in successive photographs, and non-consecutive photos of individuals of the same species at the same site were considered independent events. Blank images and images from which species could not be identified were not included in the analysis. Photo capture rate index (PCRI) is defined as independent events per camera trap days ×100 (Carbone et al. 2001).

Results

Our study in Lapchi Valley lasted from 22 October 2018 to 6 April 2019 with a total survey effort of 1,476 camera trap days. The Asiatic Golden Cat was photographed (Image 1) at a single camera trap station in altogether three independent events (PCRI 0.20), consisting of four photographs and three videos of 10 seconds each (Video 1). This station was deployed in a mixed hardwood forest comprising *Acer*, *Betula alnoides*, *Abies spectabilis*, *Tsuga dumosa*, *Rhodendron campanulatum*, *Litsea oblonga* and other associated plants. This camera trap was active for a total of 188 camera trap days and recorded altogether 239 independent events (Table 1). These events show the cat coming from uphill on a wildlife trail that was also frequented by Assam Macaque, rodents, birds, and ungulates.

Discussion

We report the first photographic record of an Asiatic Golden Cat in GCA, Nepal. This record indicates that the species occurs farther west than previously recorded (McCarthy et al. 2015), extending its distribution by about 130km farther west in the Himalaya. Interestingly, Schaller (1980) reported a direct observation of the cat in Lapchi Valley. The results of our survey corroborates this sighting after nearly 40 years, and provide important information on the overall distribution and occurrence of the Asiatic Golden Cat.

In Nepal, it is thought to also occur along mid-hills and within Annapurna Conservation Area as far west as Rara National Park (Jnawali et al. 2011). To date, it has, however, not been documented in the western Nepal Himalayas. A study conducted in the eastern mid-hills of Annapurna Conservation Area using camera trap and indirect sign surveys did not yield any evidence for the Asiatic Golden Cat in that area (Appel et al. 2012). Its occurrence in Nepal was previously authenticated only in eastern Himalaya, namely, in Makalu Barun National Park (Ghimirey & Pal 2009), Tinjure-Milke-Jaljale area in the Himalayan foothills (Rai et al. 2019), and in the Kangchenjunga Landscape (Lama et al. 2019).

In Lapchi Valley, the Asiatic Golden Cat moved along a wildlife trail in a hardwood forest that was also repeatedly used by Long-tailed Mountain Shrew, Assam Macaque, Kalij Pheasant and other birds. We therefore assume, that these species are potential prey of the Asiatic Golden Cat. Its prey spectrum is thought to consist of rodents, primates, snakes, lizards, and birds (Nowell & Jackson 1996). Scat samples of Asiatic Golden Cat collected by Kawanishi & Sunquist (2008) in a protected area in peninsular Malaysia contained remains of murids, small reptiles, *Tragulus*, and Dusky Leaf Monkey *Trachypithecus obscurus*.

As shown in Table 2, the PCRI of the Asiatic Golden Cat in our study area was similar to PCRI values obtained in Bhutan's Royal Manas National Park (Tempa et al. 2013), Nepal's Tinjure-Milke-Jaljale area (Rai et al. 2019), and India's Buxa Tiger Reserve (Ghose et al. 2019), but higher than in Makalu Barun National Park (Ghimirey et al. 2012). In contrary, in areas where survey effort exceeded 3,400 camera trap days, the Asiatic Golden Cat was recorded at PCRI values of 0.48 and higher (Johnson et al. 2009; Haidir et al. 2013; Pusparini et al. 2014; Mukherjee et al. 2016). This highlights the importance of increasing survey effort in GCA, both spatially and temporally, for obtaining meaningful data on the Asiatic Golden Cat in this area.

Gaurishankar Conservation Area is an area of high biodiversity, however, there are several threats to its ecological sustainability. The Lapchi Valley is part of an ancient trade route to Tibet. Two hydropower projects have been proposed to be constructed, and

Image 1. Asiatic Golden Cat recorded in Gaurishankar Conservation Area on 21 February 2019. © Gaurishankar Conservation Area Project, NTNC.

Table 1. Details of Asiatic Golden Cat recorded in Lapchi Valley of Gaurishankar Conservation Area, with independent images of other species recorded at this location (27.990^{0}N, 86.200^{0}E; 2,540m).

<table>
<tr><th>Date and time</th><th>Other species recorded at this location</th></tr>
<tr><td>15.ii.2019, 02.02h</td><td rowspan="3">Assam Macaque (n=36), Long-tailed Mountain Shrew Soriculus macrurus (n=18), Masked Palm Civet Paguma larvata (n=1)
Birds: Blue Whistling Thrush Myophonus caeruleus (n=35), Kalij Pheasant Lophura leucomelanos (n=11), Yellow-billed Blue Magpie Urocissa flavirostris (n=1)
Ungulates: Himalayan Goral Naemorhedus goral (n=55), Himalayan Serow Capricornis thar (n=30), Himalayan Tahr Hemitragus jemlahicus (n=23), Barking Deer Muntiacus muntjak (n=23), Domestic Yak (n=3)</td></tr>
<tr><td>21.ii.2019, 18.21h</td></tr>
<tr><td>26.ii.2019, 18.00h</td></tr>
</table>

Table 2. Photocapture rates of Asiatic Golden Cat in selected survey areas in Asia.

Study area	Total camera trap days	Independent events	Photo capture rate index (PCRI)	Source
Gaurishankar Conservation Area, Nepal	1,476	3	0.20	This study
Makalu Barun National Park, Nepal	1,184	1	0.08	Ghimirey et al. 2012
Tinjure-Milke-Jaljale area, Nepal	406	1	0.25	Rai et al. 2019
Buxa Tiger Reserve, West Bengal, India	2,366	6	0.25	Ghose et al. 2019
Royal Manas National Park, Bhutan	2,036	3	0.15	Tempa et al. 2013
Khangchendzonga Biosphere Reserve, Sikkim, India	6,278	25	0.5 (0.34–0.66)	Bashir et al. 2011
Eaglenest Wildlife Sanctuary, Arunachal Pradesh, India	8,044	39	0.48	Mukherjee et al. 2016
Nam Et-Phou Louey National Protected Area, Laos	8,499	48	0.56	Johnson et al. 2009
Gunung Leuser National Park, Sumatra, Indonesia	3,452	25	0.72	Pusparini et al. 2014
Kerinci Seblat landscape, Sumatra, Indonesia	9,255	123	1.33	Haidir et al. 2013

the government of Nepal is planning to open a road linking the border of Nepal and China, which would run through this valley. Such infrastructure development activities usually entail an increase in human presence, which in turn might lead to an increase of illegal hunting and poaching in the area. Heinen & Leisure (1993) recorded nine coats made from furs of Asiatic Golden Cat in tourist shops of Kathmandu, which were thought to have originated in India. Hunting and trapping for fur (Heinen & Leisure 1993), habitat loss and degradation, and human-wildlife negative interaction are the major threats to the Asiatic Golden Cat in the country (Jnawali et al. 2011).

In Nepal, no research activities have specifically targeted the Asiatic Golden Cat. To date, the records of the species in Nepal come in the form of anecdotal data from camera trap studies focused on other species. The finding from our study indicates that the Himalaya in Nepal likely serve as an important habitat core at the western extent of the species' range. Owing to the lack of information on the species in Nepal, and the importance of this area in the global distribution of the species, it is imperative that there be targeted studies of the species in the country, with a particular focus on its distribution, population status, habitat requirements and general ecology in Nepal.

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SHORT COMMUNICATION

First photographic evidence of the Asiatic Golden Cat *Catopuma temminckii* Vigors & Horsfield, 1827 (Mammalia: Carnivora: Felidae) in Sakteng Wildlife Sanctuary, Bhutan

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Abstract: The Asiatic Golden Cat *Catopuma temminckii* is among Asia's least studied wild felids. We report the first photographic evidence of its presence in Sakteng Wildlife Sanctuary, eastern Bhutan, where it was recorded above 3,000m. The photographs show three distinct colour morphs, viz., golden, buff brown, and melanistic. The main threat to the species in the sanctuary appears to be habitat loss due to increasing developmental activities and land use change. Future studies are needed to determine the conservation status of Asiatic Golden Cats in Sakteng Wildlife Sanctuary.

Keywords: camera trap, distribution, Merak, morphs, small wild cats, threats.

The Asiatic Golden Cat *Catopuma temminckii* has been recorded in several range countries of the Himalaya including Nepal, Bhutan, northeastern India, and Myanmar (Ghimirey & Pal 2009; Bashir et al. 2011; Dhendup 2016; Chatterjee et al. 2018; Mukherjee et al. 2019; Nijhawan et al. 2019; Than Zaw et al. 2014). Elsewhere in southeastern Asia, it occurs in Thailand, peninsular Malaysia, Sumatra, Vietnam, and Cambodia (McCarthy et al. 2015). It is listed as Near Threatened on the IUCN Red List, mainly because of habitat loss and poaching across its range (McCarthy et al. 2015). Despite its wide distribution, it is among the least studied felids in Asia (Ghimirey & Pal 2009; Dhendup 2016; Chatterjee et al. 2018). In Bhutan, it has been recorded in seven of the country's 10 protected areas (Dhendup et al. 2016).

It inhabits broadleaved forests from an elevation of 150m in the southwest (Dhendup & Dorji 2018) to montane forests at 4,282m in the north (Dhendup et al. 2016). Most of this information was obtained during camera trapping surveys targeting Tiger *Panthera tigris* and Snow Leopard *P. uncia* (Dhendup 2016). Records outside the protected area network are limited to the campus of Ugyen Wangchuk Institute for Conservation and Environment in central Bhutan (Vernes et al. 2015) and Gedu Territorial Forest Division in southwestern Bhutan (Dhendup & Dorji 2018). Research on habitat and conservation requirements of the Asiatic Golden Cat has not been carried out in the country (Dhendup 2016).

Sakteng Wildlife Sanctuary in eastern Bhutan

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represents the eastern Himalayan temperate ecosystem and harbours several globally threatened and endangered species—Tiger, Red Panda *Ailurus fulgens*, Himalayan Musk Deer *Moschus chrysogaster*, Arunachal Macaque *Macaca munzala*, Asiatic Black Bear *Ursus thibetanus*, and Himalayan Serow *Capricornis thar*—underlining its importance for wildlife conservation (SWS 2016). Here we report the first records of the Asiatic Golden Cat in Sakteng Wildlife Sanctuary obtained during a camera trapping study to assess its diversity of wildlife.

Study area

Sakteng Wildlife Sanctuary was gazetted in 2003 with the mandate to safeguard the rapidly degrading biodiversity of the easternmost part of the country (SWS 2016). It covers an area of 740.60km^2 and comprises three major habitat types from warm broadleaf, temperate, to alpine meadows, with elevation ranging from approximately 1,500 to 4,500 m (SWS 2016). It hosts a diversity of 41 *Rhododendron* species out of 46 recorded in the country, and is home to 39 mammal and 285 bird species (SWS 2016). Close to 5,000 people reside in 13 villages with 772 households in two 'gewogs' (Dzongkha: block), one each in Merak and Sakteng gewog (SWS 2016).

The temperature ranges from 5.41°C in winter to 27.75°C in summer (Gyeltshen 2010). The monthly rainfall between November and March is less than 50mm; it gradually increases from April onward to a maximum of 300.74mm rain falling in July (Gyeltshen 2010).

Our study was carried out in an area of 482.5km^2 in the Merak Range of Sakteng Wildlife Sanctuary (Fig. 1). Notable tree species in the study area are Bhutan Fir *Abies densa, Quercus, Magnolia campbellii, Acer,* Himalayan Birch *Betula utilis* and rhododendron shrubs.

Materials and Methods

A total of six HCO ScoutGuard SG560C camera traps were deployed singly. They were all attached to trees 20–30 cm above ground and placed opportunistically along trails and ridge-lines to increase the probability of recording wildlife. No baits or lures were used. They were placed at least 2km away from the nearest human settlements and 500m away from areas used as pastures for livestock. The minimum distance between camera traps was kept at 300m. They were active for 24 hours and set to record only photographs with an interval of five seconds between consecutive photos. Coordinates and elevations of the camera trapping stations were recorded

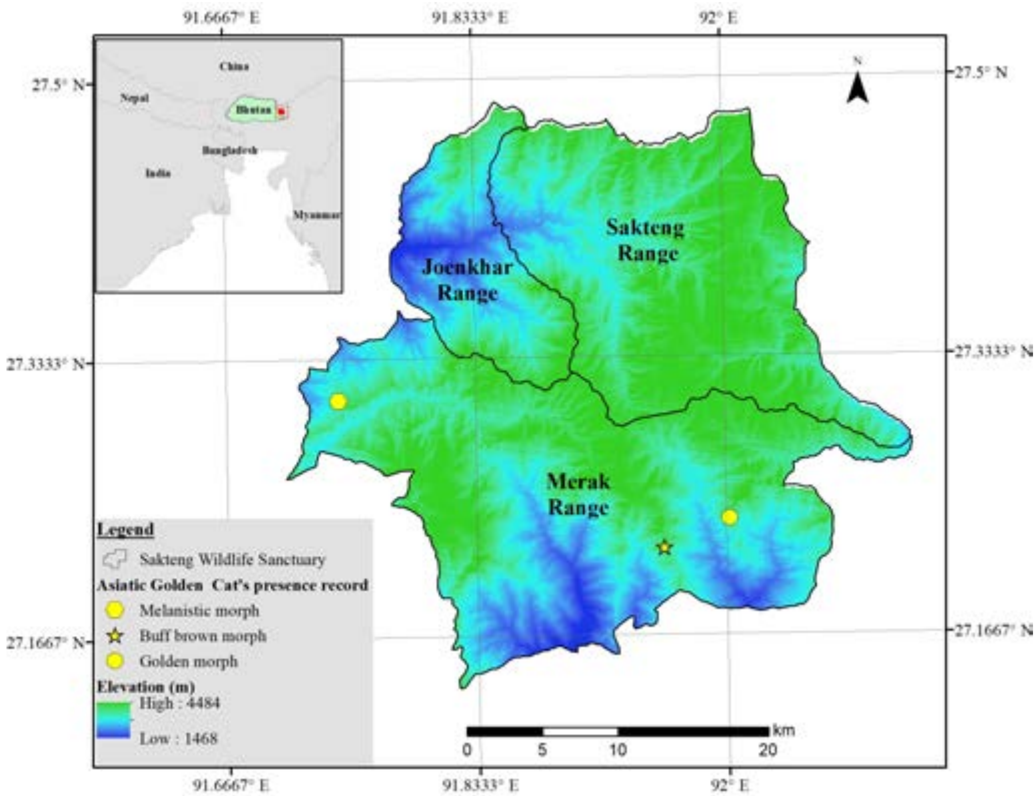

Figure 1. Study area in Sakteng Wildlife Sanctuary showing locations where Asiatic Golden Cats were recorded between July 2018 and February 2019.

using a GPS Garmin E-trex 30 device set to WGS 84 datum. Camera traps were checked once per month.

We define a notionally independent event as an interval of at least 30 minutes between consecutive photographs of the same individual Asiatic Golden Cat at the same camera trap location.

Results

Camera traps were installed from 2 July 2018 to 15 February 2019 at six locations ranging in elevation from 3,000 to 3,700 m. Our total survey effort was 824 camera trap days, with cameras being operational for 224 days. Asiatic Golden Cats were recorded at three camera trap stations in 12 independent events (Table 1), showing three morphs (Images 1–4). They were all photographed in forests dominated by Bhutan Fir, during the day in eight independent events and by night in four independent events. The other three camera traps with no records of Asiatic Golden Cat were placed 100–150 m away from pastureland where herders stayed with their livestock.

Discussion

The present camera trapping study in Sakteng Wildlife Sanctuary yielded the first records of the Asiatic Golden Cat in eastern Bhutan. Our results show that at least three morphs of the Asiatic Golden Cat inhabit the sanctuary's forest above 3,000m. Previous authors reported the occurrence of four morphs in Bhutan, namely golden, melanistic, spotted, and buff brown, which has also been called grey morph (Wang 2007; Jigme 2011; Lyngdoh et al. 2011; Chakraborty et al. 2013; Dhendup 2016; Dhendup et al. 2016). Vernes et al. (2015) reported all four morphs in the same study area in central Bhutan at elevations of 3,200–3,900 m in forest dominated by Bhutan Fir, Himalayan Birch, and Rhododendron. In contrast, Nijhawan et al. (2019) reported six morphs in Dibang Valley, Arunachal Pradesh, India: golden, cinnamon, grey, melanistic, spotted, and a dark patterned morph with tight rosettes. In Dibang Valley, however, the patterned morphs appeared to be more common than solid colour morphs above 3,000m (Nijhawan et al. 2019). An additional morph with streaking called watermarked has been reported in peninsular Malaysia (Gumal et al. 2014).

Most of the independent records of the Asiatic Golden Cat in our study area corroborate the foremost diurnal activity pattern of the species described by Mukherjee et al. (2019). In four of our 12 independent records, however, the cat was photographed at night. Similar records after dark and before sunrise were also obtained in central Bhutan (Vernes et al. 2015), in Dampa Tiger Reserve, India, (Gouda et al. 2016), in Myanmar (Than Zaw et al. 2014) and in peninsular Malaysia (Gumal et al. 2014).

The main threat to wildlife in Sakteng Wildlife Sanctuary appears to be increased developmental activities such as construction of roads and electric power transmission lines, which lead to habitat loss and fragmentation (SWS 2016). More than 85% of the people living in the sanctuary practice a semi-nomadic lifestyle and use forest areas as pasture for their livestock, mainly Yaks *Bos grunniens* (SWS 2016). Though poaching of Himalayan Goral and Musk Deer in the sanctuary has been reported in the past, this has decreased considerably due to regular monitoring and awareness raising activities carried out by the park officials. To date, poaching of Asiatic Golden Cat has not been reported in the sanctuary (SWS 2016). The impact of habitat fragmentation and development projects on the sanctuary's wildlife needs to be assessed.

The Asiatic Golden Cat is known to occur in Bhutan since autumn 2006 (Wang 2007). Yet, its habitat preferences and conservation needs in the country have not been studied to date. We therefore recommend

Table 1. Details of Asiatic Golden Cats recorded in Sakteng Wildlife Sanctuary between July 2018 and February 2019.

<table>
<tr><th>Date and time</th><th>Coordinates</th><th>Elevation (m)</th><th>Morph colour</th><th>Independent events</th><th>Wildlife recorded at this station</th></tr>
<tr><td>19.x.2018, 11.23h;
8.xii.2018, 11.39h;
11.xii.2018, 10.04h;
12.xii.2018, 19.50h</td><td>27.235°N, 92.001°E</td><td>3,340</td><td>Melanistic (Image 1)</td><td>4</td><td>Marbled Cat Pardofelis marmorata, Yellow-throated Marten Martes flavigula, Red Panda Ailurus fulgens, Dhole Cuon alpinus, Southern Red Muntjac Muntiacus muntjak, Himalayan Serow Capricornis thar</td></tr>
<tr><td>8.xi.2018, 08.32h;
9.xi.2018, 18.57h</td><td rowspan="2">27.218°N, 91.958°E</td><td rowspan="2">3,240</td><td>Buff brown (Image 2)</td><td>2</td><td rowspan="2">Southern Red Muntjac, Himalayan Goral Naemorhedus goral, Kalij Pheasant Lophura leucomelanos, Red Fox Vulpes vulpes</td></tr>
<tr><td>7.i.2019, 10.45h;
6.ii.2019, 08.12h</td><td>Golden (Image 3)</td><td>2</td></tr>
<tr><td>16.xi.2018, 21.24h</td><td rowspan="3">27.308°N, 91.741°E</td><td rowspan="3">3,698</td><td>Golden</td><td>1</td><td rowspan="3">Satyr Tragopan Tragopan satyra, Southern Red Muntjac, Assam Macaque Macaca assamensis, Himalayan Goral, Himalayan Serow</td></tr>
<tr><td>9.xii.2018, 09.43h</td><td>Buff brown</td><td>1</td></tr>
<tr><td>14.i.2019, 19.01h;
16.i.2019, 07.04h</td><td>Golden (Image 4)</td><td>2</td></tr>
</table>

Image 1. Melanistic morph of the Asiatic Golden Cat recorded at 3,340m on 11 December 2018. © Sakteng Wildlife Sanctuary.

Image 2. Buff brown morph of the Asiatic Golden Cat recorded at 3,240m on 8 November 2018. © Sakteng Wildlife Sanctuary.

Image 3. Golden morph of Asiatic Golden Cat recorded at 3,240m on 6 February 2019 © Sakteng Wildlife Sanctuary.

Image 4. Golden morph of Asiatic Golden Cat recorded at 3,698m on 16 January 2019. © Sakteng Wildlife Sanctuary.

comprehensive research focussed on the ecology of the Asiatic Golden Cat in Bhutan. The results will form a basis for developing a conservation action plan for the species in Sakteng Wildlife Sanctuary and other areas in the country.

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SHORT COMMUNICATION

Jungle Cat *Felis chaus* Schreber, 1777 (Mammalia: Carnivora: Felidae) at high elevations in Annapurna Conservation Area, Nepal

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Abstract: To date, the Jungle Cat *Felis chaus* has been recorded in the lowlands and mid-hills in Nepal. Photographic evidence, however, is scarce, particularly in alpine habitat. Here we present the first photographic records of the Jungle Cat in an alpine habitat in Lower Mustang of the Annapurna Conservation Area, Nepal. It was recorded by camera traps at elevations of 3,000–3,100 m in 2014 and 2016 in 10 detections during 2,755 trap days. In July 2016, one individual was sighted at an elevation of 3,300m. The habitat of these records comprised riverbed, a poultry farm adjacent to agricultural land and shrubland of *Juniper* and *Caragana* species.

Keywords: Camera trap, alpine habitat, Himalayas, small wild cat

The Jungle Cat *Felis chaus* is usually associated with wetlands and open habitats across a wide geographic region extending from Egypt, western and central Asia, to southern and southeastern Asia (Nowell & Jackson 1996). In the Himalayan foothills, it has been recorded up to 2,400m (Nowell & Jackson 1996; Gray et al. 2016). In Nepal, it is considered to be widely distributed and listed as Least Concern in the national Red List (Jnawali et al. 2011). Only a few authors, however, reported photographic records of the Jungle Cat in Nepal (Karki 2011; Pandey 2012; Lamichhane et al. 2014; Basnet et al. 2017). Ghimire et al. (2012) accounted of sightings by local people near settlements in the buffer zone of Makalu-Barun National Park below 2,560m, but provided only a photograph of a skin found in a village. Katuwal et al. (2018) listed it as occurring at elevations of 180–1,800m, but without photographic evidence. It was photographed at indeterminate elevations in the Himalayan foothills of Shivapuri–Nagarjun National Park (Pandey 2012). Basnet et al. (2017) reported Jungle Cats in an urban area in the Kathmandu Valley at around 1,400m. Records in the Terai lowlands range at 125–300 m (Karki 2011; Lamichhane et al. 2014).

Here, we present the first photographic records of the Jungle Cat obtained in an alpine habitat in Lower Mustang,

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Annapurna Conservation Area, Nepal. This evidence was collected incidentally during a monitoring study targeting the Snow Leopard *Panthera uncia* and other predators.

Study area

The Annapurna Conservation Area (ACA) extends over 7,629km^2 in the central Himalaya and ranges in elevation from 790m to the peak of Annapurna I at 8,091m (Bhuju et al. 2007). Our study area inside ACA was located in Lower Mustang (LM) and Upper Manang (UM), stretching from 29.336^{0}N in the north to 28.261^{0}N in the south and from 83.476^{0}E in the west to 84.426^{0}E in the east. The study area of about 250km^2 included the remote valleys of Namu-Vrapsa, Lupra, Muktinath & Jhong in LM, and Proper Manang, Khangsar, Tilicho & Yak Kharka in UM (Figure 1). These are U-shaped valleys with broad ridges running northwest to southeast and covering alpine habitats at elevations of 2,500–4,700 m. Their exposure determines the natural vegetation. The cool, north-facing slopes are densely forested with Himalayan Pine *Pinus wallichiana*, Himalayan Fir *Abies spectabilis*, and Himalayan Birch *Betula utilis*, while only Juniper *Juniperus* bushes and some grasses thrive on the drier south-facing slopes, which have higher evaporation rates. These alpine valleys fall in the rain-shadow of the Annapurna Mountain Range, with a dry and cold climate. It is a transition zone between the moist, southern Himalayan slopes and the high deserts of Tibet (Ale et al. 2014; Shrestha et al. 2018).

The total annual precipitation is 1,099mm at 2,760m elevation in the northern rain shadow (Putkonen 2004). In the upper part above 3,000m, the rain shadow area of LM and UM receives an average rainfall of less than 260mm. The mean minimum monthly air temperature falls to −2.7^{0}C in winter, while the maximum monthly air temperature reaches 26^{0}C in summer (NTNC 2008; Koirala & Shrestha 2017). The maximum snow water equivalent increases from about 220mm at 3,000m to about 1,078mm at 4,400m (Putkonen 2004).

Snow Leopard, Leopard *Panthera pardus*, Wolf *Canis lupus*, Golden Jackal *Canis aureus*, Red Fox *Vulpes vulpes*, Eurasian Lynx *Lynx lynx*, and Pallas's Cat *Otocolobus*

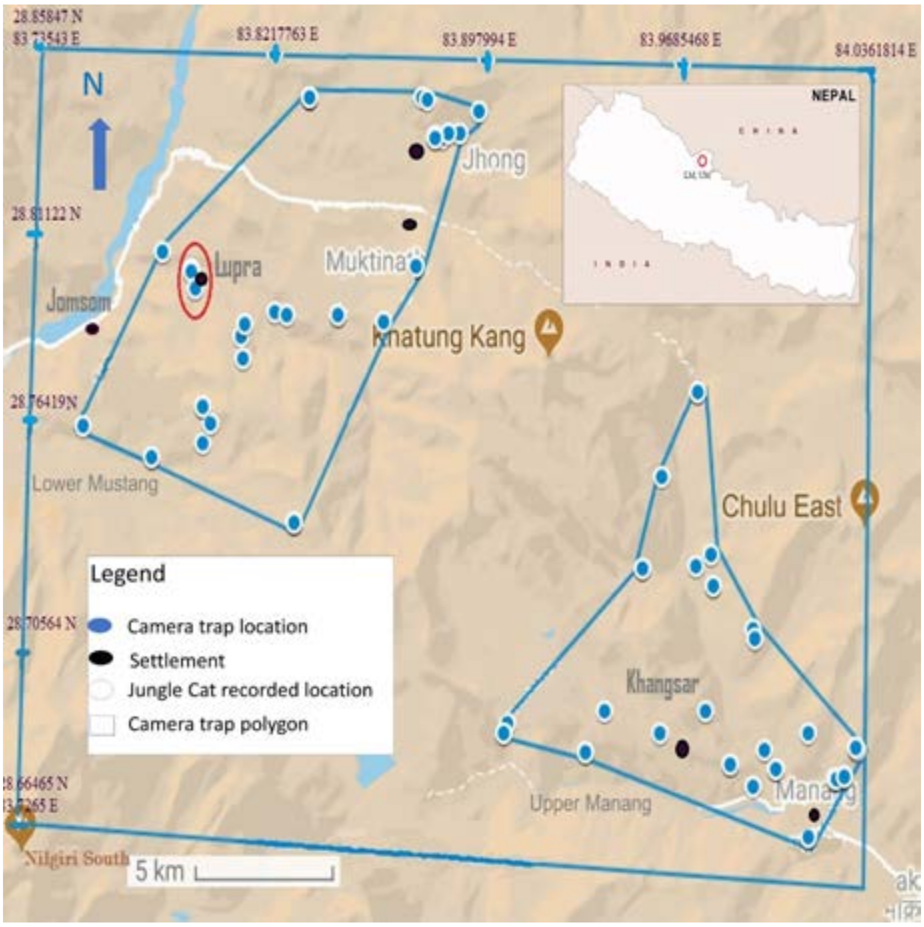

Figure 1. Study area in Lower Mustang and Upper Manang, Annapurna Conservation Area, Nepal.

manul were detected by camera trap surveys and scat DNA tests (Shrestha et al. 2018). Blue Sheep *Pseudois nayaur* and Himalayan Muskdeer *Moschus leucogaster* are the only wild ungulates in the study area (Shrestha et al. 2014, 2018); small mammals include Royle's Pika *Ochotona roylei*, Woolly Hare *Lepus oiostolus*, Siberian Weasel *Mustela sibirica*, Stone Marten *Martes foina*, rat species, and Sikkim Vole *Alticola sikkimensis* (Shrestha et al. 2018).

Material and Methods

For a survey on Snow Leopard and other predators, we deployed remotely-triggered camera traps (Bushnell, passive infrared detector Trophy Cam HD model no. 119676) along well-defined, narrow ridge-lines, valleys or adjacent to frequently scent-sprayed rocks and scrapes. The study area was divided into a grid of 4x4 km cells representing the probable average home range size of female Snow Leopards (Jackson 1996; Oli 1997). We placed 32–48 camera traps in 17 locations in LM and 17–20 in UM in 2014 and 2016 during two camera trapping sessions in each site, including dry (October–January) and wet seasons (June–August). In each location, we deployed one or two camera traps depending on the accessibility of locations; two camera traps were installed along trails and ridges, and one at places where Snow Leopards regularly spray on rocks. The duration of our field work was affected by heavy snow in October and November 2014.

The camera traps were placed 40–50 cm above ground, 2–3 m away from the anticipated path of the Snow Leopard, thus facilitating recording of both large and small mammals. The camera traps were active for 24 hours, and the interval between consecutive photographs was set to one second. They were checked approximately every seven to 10 days, and batteries were changed if necessary.

The GPS coordinates and elevation of the camera trap locations were recorded using a handheld device Garmin GPSMAP device. We identified photographs of recorded species using Baral & Shah (2008), and categorized the photographs of identifiable species into full images showing the whole body and partial images showing only part of the body. Photographs of the same species at the same locations taken an hour apart were considered as independent detections.

In 2016, one local person claimed that he frequently lost his chicken and pigeons from his poultry house in Lupra Village at 3,000m (Placemark #1 in Figure 2). Therefore, one camera trap was placed there for one month targeting the entrance of a poultry shed.

Results

The total survey effort of 2,755 camera trap days comprised 735 days in the dry season of 2014 and 2,020 days in the wet season of 2016. This survey effort yielded 11,036 photographs of 15 wild mammals, one bird species and domestic animals. These photographs include 10 independent detections of a single Jungle Cat (Table 1). In 2014, a Jungle Cat was recorded in six detections with seven full and 18 half images (Image 1). In 2016, it was recorded in four detections with 10 full and 56 half images by the camera trap in Lupra Village (Image 2). A single Jungle Cat was sighted above Lupra Village at an elevation of 3,300m on 4 July 2016 in a shrubland dominated by tall *Juniper* and *Caragana* shrubs (Placemark #2 in Figure 2).

Discussion

Our photographic records obtained at 3,000–3,100 m represent the highest elevations recorded for the species in Nepal. In the snow-free season, one individual moved up to an alpine shrubland at an elevation of 3,300m. The association of the Jungle Cat with shrublands and riverine habitats is well established (Gurung 1983; Mukherjee 1989; Nowell & Jackson 1996). The photographs taken at the entrance of a poultry shed in winter corroborate the observation that it seeks for prey close by human settlements (Ogurlu et al. 2010; Sanei et al. 2016), at least during the cold season.

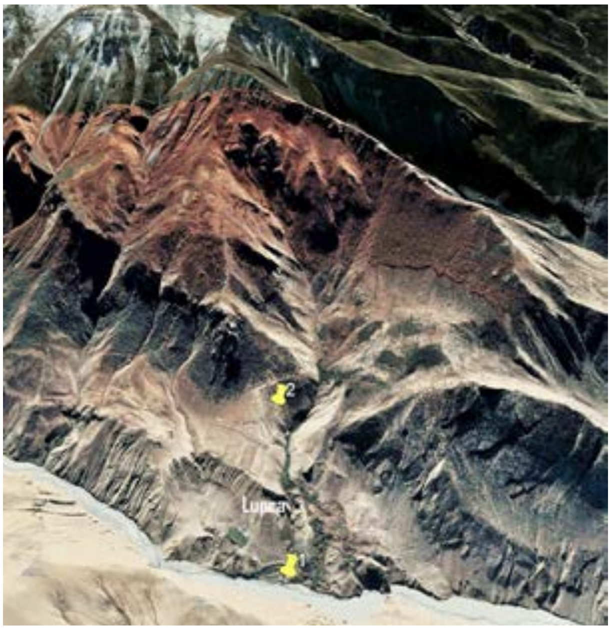

Figure 2. Satellite view of the site where the Jungle Cat was recorded in a riverbed (# 1) on 16–18 December 2014 and sighted (# 2) on 04 July 2016.

Table 1. Details of independent detections of Jungle Cat between December 2014 and July 2016 in Lower and Upper Manang of the Annapurna Conservation Area.

Date and time	Location	Detections	Elevation	Habitat
16.xii.2014, 20.11h–21.25h; 17.xii.2014, 00.22h–01.00h; 18.xii.2014, 03.41h	28.803°N, 83.791°E	2 3 1	3,000m	Riverbed, about 50m far from Lupra Village
23.vi.2016, 02.15h–03.32h; 25.vi.2016, 07.04h–22.29h	28.819°N, 83.791°E	2 2	3,100m	Poultry farm in Lupra Village
04.vii.2016, 17.55h	28.794°N, 83.794°E	1 (sighted)	3,300m	Shrubland adjacent to agriculture land

Image 1. Jungle Cat recorded on 16–18 December 2014 in a riverbed at an elevation of 3,000m in Lupra. © Bikram Shrestha and Gyurmi Gurung.

Image 2. Jungle Cat recorded on 23 June 2016 at a poultry farm at an elevation of 3,100m in Lupra. © Bikram Shrestha and Gyurmi Gurung.

Pocock (1939) accounted of Jungle Cat skins collected in the Indian Himalayas up to elevations of around 2,400m. Sathyakumar et al. (2011) reported its presence at between 1,750m and 3,950m in Khangchendzonga Biosphere Reserve, Sikkim. In Nepal, it was recorded at lower elevations by camera traps in Shivapuri–Nagarjun National Park (Pandey 2012), and in Chitwan National Park (Karki 2011; Lamichhane et al. 2014). These two protected areas harbour temperate and subtropical to tropical bio-climatic zones, respectively (Bhuju et al. 2007). In Chitwan National Park, it inhabits grasslands and forest fringes (Gurung 1983).

Most of our photographic records of the Jungle Cat in the vicinity of Lupra Village were obtained after dark and by night. We, therefore, assume that it hides farther away from the village during the day. It has, however, also been observed by day in India and Iran (Kalle et al. 2013; Sanei et al. 2016).

Little is known about the ecology of the Jungle Cat in Nepal due to lack of targeted studies; only ad-hoc presence records and incidental sightings are available. Basnet et al. (2017) reported five incidents of Jungle Cats being chased by free-ranging dogs, and two Jungle Cats being killed in an urban area at the Pulchowk Engineering Campus in the Kathmandu Valley.

The diet of the Jungle Cat has only been studied in India's Sariska Tiger Reserve in Rajasthan, where small mammals, rodents and birds constituted its main prey (Mukherjee et al. 2004). The authors concluded that one Jungle Cat eats up to 7,300 rodents per year. We, therefore, assume that Royle's Pika, Woolly Hare, rat species and Sikkim Vole are among the potential prey species of the Jungle Cat in our study area. As suggested by Mukherjee et al. (2004), its protection has economic benefits for farmers, as it contributes to controlling rodents in agricultural environments.

At present, it remains unclear whether the Jungle Cat observed in our study area is a rare wanderer to the remote Lupra Valley. Local people in neighbouring valleys did not indicate a sighting of a Jungle Cat.

Further research is needed on the adaptive capability of the Jungle Cat to alpine environments.

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NOTE

Record of a 10-year old European Wildcat *Felis silvestris silvestris* Schreber, 1777 (Mammalia: Carnivora: Felidae) from Mt. Etna, Sicily, Italy

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Information on longevity is key to the understanding of population biology of a species (Healy et al. 2014) and is being collected by researchers across taxa (Cutler 1979; Wilkinson & South 2002; De Magalhaes & Costa 2009; Gonzalez-Lagos et al. 2010; Tidiere et al. 2016). Longevity data of wildlife can be collected through long-term monitoring programs (Smith et al. 2017), but is often difficult to apply to rare and elusive species, such as small carnivores. Alternatively, longevity data can also be collected both from dead animals by using cementum annuli to estimate the age of death (Kamler & Macdonald 2006) and from species held in captivity, although it is well-known that captive animals generally live longer than those in the wild (Ricklefs & Cadena 2007; Tidiere et al. 2016).

Within the Felidae there is a consistent bias in the scientific community to study larger species rather than smaller ones (Brodie 2009; Macdonald et al. 2010; Anile & Devillard 2015, 2018), and hence scientific data on life history traits for smaller species are lacking. Given the aforementioned constraints, knowledge of longevity of small carnivores in the wild is rare. To our knowledge, the only longevity study of European Wildcats is that of Hartmann (2005) in Switzerland, where captive animals attained 12–16 years of age. Here we report our recent finding of a European Wildcat recaptured by camera traps after nine years on Mt. Etna in Sicily, Italy.

Our study area was located on Mt. Etna in Sicily, Italy (Fig. 1A), the highest active volcano in Europe and a World Heritage Site by UNESCO in 2013 (UNESCO World Heritage Center 2019). Extensive descriptions of our study area are reported elsewhere (Anile et al. 2014, 2019).

We have been using camera traps to survey the Wildcat population on Mt. Etna since 2006 (Anile et al. 2009, 2010, 2012a,b, 2014, 2019). Extensive details about the methods and materials used in the surveys related to the present study are reported in Anile et al. (2012b) (Fig. 1B) and in Anile et al. (2019). With respect to the methods reported in Anile et al. (2019), the 2018 survey was conducted from 30 May 2018 to 14 November 2018, with fewer cameras (n = 76 across seven line transects) and with a reduced trap-days effort (n = 1,985) due to the reduced availability of camera traps (Fig. 1B).

In the first photograph dated 26 May 2009 (Image

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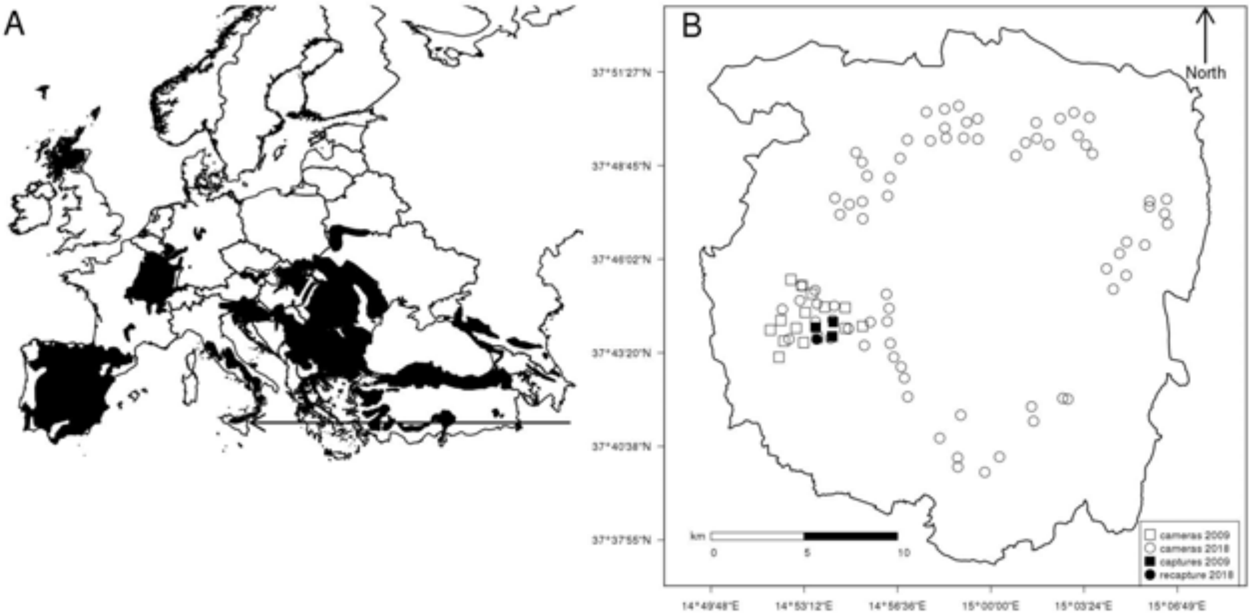

Figure 1. The location of Mt. Etna (A) and European Wildcat distribution range. The inset (B) shows the study area with camera stations used during the 2009 and 2018 surveys.

Image 1. A & B—European Wildcat photographed at Mt. Etna on 26 May and 15 June 2009 | C—European Wildcat photographed at Mt. Etna on 10 June 2018. © Stefano Anile.

1A) this Wildcat was clearly identifiable by the absence of the typical black-tipped tail of the European Wildcat (Ragni & Possenti 1996); its tail showed only a clear white ring (Image 1B). In addition, the shape of the dorsal stripe aided to confirm its recapture. During the same survey, two additional photographs of this individual were obtained at two other camera stations. Collectively, three photographs at three neighbouring camera stations were recorded. During the camera trapping survey conducted in 2018, this individual Wildcat was recaptured on 10 June 2018 at one camera station (Image 1C), relatively near to where it was captured during the 2009 survey. The mean distance from the other camera stations where it was previously recorded was 960m. The time between the first and last photograph was 3,302 days (9.04 years). Hence, the likely minimum age of this individual at the time of recapture must have been at least 10 years.

Camera trapping has greatly increased our scientific knowledge on many cat species worldwide. Indeed, many central topics for the proper management of Felidae have been investigated, such as population density estimation (Anile et al. 2014), habitat selection (Lesmeister et al. 2015; Anile et al. 2019), population dynamics (Karanth et al. 2006; Sharma et al. 2014; Duangchantrasiri et al. 2015; Majumder et al. 2017), and adult sex ratio (Anile & Devillard 2018). Furthermore, recent years have seen an increased collaboration among researchers for sharing camera trapping data, and hence the investigation of ecological patterns at larger scales, i.e., across study areas (Steenweg et al. 2017; Davis et al. 2018; Khwaja et al. 2019).

The Wildcat population dwelling on Mt. Etna has been extensively (n = 41 individuals from 2010–2018) screened for detecting hybridization with Domestic Cats *Felis catus*, but no evidence of hybridization has been detected in this population (Mattucci et al. 2013; Anile et al. 2014, 2019). Hence, we consider more likely that a mutilation occurred at the end of the tail, which was also shorter than the normal size, ~30cm, that caused the loss of the black tip, rather than considering this anomaly in the typical Wildcat marking system pattern due to hybridization.

The Wildcat we recaptured after nine years was surely not a kitten at the time of the first capture, hence we think that 10 years is the minimum reasonable age estimation for this individual. This age estimate still lies at the lower range when compared to ages of captive Wildcats ranging from 12–16 years studied by Hartmann (2005).

Long-term camera trapping studies have been conducted on Tigers *Panthera tigris* and Ocelots *Leopardus pardalis*, however, the maximum ages attained were not reported (Karanth et al. 2006; Duangchantrasiri et al. 2015; Majumder et al. 2017; Satter et al. 2019). On the contrary, Harmsen et al. (2017) reported a maximum age of 14 and 13 years for male and female Jaguars *Panthera onca*, respectively. When comparing the maximum age we recorded with the few other longevity records of cat species from the wild (Hunter 2015), we note that our estimate is considerably high, but still within the range of those reported for the species, especially when considering the small body mass (3.7–4.9 kg; Johnson et al. 2017) of the European Wildcat.

The longevity of an individual European Wildcat might be influenced to some extent by local circumstances, e.g., absence of natural predators and widespread refuges as in our study area. In general, longevity is also shaped by ecological traits such as body mass (Healy et al. 2014), with larger species living longer than smaller ones. Long-term monitoring using camera traps can help understand patterns, which cannot be detected when using a small window in time, but this would require a more sustainable support from funding agencies as the costs involved with this kind of studies are certainly higher than surveys running over a shorter period.

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NOTE

Filling a gap in Andean Cat *Leopardus jacobita* (Cornalia, 1865) (Mammalia: Carnivora: Felidae) distribution range: new record in La Rioja province, Argentina

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The Andean Cat *Leopardus jacobita* is one of the least known felids in South America (AGA 2011; Hunter 2015). Its distribution is restricted to arid regions of the High Andes of Argentina, Bolivia, Chile, Peru and a portion of the Patagonian steppe in Argentina. It is classified as Endangered by the IUCN (Villalba et al. 2016). Main threats for this species, evaluated and categorized by the Andean Cat Alliance (2011), are habitat loss and degradation, opportunistic and traditional hunting and reduction of prey populations.

In 1998, all our understanding of Andean Cat was based on only 18 museum specimens. During the last 20 years, knowledge about the species has increased greatly. Andean Cat diet, distribution, habitat use, population density, activity patterns, genetic structure and some other aspects have been studied in several areas across its range. Many aspects of its ecology and biology, however, remain unknown (Walker et al. 2007; Napolitano et al. 2008; Lucherini et al. 2009; Reppucci et al. 2011). Basic knowledge on the distribution of the species has improved in the past few years because of new data. In 2006, a new record expanded the range 500km south, and four years later, another record expanded it another 150km south to a new ecoregion

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Figure 1. The reported Andean Cat record (red dot) and the currently identified evolutionarily significant units for Andean Cat (green areas). Adapted from Cossíos et al. (2012).

(Patagonian steppe) 80km east of the Andes (Sorli et al. 2006; Novaro et al. 2010). This last record at 650m updated the known elevation range for the Andean Cat, which was until then thought to be above 3,500m (Lucherini & Vidal 2003). We have gained a more complete understanding of Andean Cat distribution, but some questions remain unanswered. Particularly in Argentina, there is a large region in the province of La Rioja where no records have been found, and despite sampling efforts in the neighbouring province of San Juan, only one record was found; these provinces provide a large amount of suitable habitat for Andean Cats (Marino et al. 2011).

Genetic diversity across the currently known distribution has been studied. The Andean Cat populations have low genetic diversity, and two evolutionarily significant units (ESU) have been suggested for Argentina (Cossíos et al. 2012). The two ESU are separated by a large gap in the distribution range between 26^0S and 35^0S, which corresponds to the mentioned area with suitable habitat, but no records in La Rioja province. Genetic information was not obtained from the only sample collected in San Juan province.

Image 1. Pelt of the Andean Cat individual poached in Las Cuevas, La Rioja Province, Argentina.

Here we present the first Andean Cat record for La Rioja province in northwestern Argentina (Image 1), from a pelt found in General Felipe Varela Department in the west of La Rioja Province (Figure 1) in an area called Las Cuevas (29.22^{0}S, 68.71^{0}W) at an elevation of approximately 1,815m. The animal was poached in retaliation for alleged harm to domestic goats, and the pelt was kept as ornament in Villa Unión City. We collected a sample from the skin and conducted genetic analysis as described in Cossíos et al. (2012) to confirm that it was an Andean Cat. Using multi-locus genotype data, further analysis is currently ongoing to assign this specimen to a known genetic population and ESU, and to integrate this new data into the overall genetic structure analysis within known Andean Cat populations.

This record is particularly important because it fills an extensive gap in the distribution range of the species and will also provide relevant genetic information for a better understanding of the relationship between the two currently identified evolutionarily significant units.

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