

Carnivores recorded in Sakteng Wildlife Sanctuary, Bhutan

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Abstract

A camera trap survey was conducted from October 19, 2021, to January 19, 2022, in the Sakteng Wildlife Sanctuary, Trashigang, Eastern Bhutan as a part of nationwide tiger survey. Ten carnivore species including Asiatic black bear, Asian golden cat, Clouded leopard, Dhole, Leopard, Marbled cat, Red fox, Red panda, Bengal tiger, and Yellow-throated martens were captured by cameras in 32 different locations, ranging in elevation from 1,500 to 4,500 meters above sea level. Despite the presence of large numbers of herders within the sanctuary, which places significant pressure on forest resources, these species were successfully documented. Species independent events, relative abundance index and photographic capture frequency were calculated. Most of the recorded species are classified as Endangered (EN) or Vulnerable (VU) according to the latest IUCN Red List of Threatened Species. Red fox was the most frequently captured species while Bengal tiger and Clouded leopard were the least. A diverse carnivore population coexists with a large number of livestock within the sanctuary. To gain a comprehensive knowledge on carnivores, a more intensive camera trap survey is necessary to determine suitable habitats, activity pattern and prey preference of different carnivores.

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Introduction

Carnivores play a pivotal role in maintaining ecological balance through various mechanisms. They regulate prey populations, thereby preventing overgrazing and maintaining vegetation structure (Ripple et al., 2014). This regulation helps in preserving habitat integrity and biodiversity by preventing dominant herbivore species from monopolizing resources. Although carnivores typically exist in relatively low numbers, they are vital components of mammal communities and exert significant influence on other species (Vernes et al., 2021). They contribute to the stability and resilience of ecosystems by exerting top-down control on food webs. This interaction enhances species diversity and ecosystem functionality, as highlighted by Estes et al. (2011).

Additionally, carnivores facilitate nutrient cycling through their consumption of prey and scavenging behaviors, which redistributes nutrients across landscapes and influences plant productivity (Pringle et al., 2017). Their presence can also induce behavioral and evolutionary changes in prey populations, affecting their distribution and dynamics over time. Therefore, carnivores are essential for maintaining the structure, function, and health of ecosystems, underscoring their critical role in ecological balance. Despite their ecology importance, approximately 25% of all mammals are threatened with extinction. The primary threats include habitat loss and degradation, and biological resource extraction (Schipper et al., 2008; Ceballos et al., 2020; Shrestha et al., 2022). Large carnivores are more susceptible to human-related conflicts due to

their large home ranges and dietary needs, which often overlap with human activities (Linnell et al., 2001; Macdonald and Sillero-Zubiri, 2002). Furthermore, the reduction of natural herbivore populations by humans decreases the availability of natural prey, leading carnivores to prey on livestock (Ahmad et al., 2016).

Bhutan is among the 234 globally outstanding ecoregions of the world, according to a comprehensive analysis of global biodiversity by the World Wildlife Fund (Banerjee and Bandopadhyay, 2016). Despite its small geographical size, the rich diversity of species can be attributed to its location at the intersection of the Indo-Malayan and the Palearctic biogeographic realms (Dhendup et al., 2019). The elevation ranges from as low as 100 m a.s.l. to as high as 7,000 m a.s.l., encompassing a wide range of forest types from subtropical forest to alpine scrub, and supporting close to 200 species of mammals, including 39 species of carnivores (Wangchuk et al., 2004). Currently, Bhutan has 69.71% forest cover with 52% of that area falling under the protected area network due to strong conservation policies (FMID, 2023). The country's forest is conserved by five National Parks, four Wildlife Sanctuaries and one Strict Nature, all interconnected by nine biological corridors (SWS, 2019; Bhutan Trust Fund, 2023; WWF, 2023). Among these, the Sakteng Wildlife Sanctuary (SWS), located in eastern Bhutan, covers different agro-ecological zones providing suitable habitats for diverse wildlife. The occurrence of a particular carnivore species within a given environment results from a delicate trade-off between habitat quality and its ability to effectively compete with other species for resources, thereby directly or indirectly affecting resource access (Araujo and Guisan, 2006; Soberón, 2007). Although SWS is a designated protected area, allocation of resources such as timber, firewood and other non-timber forest products are constantly carried out putting significant pressure on the forest resources and wildlife habitats. The sanctuary is under high pressure from the nearby settlement as the community rely highly on forest produce and livestock for their livelihood (SWS, 2019).

Camera trap techniques have been shown to be effective non-invasive survey method for detecting rare and elusive carnivore species in mountainous regions (Trolle and Kéry, 2005; Rovero and Marshall, 2009; Jiménez et al., 2010; Treves et al., 2010; Ahmad et al., 2016). Using this method as a part of nationwide tiger survey, diversity of carnivores was captured in one of the smallest protected areas in the country. Such comprehensive understanding of the dynamics within a carnivore community is imperative for effectively managing and conserving these ecosystems (Rabinowitz and Walker, 1991). The study presents the diversity of carnivores recorded from the survey and the possible reason for their coexistence and survival.

Material and Methods

Study area

SWS is one of the ten protected areas in Bhutan (Fig. 1), established in 2003, it represents the easternmost

temperate and alpine ecosystem of Bhutan. Located between the latitudes; 27°09'00"–27°28'08" North and longitudes; 91°47'04"–92°07'02" East covering an area of 742.46 km². It borders with the Indian state of Arunachal Pradesh to the north and east, Phongmey gewog under Trashigang Dzongkhag to the west and Lauri gewog to the south (SWS, 2019). SWS is connected to Jomotsangkha Wildlife Sanctuary (JWS) and Bumdeling Wildlife Sanctuary (BWS) through biological corridor (BC) 6 and 9, respectively. The Sanctuary covers two gewogs (administrative block): Merak and Sakteng. The elevation ranges from 1,500 m a.s.l. to 4,500 m. a.s.l. covering a diverse range of vegetation types from warm broad-leaved forest to dry alpine scrub (SWS, 2019).

Camera trap survey

Camera trap survey was conducted from October 19, 2021, to January 19, 2022, across all Protected Areas and Divisional Forest Offices. To ensure consistency, a standardized survey protocol was followed by all the field offices. The Sanctuary was divided into 5 km x 5 km grid within the tiger-suitable habitats. Cameras such as Reconyx (HC500 Hyperfire) and Cuddeback manufactured in the United States of America were used and were kept at a height of 50 cm for better capture of the species. The models were installed opposite to each other in such a way that the photo captured by one camera doesn't affect the other camera. A total of 34 camera traps were installed across the sanctuary covering warm broadleaved forest to alpine scrub forest. Although the survey duration was three months, 11 cameras could not be retrieved due to heavy snowfall and were retrieved only in February 2022. Animal signs, animal trails and previous knowledge on tigers were used for placing the camera for higher detection probability. Cameras were monitored monthly, and data were organized and analyzed using Camera Trap File Manager (CTFM). Map was created using QGIS 3.32.2 and other analyses such as relative abundance index, photographic capture frequency and independent events were conducted using MS Excel 2016.

Conservation status data were obtained from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2025) and the IUCN Red List of Threatened Species (IUCN, 2025). Schedule class of the species was obtained from the Forest and Nature Conservation Act of Bhutan, 2023 (FNCA, 2023). Single independent events were taken for every 30 minutes. The relative abundance index was calculated using (total independent events/total trap days) × 100. Photographic capture frequency was calculated as (Total number of photographs/total camera days) (Carbone et al., 2001; O'Brien et al., 2003; Bhatt et al., 2022).

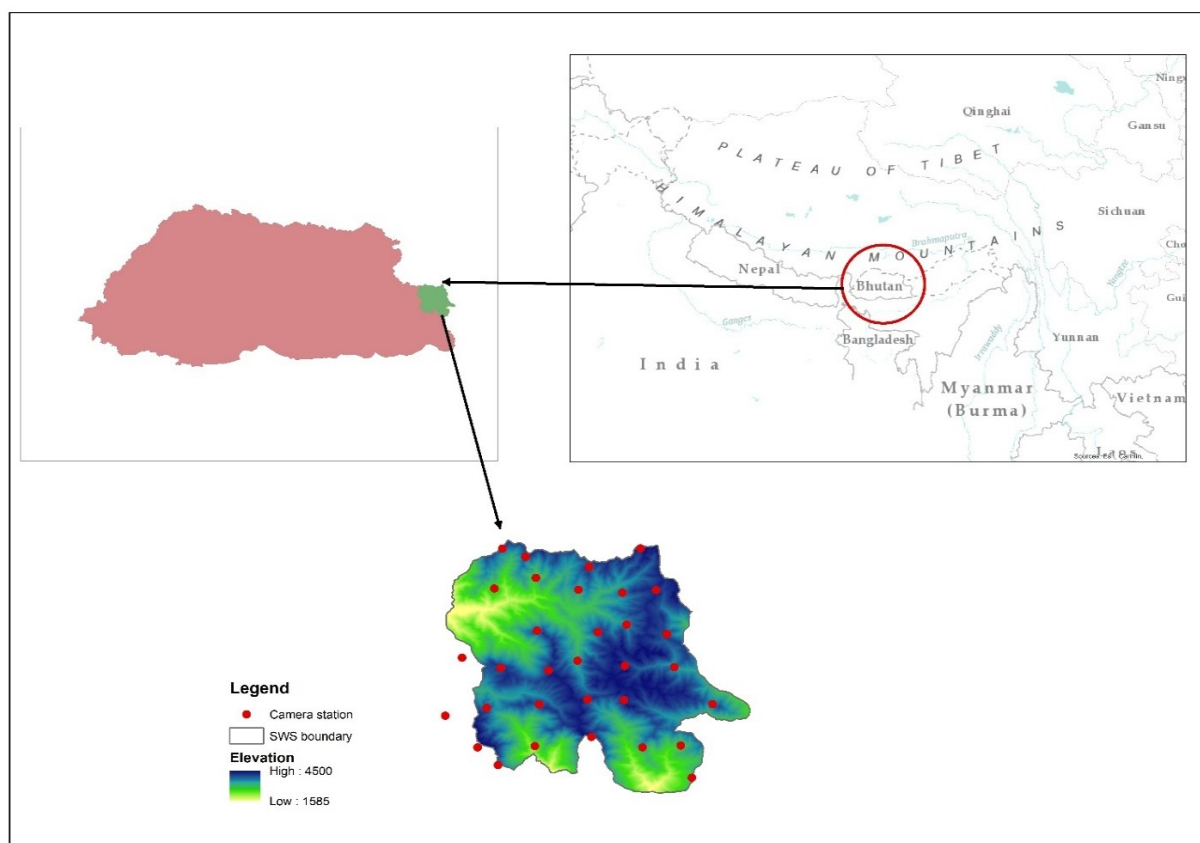


Figure 1: Map of Sakteng Wildlife Sanctuary and camera trap locations.

Table 1: Independent events, relative abundance index and photographic capture frequency of different carnivores. Conservation status of carnivore species based on International Union for Conservation of Nature (IUCN) Red List of Threatened Species, Appendices of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Forest and Nature Conservation Act of Bhutan (FNCAB), 2023 under Sakteng Wildlife Sanctuary, Bhutan.

Sl No	Scientific name	Common name	CITES appendices	Schedule	IUCN Red List	No. of camera stations recorded	Independent events	Relative abundance index	Photographic capture frequency
1	<i>Cuon alpinus</i> (Pallas, 1811)	Dhole	I	II	EN	4	6	0.192	0.5
2	<i>Ailurus fulgens</i> Cuvier, 1825	Red panda	I	II	EN	2	6	0.192	0.37
3	<i>Pantehra tigris</i> (Linnaeus, 1758)	Bengal Tiger	I	I	EN	1	1	0.032	0.08
4	<i>Vulpes vulpes</i> (Linnaeus, 1758)	Red fox	III	II	LC	17	171	5.467	7.91
5	<i>Martes flavigula</i> Bodaert, 1785	Yellow-throated marten	III	III	LC	11	42	1.343	1.93
6	<i>Pardofelis marmorata</i> (Martin, 1836)	Marbled cat	I	II	NT	7	14	0.448	0.79
7	<i>Nefolis nebulosa</i> (Griffith, 1821)	Clouded leopard	I	I	VU	1	1	0.032	0.07
8	<i>Catopuma temminckii</i> (Vigors and Horsfield, 1827)	Asian Golden cat	I	II	VU	1	6	0.192	0.3
9	<i>Panthera pardus</i> (Linnaeus, 1758)	Leopard	I	II	VU	6	11	0.352	1.42
10	<i>Ursus thibetanus</i> Cuvier, 1823	Asiatic Black bear	I	II	VU	3	3	0.096	0.24

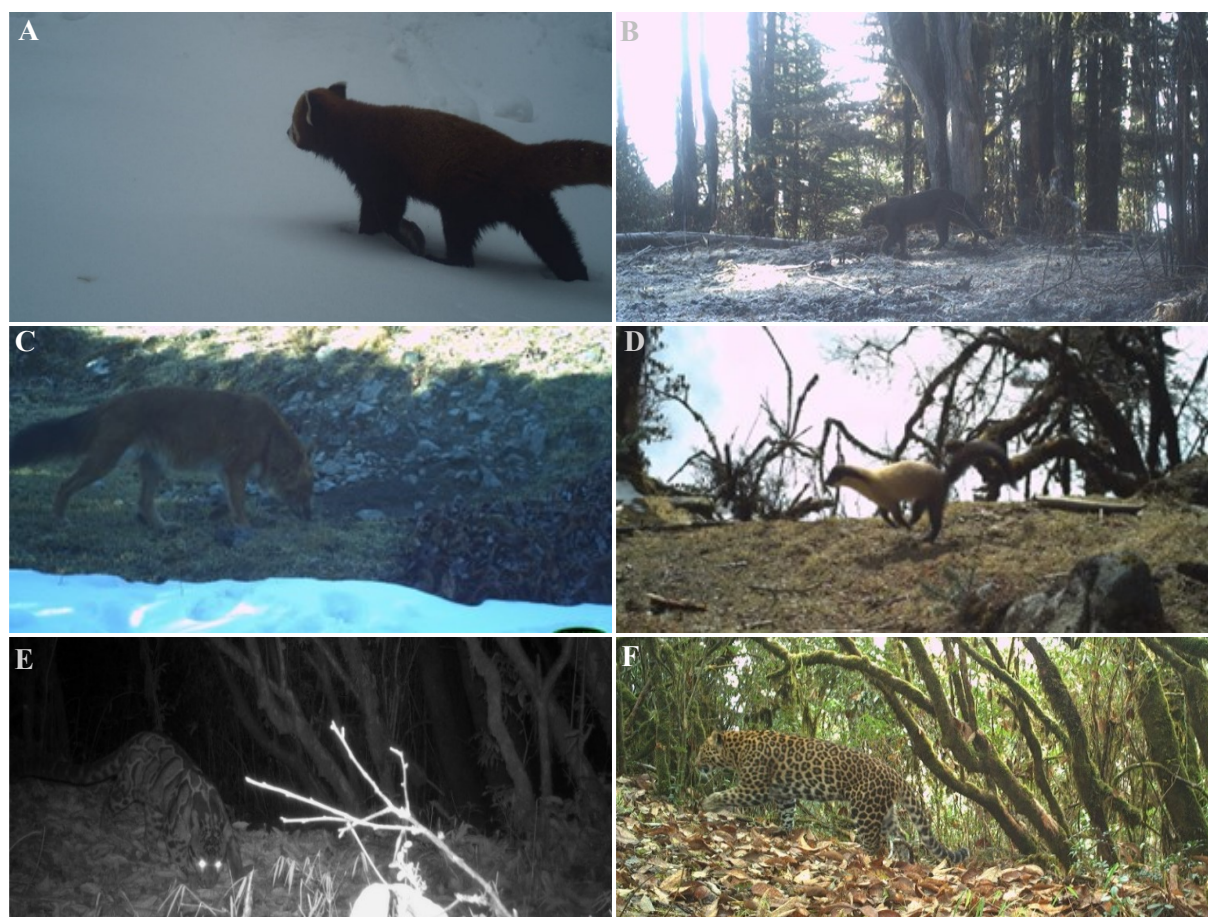


Figure 2: Carnivore species captured during the 2nd Nation Wide Tiger Survey under Sakteng Wildlife Sanctuary, Bhutan. (A) *Ailurus fulgens*, (B) *Catopuma temminckii*, (C) *Cuon alpinus*, (D) *Martes flavigula*, (E) *Neofelis nebulosi*, and (F) *Panthera pardus*. Picture Courtesy: Sakteng Wildlife Sanctuary under Department of Forest and Park Services, Bhutan.



Figure 3: Carnivore species captured during the 2nd Nation Wide Tiger Survey under Sakteng Wildlife Sanctuary, Bhutan. (A) *Pardofelis marmota*, (B) *Panthera tigris*, (C) *Ursus thibetanus*, and (D) *Vulpes vulpes*. Picture Courtesy: Sakteng Wildlife Sanctuary under Department of Forest and Park Services, Bhutan.

Result

Using the camera traps, the carnivores were captured in 34 different camera trap locations within 3,128 camera trap days (Table 1, Figs. 2–3). A total of 133,556 photographs were captured during the survey period. Ten different species of carnivores from nine genus belonging to five families were captured during the survey which includes the Red panda *Ailurus fulgens* Cuvier, 1825 (Ailuridae), Wild dog *Cuon alpinus* (Pallas, 1811) and Red fox *Vulpes vulpes* (Canidae), Asiatic Golden cat *Catopuma temminckii* (Vigors and Horsfield, 1827), Clouded leopard *Neofelis nebulosi* (Griffith, 1821), Leopard *Panthera pardus* (Linnaeus, 1758), Bengal tiger *Panthera tigris* (Linnaeus, 1758), Marbled cat *Pardofelis marmorata* (Martin, 1836) (Felidae), Yellow-throated marten *Martes flavigula* Bodaert, 1785 (Mustelidae) and Asiatic Black bear *Ursus thibetanus* Cuvier, 1823 (Ursidae). Out of ten different carnivores captured by camera three species were classified as Endangered (*Ailurus fulgens*, *Cuon alpinus*, *Panthera tigris*), two were Least Concern (*Martes flavigula*, *Vulpes vulpes* Linnaeus, 1758), four were Vulnerable (*Catopuma temminckii*, *Neofelis nebulosa*, *Panthera pardus*, *Ursus thibetanus*) and one was Near Threatened (*Pardofelis marmorata*) as per the IUCN Red List of Threatened Species (IUCN, 2025). Bengal tiger and Clouded leopard falls under the Schedule I of Forest and Nature Conservation Act of Bhutan, 2023 (FNCA, 2023). The survey shows highest occurrence from Family Felidae (n= 5).

Discussion

Red fox was the highest captured carnivore (17 camera stations) during the survey with 163 independent events. The highest capture of Red fox could be attributed to its adaptability and ability to thrive in different types of habitats (Naseer et al., 2020). In contrast, Bengal tiger and Clouded leopard were captured at only one camera station, SWS 27 and SWS 5, respectively, due to their large home ranges and elusive nature. Albeit potential reintroduction and habitat for Snow leopard *Panthera uncia* (Schreber, 1775) exist in the sanctuary based on its altitudinal range and habitat characteristics (DoFPS, 2016; Letro et al., 2021), no images of Snow leopards were captured up to date. This could be attributed to the absence of Blue sheep *Pseudois nayaur* (Hogdson, 1833), which is the primary prey species. However, the recent establishment of Biological Corridor 9, which connects BWS to SWS, may facilitate future dispersal of snow leopards and their prey. The survey also captured the elusive Clouded leopard within a limited trap duration although Jamtsho et al. (2021) mentioned the difficulty in capturing such species even in the felid hotspot area of Jigme Dorji National Park due to its rare and elusive nature. This signifies the conservation efforts of protected area networks.

Bumdeling Wildlife Sanctuary (BWS) towards north and Jomotsangkha Wildlife Sanctuary (JWS) towards south host diversity of mammals including the rare tiger, clouded leopard and snow leopard (BWS, 2020; JWS, 2023). The presence of diversity of carnivores within one of the smallest wildlife sanctuaries could be attributed to its connectivity to JWS in the south through biological corridor (BC) 6 (Wangdi et al., 2019) and BWS through BC 9 (WWF, 2023) as BCs allows continuous gene flow of animals through uninterrupted movement (Zhemgang Forest Division, 2023).

The survey also captured different mammalian prey species belonging to various families such as Serow *Capricornis sumatraensis* (Bechstein, 1799), Himalayan porcupine *Hystrix brachyura* Linnaeus, 1758, Musk deer *Moschus leucogaster* Hodgson, 1839, Barking deer *Muntiacus muntjak* (Zimmermann, 1780), Himalayan goral *Naemorhedus goral* (Hardwicke, 1825), Sambar *Rusa unicolor* (Kerr, 1792), Wild pig *Sus scrofa* Linnaeus, 1758 and Himalayan striped squirrel *Tamiops mccllellandii* (Horsfield, 1840). The sanctuary also supports a high density of livestock (30.5 heads/km²), grazed freely by herders. Studies carried out by Shao et al. (2021) in China suggested that leopard avoided livestock while other carnivore like Brown bear and Dhole showed negative selection to wild ungulates but positive to livestock. The occurrence of carnivores could be attributed to presence of high density of different size classes of wild prey and free grazing livestock within a guild thereby favoring their coexistence (Karanth and Sunquist, 1995; Sunquist et al., 1999; Karanth and Sunquist, 2000; Karanth et al., 2004; Andheria et al., 2007; Shrotriya et al., 2022).

The survey covered a wide range of forest types ranging from warm broad-leaved forest to dry alpine scrub, covering habitats of different classes of carnivores. This broad range of habitats along with sufficient resources probably has contributed to the co-occurrence of carnivores as reported by Ramírez-Álvarez et al. (2023). Moreover, the expansion of protected area network in Bhutan has led to an increase in livestock depredation, which could be linked to presence of diverse carnivore species highlighting the direct impact of successful conservation efforts (Layrab, 2023). To ascertain the coexistence and assemblage of such diversity of carnivore community, focused research is needed on alternate food preferences, its abundance, activity pattern, prey and habitat relation and distribution modeling (Borah et al., 2012; Shao et al., 2021). The rising rate of habitat fragmentation, coupled with population growth can intensify human-carnivores conflict, making it a common phenomenon. Human-wildlife conflict is increasing globally, especially in and around protected areas (NCD, 2008). However, very few incidents have been reported within the sanctuary. Poor compensation scheme for livestock depredation have discouraged people from reporting. A well-structured compensation scheme could help mitigate

conflicts and promote harmonious coexistence between people and carnivores. Given the high demand in international markets and porous border, large carnivores remain at risk of poaching for commercial purposes. A comprehensive management plan that integrates carnivore conservation with sustainable livestock practices would facilitate species dispersal and support their long-term survival (Dhendup and Letro, 2016).

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Author contributions

Dorji Phuntsho: Conception, design, collection/analysis of data and revision of manuscript. Jigme Wangchuk and Tshewang Tenzin: drafting and revising the manuscript. All authors contributed equally in developing the final version of the manuscript.

Conflict of interest

The authors declare that there are no conflicting issues related to this research article.

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