Assessing snowleopard (*Uncia uncia*) by sign surveys and camera trapping in Northern Pakistan

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Dedication

I would feel pride to dedicate this research work to my lovely and sweet mother who is heaven for me and whose super moral training enable me to build my personality. I cannot go further before special dedication to my loving and caring elder sister whose prayers always aided me to achieve the goals. I also dedicate this manuscript to one of my ever close friend whose moral encouragement and support during my tense and stress moments endorsed me to complete my thesis. These feelings of closeness will always be with me like banks of stream which goes together.

The Department of Ecology and Natural Resource Management (INA) was found on October 1st 2003. The department's subject area includes fundamental biology and ecology, natural resource management and forest science. The department is responsible for education, research and information within its subject area. The education at INA follows international standards and includes Bachelor's Degree, Master's Degree and PhD. INA also offers continued and further education.

INA master theses are final thesis submitted by students in order to fulfill the requirements under the INA master program specialization in Natural Resource Management.

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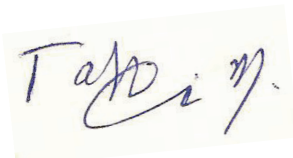
Declaration:

I, Tahir Mahmood, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university or institution for award of any type of academic degree.



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Abstract

The snow leopard (*Uncia uncial*) is an elusive carnivore often used as an indicator of human health or a flagship species in conservation programs. Like many other carnivores snow leopard is also an endangered species and needs attention of environmentalists and ecologists for its survival. Its conservation is a challenging issue because it lives in far ranging, large home ranges and its low density population makes difficult to monitor its population. To monitor snow leopards, various noninvasive techniques have been used i.e. camera trapping, sign survey, track plates and Snow Leopard Information Management (SLIM) surveys. We conducted sign surveys and camera trapping in Khunjerab National Park (KNP) in 2010-2011 to evaluate the detection probability (*P*) and occupancy (ψ) for the snow leopard presence. Occupancy means the snow leopard actually present in the study area and detection probability means the ratio of snow leopard detected during survey and it is always less than occupancy. The data of camera trapping from Chitral Gol Nation Park (CGNP) collected in 2009 was also used to increase the sample size. We used PRESENCE 2.1 program for sign survey data analysis and logistic regression for the camera trapping data. Detection probability (*P*) of snow leopard against fresh scrapes sign (<7 days) was 0.600 (S-E. 0.100) and for all combined fresh signs the estimate was 0.646 (S-E. 0.041). Occupancy (ψ) for snow leopard in the area was estimated to be 0.855 (S-E. 0.043), based on scrapes and 0.849 (S-E 0.100) for all combine fresh signs (scent spray, scats, pugmarks) other than scrapes. Camera trap captured 606 (64%) images of snow leopard of 934 images captured in KNP. The camera trap success rate for all species in KNP was 0.051 per 100 trap nights. In CGNP no snow leopard was photo-captured, however we got we got 25 images of different carnivore species. This makes a low success rate of 0.00053 per 100 trap nights in CGNP. The selected regression model indicates that scent lures successfully attracted canid species but not overall carnivores. Our results suggested that sign surveys and camera trapping are valuable techniques for monitoring carnivores, especially the snow leopards. It is also believed that larger sample size is essential for satisfactory statistical outputs. Moreover lure treatment also proved to be a useful tool to attract carnivores, especially canid species.

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1. Introduction

1.1. Importance of monitoring carnivores and snow leopard

During the last decades, habitat loss and fragmentation, illegal hunting, decline prey species, changes in land use patterns, and different diseases have caused significance declines in carnivore populations (Gese 2001). Furthermore, increasing human populations is also another reason for the continued elimination of carnivores. Carnivores like the snow leopard *(Uncia uncia)* are kept away from human settlements, as they are real threat for livestock and other competition of game species (Breitenmoser 1998). The decline of carnivore populations has had a great impact on lower trophic level mammals (Terborgh et al. 2001). For these reasons, monitoring and conservation of carnivores has become an important need for most of the ecologist, environmentalists and different agencies and organizations (Gese 2001).

Top predators like the snow leopards are ecologically important. It is also used as flagship and umbrella species for conservation efforts, because its conservation is tightly linked to the overall biodiversity in Central Asian mountain ecosystems (Poyarkov and Subbotin 2002). By protecting the snow leopard and its habitat, the high altitudes grasslands and wetlands are also protected. Being a top predator of high mountains, it controls the population and health of ungulate species (Moheshwari and Sharma 2010; WWF 2012). In Kanchenjunga Conservation Area (KCA) of Eastern Nepal, the snow leopard was used as flagship species with the implementation of wildlife conservation projects.

1.2. Snow leopard status and conservation

The snow leopard is an elusive large cat that is secretive and shy in nature (Jackson 1996). According to the IUCN Red List; it is an endangered species (IUCN 2002). It is listed in Appendix I of the Convention on International Trade in Endangered Species (CITES) and declared endangered by the US Endangered Species Act of 1973 (Hussain 2003).

Preferably it inhabits mountains of elevations between 3000 to 4500 m, but can also be found up to 5500 m (Fox 1989; McCarthy and Chapron 2003). In winter it migrates to lower elevation i.e. 900-2500 m in Northern Pakistan, Russia, India and Tien Shan Mountains to follow prey species i.e. ibex *(Capra ibex)* (McCarthy and Chapron 2003; Nowell et al. 1996). The snow leopard's core habitat is cold, arid and semiarid alpine and subalpine ecological zones. It is found in broken and rocky terrain with vegetation of shrubs or grasses (Jackson 1996; McCarthy and Chapron 2003).

Snow leopard is found mainly in the high Himalayan mountainous system of 12 countries; Bhutan, Nepal, India, China, Pakistan, Afghanistan, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, Uzbekistan and Russia (Jackson and Hunter 1996; Jackson et al. 2006). It is estimated that 4500-7350 snow leopards are present on 1,835,000 km^2 potential habitat (Fox et al. 1991). However, McCarthy and Chapron (2003) claimed that 3500 snow leopards are left in the wild and only China contains almost 60% of the snow leopard's habitat. Nevertheless, its actual status is yet unknown. In Afghanistan, it is estimated that only 100-200 snow leopards are left (Habib 2006). The population figures of snow leopards available in other countries include; 2000-2500 animals in China, 800-1700 individuals in Mongolia McCarthy (2000), about 500 individuals in India Fox et al. (1991), and 150-200 in Russia (Poyarkov and Subbotin 2002).

In Pakistan, the snow leopard is present in the inner Himalayan ranges in all five districts of the Federally Administered Northern Areas (FANA) i.e. Swat, Dir, Chitral, Azad Jammu & Kasmir and in some other Northern Areas districts of North West Frontier Province (NWFP) i.e. Gilgit, Hunza and Baltistan (Malik 1997; Robert 1997b; Wegge 1988). The presence of the snow leopard was affirmed in the Pamir, Braldu, and Batura drainages (Gaines 2001). The total availability of snow leopard habitat in Pakistan is 80,000 km^2 of which around 50% is supposed to be the prime habitat of snow leopard (Fox 1989). According to Schaller (1976) the population of snow leopard in Pakistan is 100-250, but (Malik 1997) estimated it to be 400±50. Hussain (2003) confirmed that only in one Baltistan District, there were 90-120 snow leopards and 300 to 420 in the entire range within Pakistan. Snow leopards also exist in Khunjrab National Park; most potentially in Dhee nullah (Robert 1997b).

1.3. Conservation of snow leopard

The snow leopard faces great threats which must be are addressed for the species' conservation, habitat degradation, declining prey species abundance, habitat fragmentation, diseases anthropogenic activities like war in Afghanistan and military operations in Pakistan (Blomqvist 2005; Nowell et al. 1996). Also, snaring, poaching for bones, pelts and other body parts are common threats in Central Asia. Moreover, retaliatory killing of snow leopard is also a common threat, as a revenge of livestock depredation in the Himalayas region (McCarthy and Chapron 2003).

1.4. Challenges of monitoring carnivores and snow leopard

For informed the management and conservation of large carnivores, baseline data on population status and trends are essential (Gese 2001). Assessing these, however, is challenging for a number of reasons. Large carnivores are inherently difficult to monitor, due to their low densities, large home ranges, nocturnal and secretive behavior and kinship to remote and far-ranging areas (Gese 2001; Linnell et al. 1998). These challenges are elevated for the snow leopard because it's densities are especially low, it inhabits some of the most hostile habitat of any cat species and is well camouflaged (Jackson and Hunter 1996; Janecka et al. 2008; Nowell et al. 1996). Its presence at high elevation and prey-poor habitat also impairs monitoring and hinders conservation efforts (Jackson et al. 2006). Additional problems for snow leopard monitoring and conservation are posed by a shortage of trained staff and lack of funds (Jackson et al. 2006; Nowell et al. 1996). Therefore, a lack of reliable information on remaining snow leopard population, location of core habitat and decaying regions of this flagship species create challenges for monitoring and conservation (Jackson 1996; Janecka et al. 2008).

1.5. Noninvasive monitoring of carnivores and the snow leopard

Reliable techniques are always necessary to monitor carnivores for conservation strategies and these techniques are difficult to implement due to elusive, wide ranging and low densities species. Fortunately, non-invasive techniques are increasingly used to monitor multiple species over large area. The selection of technique depends on the species of interest and can be implemented over large area for multiple species (Marucco et al. 2009). Moreover, various challenges of evaluating population and animal welfare concerns have prompted the development of non-invasive methods for monitoring carnivores and other wildlife. Such methods include sign surveys Jackson and Hunter (1996b), fecal genetics (Gompper et al. 2006; Janecka et al. 2008), camera trapping (Gompper et al. 2006; Jackson et al. 2009), snow tracking and covered track plates and scent stations (Gompper et al. 2006) to estimate population size of secretive mammals including the snow leopard. These methods are useful to provide information regarding wild animals' distribution and their presence and absence in particular areas (Linnell et al. 1998).

Detailed information about the snow leopard's status is still confined, since logistic challenges are hard to overcome (Janečka et al. 2011). However, non-invasive survey methods are proving to be effective for monitoring rare and secretive species such as snow leopards. Specifically, the development of Snow Leopard Information System (SLIMS), have provided a practical and standardized approach for monitoring snow leopards. In SLIMS surveys, repeated sign surveys are conducted to evaluate snow leopard abundance. Other non-invasive techniques used for snow leopard monitoring include; genetic analysis, camera trapping and capture-recapture statistical surveys (McCarthy et al. 2008). Interviews of the local communities (Hussain 2003) and DNA sampling of scats and hair are also useful for snow leopard population estimation (Janecka et al. 2008).

1.5.1. Camera trapping

During the last decades, remote by triggered camera trapping has become a popular technique for inventories and cryptic species monitoring Kranath (1995) and for conservation (Nichols et al. 2011). Camera trapping is an efficient non-invasive technique that normally causes minimal disturbance to the target species of large-and medium-sized mammals. It works effectively in inaccessible terrain where other field methods fail, and collects data efficiently both day and night (Silveira et al. 2003). Camera traps provide reliable information to wildlife scientists to discover rare and cryptic carnivores' specific habitat distribution, relative and absolute abundance and their activity behavior (Karanth 1995; O'Connell et al. 2011; Silveira et al. 2003) . It requires high initial cost, careful attention and experienced field staff and its performance depends somewhat on weather conditions, (Silveria et al. 2003; Janicka et al 2011; Swann et al. 2011). Camera stations are usually set along animal trails or other environmental features that enhance capture probability Jackson et al. (2005), and in some studies baited camera stations have been used (Trolle and Kery 2005).

1.5.2. Camera trapping for snow leopard

Camera trapping is a reliable and successful technique to give information on abundance and distribution of snow leopard (Janečka et al. 2011). Inaccessible and rugged snow leopard habitat makes it difficult to set and maintain camera stations (Jackson et al. 2006). However, camera trapping always easy identification and differentiation of individual snow leopards based on their discrete pelage patterns. Every animal has unique characteristics of shape, size and color of individual spots and rosettes. Pelage trends are irregular and vary mostly between the lower side's limbs and tail (Jackson et al. 2005).

1.5.3. Occupancy sign surveys

Likewise, sign surveys are a widely used technique for monitoring large carnivores. It has been done to estimate the presence, absence and distribution patterns of carnivores (Schaller and Crawshaw 1980). During the survey, transects/points are explored to find carnivore sign, such as pugmarks, scrapes, tracks, feces, droppings and pellets etc. It is also assumed that rich carnivore-populated area contain more sign (Linnell et al. 1998). Sign surveys are an efficient way to evaluate the presence and abundance of snow leopards for further conservation (Ahlborn 1988). For example, in northern India, it was found that sign surveys could be used effectively to examine snow leopard populations where the density is more than 2 or 3 individual/100 km^2 (Jackson et al. 2006). Similarly, Ahlborn and Jackson (1988) also conducted sign surveys in Nepal and confirmed that it is an effective technique for snow leopard presence and relative abundance estimation. Sign surveys have some advatages and disadvantages. For example, i) they have low cost, compares with other survey techniques, ii) sign survey can cover larger areas, iii) they can detect far-ranging and rare species, even the target species does not have to be at the survey location at the time of the survey. In contrast, during sign surveys, i) it may be possible to misidentify sign, especially due to insufficiently trained researchers or obscured sign ii) the age of sign is often not clear, iii) individual species can not be distinguish easily, iv) unfavourable environmental conditions i.e. heavey rain, snow or wind between the time of sign deposition and the survey can reduce detection.

Occupancy is defined as the probability that a site or area is occupied by the targeted species (O' Connell and Bailey 2011). However, the relationship between sign frequency and snow leopard density is still poorly described to measure its population. Therefore, conservationists need repeated and consistent surveys to find snow leopard changes in the population (Jackson et al. 2006). Estimating the proportion of sites occupied by a target species is valuable in both long-terms monitoring projects and collecting population trends data Gittleman and Gompper (2001) and it can be an alternative or complement to abundance estimation.

The present study was conducted in Khunjerab National Park (KNP) within the snow leopard range in Pakistan (Qureshi et al. 2011). Despite a growing understanding of the snow leopards' distribution and ecology, many areas remain un-surveyed and information about its population status is limited. I used two non-invasive survey methods, sign-based occupancy surveys and camera trapping, with the following main objectives:

1) Estimate snow leopard occupancy on KNP in Pakistan using sign surveys and camera trapping.
2) Test whether the application of scent lures increases the effectiveness of capturing carnivores with camera traps in Pakistani mountain ecosystems (KNP, with additional data from Chitral Gol National Park).

2. Methodology

2.1. Study area

KNP study was conducted in Khunjerab National Park (74° 55’ E to 75° 57’ E and 36° 01’ N to 37° 02’ N , KNP), located within Gilgit Baltistan, formerly known as Northern Areas (NAs) of Pakistan. In Pakistan, 14 national parks exist and KNP is the third biggest park (WWF Pakistan 2011) of them with an area of 50031 km^2 (Fig. 1) (SLF 2012). KNP has an elevation ranging from 3200 m to 6000 m Wegge (1988) and is the world’s highest park, with average elevation over than 4000 m (Shafiq 1998; Wegge 1988). The park contains rugged peaks and glaciers. Two main rivers, Khunjerab and Ghunjerab, flow through the park. It also comes under IUCN’s Protected Areas Category II, which defines it as an area set aside “Protected Area (PA)” for ecosystem protection and management (Imam 2007).

KNP consists of three main-valleys; Khunjerab (through which the Karakoram Highway passes), Ghujerab and the remote Shimshal Valley. Most of the valleys have stone beds surrounded by gravel hill slopes but a few are hilly slopes with almost 50% soil particles (Qureshi et al. 2011). My study took place in Khunjerab Valley and the surrounding mountains.

In KNP summers are dry and hot, and from July to August, the average temperatures can rise to 14°C. Winters are cold and severe and during winter, there is much snow and temperatures reach down to -12°C from December to January (Green 1990).

The park contains four types of vegetation zones; dry alpine scrub*,* moist alpine pastures, dry alpine plateau pastures and sub-alpine scrub and birch (*Betula*) forests. Tree and shrub species include *Salix spp., Betula utilis* and *Myricaria germanica, and Poa pulbosa* and *sinaica* are main grass species (Qureshi et al. 2011).

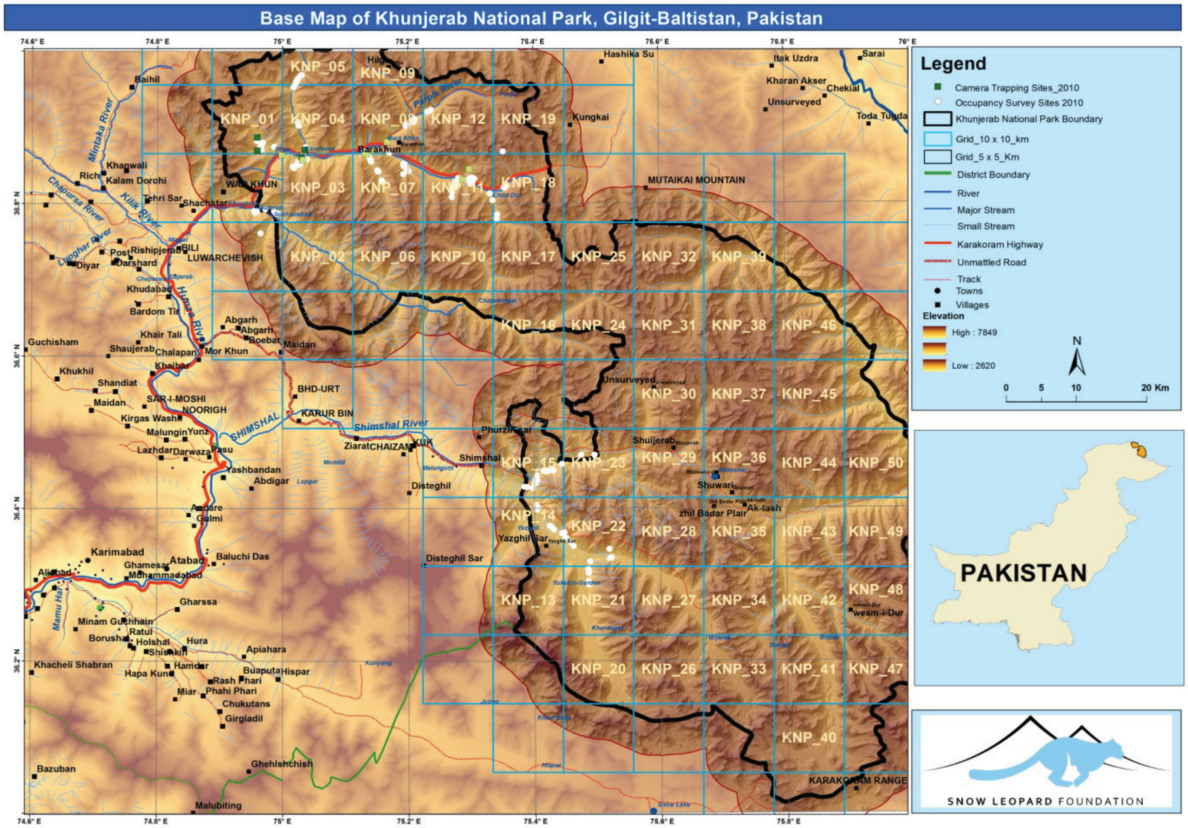

Figure 1. Location of study site, sign surveys and camera trapping stations (shown as white dots and green boxes respectively) for monitoring snow leopard within Khunjerab National Park, Gilgit Baltistan, Pakistan 2010-2011.

My researches focused on the snow leopard, but in the park are found two reptilian, 46 avian and 25 mammalian species (Qureshi et al. 2011). Medium-sized and large mammals include the brown bear *(Ursus arctos)*, red fox (*Vulpes vulpes*) and Indian wolf (*Canus lupis pellipase*) etc (Khan 1996; Shafiq 1998) and several ungulate species Marco Polo sheep *(Ovis ammon polii)*, blue sheep (*Pseudois nayaur)* and Himalayan ibex (Khan 1996; Qureshi et al. 2011; Shafiq 1998). Small mammals include Golden marmot *(Marmota caudata),* cape hare *(Lepus capensis),* migratory hamster *(Cricetulus migratorius)* and field mouse *(Mus musculus) (Qureshi et al. 2011).*

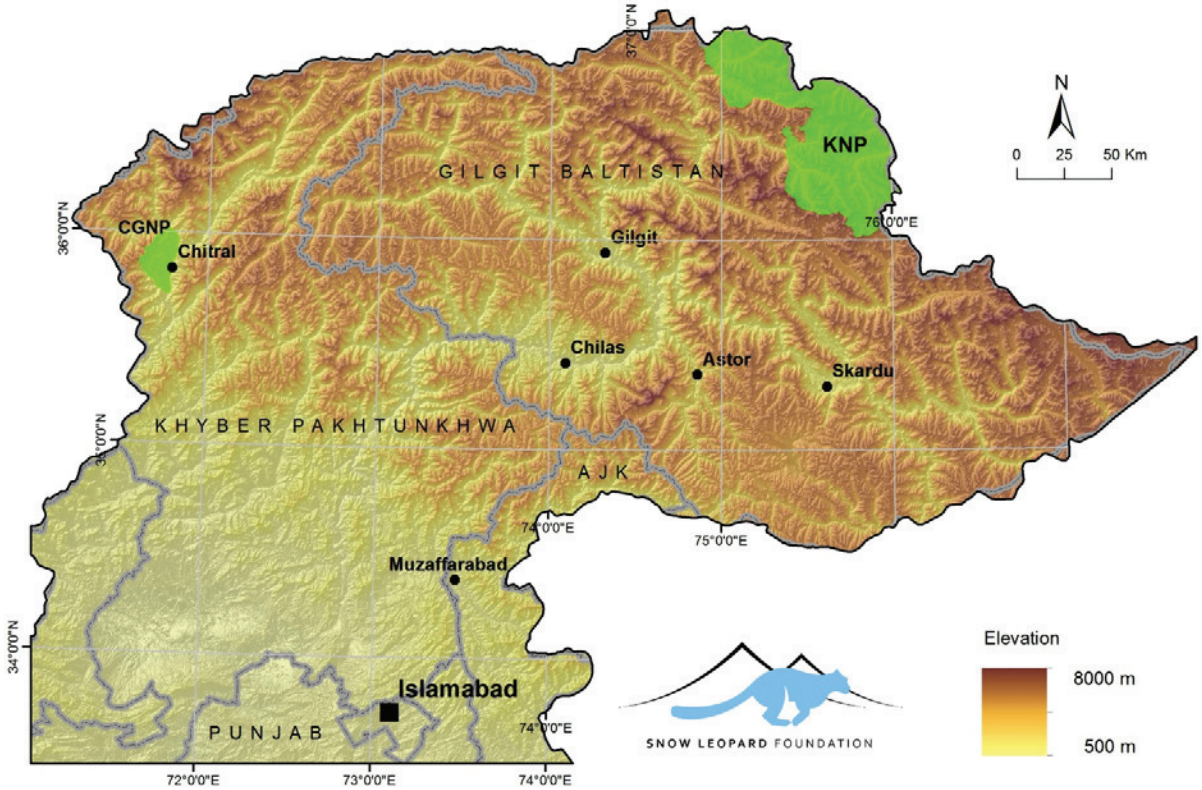

Figure 2. Location of study area sites of KNP and CGNP, showing the distance from each other.

KNP contains no permanent human settlements but a few shepherds move in during different periods. The closest settlement is in Shimshal Valley at the southern boundary, comprising of six small villages with a total of 355 households and almost 1740 people (Imam 2007). Disturbance factors include livestock grazing, hut and corral construction, fuel wood collection, and poaching (Wegge 1988). The park's limited staff and funds are insufficient to combat poaching, which threatens the park's small population of endangered Marco Polo sheep (Knudsen 1992). Furthermore, livestock depredation, mostly by snow leopard and wolves, leads to illegal killing of carnivores through hunting, trapping and poisoning (Ahmad 1996).

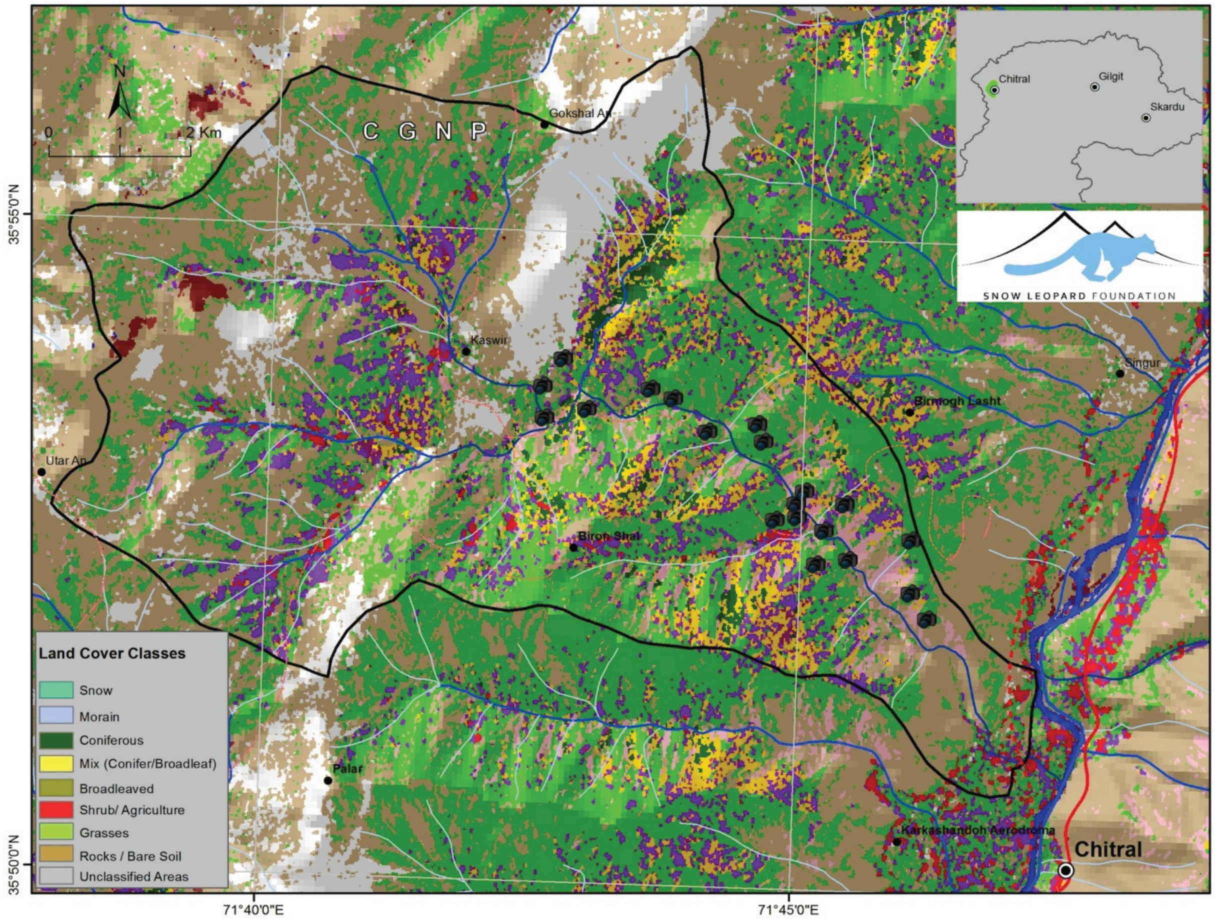

Figure 3. Location of Chitral Gol National Park (CGNP) and camera trapping (showing in black dots) for snow leopard monitoring in Chitral, 2009.

2.2. Chitral Gol National Park (CGNP)

CGNP was established in 1984 and is located in North West Frontier Provinces (71^{o}42'12.60" E, 35^{o}53'30.34" N, NWFP) (Fig.2). Due to a very small number of functional camera traps in KNP, I also included camera trapping data from Chitral Gol National Park (CGNP) in my analysis (Fig. 3). The park consists of an area 77.5 km^2 and lies in the Hindu Kush Mountains, with an elevation from 1450 to 4979 m (Inamu-ur-Rahim 2005). In summers, the park's average temperature is 29^{o}C but it sometimes reaches beyond 35^{o}C. Winters are cold and severe and sometimes temperatures drop to -20°C. The park receives 462 mm precipitation annually (Inamu-ur-Rahim 2005). The park consists of alpine meadows and temperate forests. Snowy and cold winters and dry summers create drought-resistant and cold-tolerant vegetation in the park (Wildlife of Pakistan 2007). In CGNP, 42 mammal species were confirmed (Robert 1997a)

Present research covered the Himalaya mountain system in Pakistan; a well known area for snow leopard habitat. The Himalayan mountain system stretches between latitudes of 26° 20' N and 35° 40' N and longitude 74° 50' E and 95° 40' E (Ives 2006) and extends from east to west with the total length of 2400 km and width from 150 to 300 km (Negi 1998). These are high altitude peaks and glacial land with 12,000 feet average peak height (Menon 1954). The system goes across several Asian countries including Bhutan, Nepal, China, India and Pakistan (Ives 2006). The Himalayas receive a variety of climatic conditions. A heavy monsoon rainy season dominates from June to December. Himalaya's summers (April – June) are hot while, winters (November-March) are cold and severe. In winter temperatures fall below the freezing point and snow falls above an elevation of 2000 m (Negi 1998). The Himalayas contains tropical forest below 1500 m, but few oak trees can be seen even above 1500 m. Coniferous forest prevails above 2500 m but some alpine meadows occur near 3500 m. Probably, the drier west and the humid east regions of Himalayas are known to be the habitat of snow leopard. In Pakistan, the Himalayas extend southeast to northwest from Indian occupied Jammu & Kashmir to Azad Kashmir Pakistan.

2.3. Snow leopard features

The snow leopard's length is approximately 100-120 cm long with a tail of 80-100 cm (Robert 1997a). It has a shoulder height of 56-60 cm (Fox 1989; Robert 1997a). Adults have body weight between 35-55 kg (Habib 2006; Schaller 1977). It has a small nose with short rounded ears and powerful jaws (Robert 1997). The body has whitish grey color with scattered irregular black spots (McCarthy and Chapron 2003). It can live up to 21 years in captivity (Fox 1989), but (Blomquist 1982) claimed that it can live 12 years in captivity and half of that in wild habitats.

The snow leopard's mating season starts between January and mid-March, which coincides with a peak of scent marking and vocalization (Ahlborn 1988; Wilson 2009). Both males and females scent mark frequently, but the male does this more often (Blomquist 1982). Following 93-110 days of gestation, females give birth to 1-5 cubs in June or July (McCarthy and Chapron 2003), with typical litter sizes of 2-3 cubs (Habib 2006).

Snow leopard prey mainly on large wild goats and sheep; such as Bharal or blue sheep, argali (*Ovis ammin*), urial sheep (*Ovis orientalis*), Siberian ibex (*Capra sibirica*) (Schaller et al. 1988) Himalayan tahr (*Hemitragus jemlahicus*) and markhor (*Capra falconeri*) (Wilson 2009). Smaller prey species including Marmots (*Marmota spp),* pikas (*Ochotona spp) and* zokors (*Myospalax spp)* are important food items (Schaller et al. 1988; Wilson 2009). It also eats domestic sheep, goats, cows, yaks and dogs. Unusually, some scat samples show that the cat also eats some vegetation i.e. twigs of Mryricaria and bushes (Tamaricaceae) (Wilson 2009). Snow leopards can kill animals more than three times its own body weight (McCarthy and Chapron 2003; Schaller 1977) and kills the prey species with the bite on their nape or throat (Wilson 2009).

2.4. Site occupancy sign surveys

2.4.1. Data collection

Site occupancy sign surveys were conducted to identify areas occupied by carnivores, especially snow leopards. Snow leopard sign surveys are facilitated by snow leopards' marking behavior and tendency to leave signs, such as scrapes, scats, scent spray, urination, claw raking and cheek rubbing (Fig. 4). Among these, scraping and scent spraying are used most frequently for marking (Jackson and Hunter 1996).

Scent spray is mostly related to sexual activity during mating season to attract females for copulation (Rieger 1978). According to Macdonald (1980) scent spray is a mixture of urine and glandular secretion. Both males and females use scent marks, but marking is more common in males (Blomquist 1982). Rock faces are preferred for scent sprays and tree trunks for claw raking (Fox 1989; Jackson 1996; McCarthy and Chapron 2003). Cheek rubbing on scent marked vertical surfaces spreads the scent (Rieger 1978).

Scrapes are the most reliable signs to identify the presence of snow leopards in a given area (Ahlborn 1988). Loose soil and gravel are scraped with the hind feet, usually into a small pile. A scrape is normally 20 cm in pit length, 19 cm in pit width and 5 cm in pit depth while a 6 cm high pile of material (Fox 1988). This pile is then sometimes urinated on and feces can also be deposited on it or nearby. Sign is applied on frequently used routes and near prominent features, such as around large boulders, saddles, cliffs, ridgeline, river beds, slopes and at the bends of trails (Ahlborn 1988; Schaller 1977). The tendency of leaving sign is also effected by various

Figure 4. Examples of snow leopard marking behaviour identified during surveys within CGNP and KNP in 2009 and 2010. Figure (a) showing snow leopard scat sample, (b) pugmark and (c) scent spray found in Chitral Gol National Park, while figures (d), (e) and (f) show scrape sign observed during occupancy sign surveys in Khunjerab National Park.

biological and environmental factors, including the structure of the availability of suitable substrate, social status, and time of year, and reproductive status of females (Jackson and Hunter 1996).

Sign surveys in KNP were conducted in November/December, 2010. The study area i.e. 50031 km^2 was divided into 50, 10x10 km^2 cells. After an initial training and calibration period, sign surveys were conducted by 3 teams of 3-4 people. We walked through areas that constituted potential snow leopard habitat and concentrated on terrain features that were likely to be used for sign deposition (ridgelines, saddles, broken and rocky terrain, cliff bases along streams or trails and well defined valleys). Terrain brokenness was categorized like broken (1), slightly broken (2), moderately broken (3) and very broken (4). Terrain brokenness means the land surface broken by irregular slopes, rocky outcrops, gullies, cliffs and well formed mountain slopes and ridges (Jackson and Hunter 1996). Upon finding snow leopard and other carnivore sign, the following information was recorded: latitude, longitude, elevation, vegetation type, topography, terrain brokenness, and substrate. Odometer reading was also noted on a GPS to determine the total length of surveyed point. A point is of 100 m length with 50 m radius. Whenever a scrape/sign was identified, we moved at least 50 meters along transect before beginning the search again. During survey, if many scrapes were found within 100 m, then we considered only the fresh sign and skipped the older ones. If all scrapes were fresh, we considered only one. The intention was to get the standard “1” (detection) and “0” (non detection) to analyze the data (MacKenzie et al. 2006).

Due to the ruggedness of the area and access limitations only 15 cells were surveyed. Within each cell, we typically explored 10-12 points for presence, with points at least 100 m apart.

The age of sign found was categorized as very fresh (moist, ≤2 days old), fresh (soft, >2 & ≤7 days old), old (hardened, >7 & <30 days old) or very old (hard, disintegrating, >30 days old) (McCarthy et al. 2008). The protocol was designed to rely only on fresh signs (<7 days) for the presence of snow leopards. The protocol was developed by the Snow Leopard Trust (SLT) and (McCarthy et al. 2010).

2.4.2. Data analysis

I used PRESENSE 2.1 (Hines 2006) occupancy model for estimating presence and absence of snow leopards and other mammals in the study areas. The standard occupancy model is based on two parameters i.e. (ψ) "Psi" and "P". Psi means the probability that the given area is occupied by a given species and "P" is the probability of detecting the species in given area if it is present (Karanth et al. 2011). We used single-season occupancy models, because the survey was conducted just once. We constructed capture histories for each survey site in such a way that we can estimate detection probabilities that are less than one. Two covariates i.e. ridge and area was used to find out what affects the detection probability or occupancy. I tested a series of candidate models and selected the top model as the one with the lowest Akaike Information Criterion (AIC) value (Khorozyan et al. 2008).

Two predefined models considering *P* as a constant for 1 group i.e. carnivores, were run for both scrapes and all combined fresh (<7 days) snow leopard signs to estimate presence and occupancy of snow leopards in KNP. We focused our analysis mainly on fresh scrapes because they are most reliably identified as snow leopard sign. Although the variable "survey" had no significant effect on detection probability, we kept using in all models because it was controlling for significant differences between study areas and cameras.

2.5. Camera trapping in KNP

Camera trapping in KNP was conducted in December2010 to January 2011, immediately after conclusion of the sign surveys. Ten suitable sites for camera trap stations were identified based on the sign surveys. Each site was monitored with paired automatic cameras (motion-triggered digital or non-digital) facing each other on both sides of trail to capture both sides of animal species. Two types of passive infrared cameras (CamTrekker^{TM} Ranger, Wattkinsville, GA, USA) and (Reconyx^{TM} HC500, Hyperfire^{TM}, USA) were used. CamTrekker is a non-didgital camera system and Reconyx cameras are digital. Both systems are triggered when a moving animal with a higher body temperature than the ambient temperature crosses the camera detection zone. Camera traps were set at trail mode for one second interval and in one shot 3 photographs are taken. There was a set 14 CamTrekker cameras and 6 Reconyx cameras. For CamTrakker, 8 cameras were lure based and six were without any lure treatment. Similarly, for Reconyx, 2 cameras were lure based and 4 left without any lure. Lure was used in random fashion and re-baited after one week with the same lures. Each camera station was randomly assigned to one of the three treatments: 1) no scent lure (control, 10 camera stations), 2) plaster tablet soaked in fish oil + skunk (*Mephitis mephitis*) based (Blackie's Blend Magnum-Call lure, F & T Fur Harvester's Trading Post, USA) commercial trapping lure (4 camera stations, and 3) plaster tablet soaked in fish oil + beaver (*Castor canadensis*) based (Kaats Brothers Evanescence Lure, F & T Fur Harvester's Trading Post, USA) commercial trapping lure (6 cameras stations. Camera stations were not relocated, due to the harsh climatic conditions and limited accessibility. Camera stations were set at least 1 km apart to minimize spatial autocorrelation and achieve greater geographic coverage. At designated camera stations, commercial trapping lures (gland based) were applied in a small quantity that act as a long-distance attractant and the plaster tablet soaked in fish oil was placed within the cameras' view (3-6 m from the cameras) as a short-range attractant. Camera stations remained active for one month (McCarthy et al. 2010). Typically (non-digital) camera stations were inspected every 7-10 days to assure proper functioning, collect potential images taken, and to replace lures and the plaster tablet if required.

2.5.1. Camera trapping in Chitral Gol National Park (CGNP)

Camera trapping in CGNP took place during October/November 2009. The methods and lure treatments were almost identical to the KNP camera trapping. Therefore we pooled the data of the sites to increase sample size. In CGNP, 20 camera stations were set in areas with likely carnivore presence. At each site, one camera (camTrekker^{TM}) was deployed instead of pairing (camTrekker^{TM} + Reconyx), used in KNP. Camera traps were set at least 1 km apart from each other throughout CGNP, although this was not always possible due rugged terrain and limited accessibility. Camera stations were visited to check the functioning of cameras and to re-bait after every 3-9 days.

2.5.2. Data analysis

I used logistic regression models to test whether the probability of capturing carnivores with camera traps was affected by station treatment (scent lure vs. no scent lure) and several other covariates. The other covariates included: vegetation, topography, terrain brokenness and substrate. I compared 5 candidate models and selected the top model based on AIC value. The covariate "survey" (KNP vs. CGNP), was included in all candidate models, to account for differences between the surveys (digital vs. analogue cameras, etc.).

3. Results

3.1. Snow leopard occupancy in KNP

The presence of snow leopard, brown bear, Indian wolf and red fox was confirmed based on sign. For snow leopard, scrapes were the most abundant sign (145, 73%) followed by scats (28, 14%; Fig. 5). We also found signs of endangered ungulate species in KNP, such as Marco Polo sheep and blue sheep. During sign surveys, 130 out of 151 points had snow leopard sign. Snow leopard sign was detected in 14 of 15 cells and a total of 198 snow leopard signs (scrapes, scats, pugmarks and scent sprays) were recorded. It was observed that KNP_01 (Dhee) had the highest no. of signs (20) as compared to other grid cells.

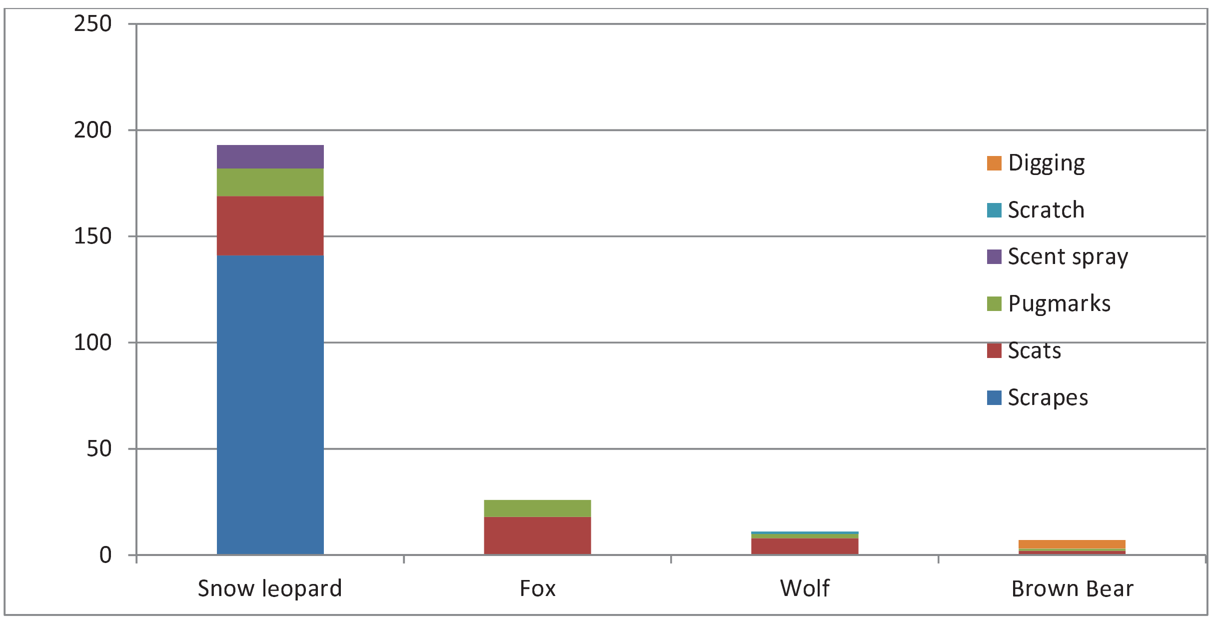

Figure 5. Frequency of different sign types detected from 4 carnivore species during occupancy sign surveys in Khunjerab National Park, November-December 2010.

The density of snow leopard sign was associated with certain topographic characteristics, e.g. most scrapes were associated with valleys (Fig. 6). Snow leopards also showed a strong correlation with vegetation and preferred scrub vegetation to inhabit because 52 signs were recorded at scrub (Fig. 7). We found snow leopard signs at elevations ranging from 3101 m to 4499 m.

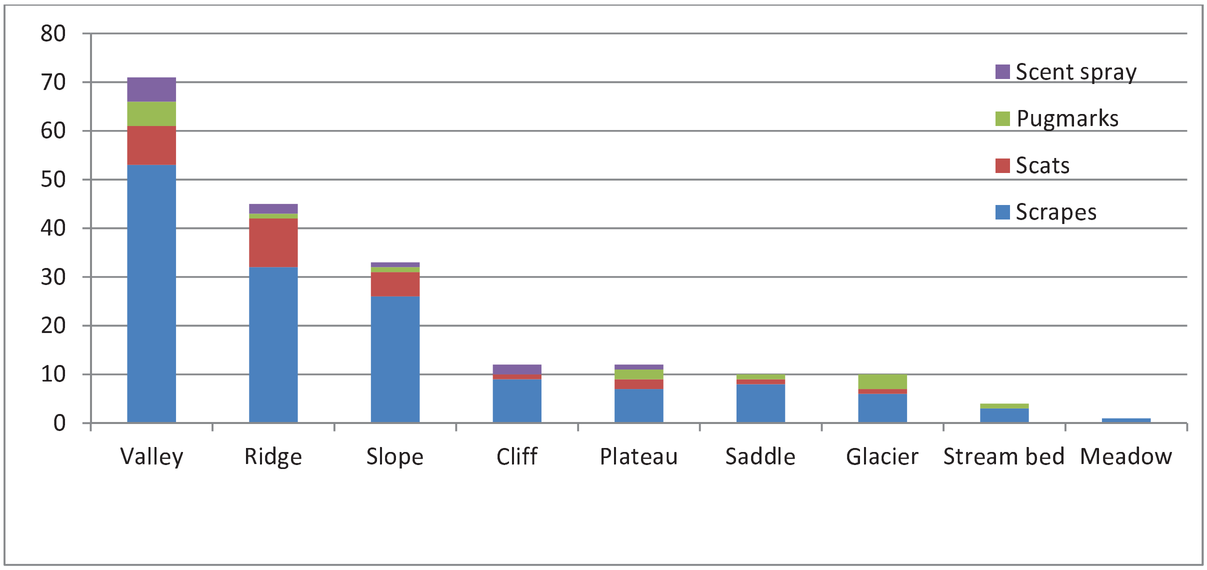

Figure 6. Relative frequency of snow leopard sign types detected in association with different topographic categories during occupancy sign surveys in Khunjerab National Park November-December 2010.

The results of occupancy models indicated that the detection probability (*P*) of snow leopards, based on fresh scrapes, was 0.600 (S.E. 0.100) and for all combined fresh signs the estimate was 0.646 (S.E. 0.041). Occupancy (ψ) for snow leopards in the area was estimated to be 0.855 (S.E. 0.043), based on scrapes and 0.849 (S.E 0.100) for all combine fresh signs (Scats, scent spray, pugmark) other than scrapes. I compared 16 alternative occupancy models against snow leopard scrape signs (<7 days) and an equivalent set for all combined signs (<7 days) (Table 2).

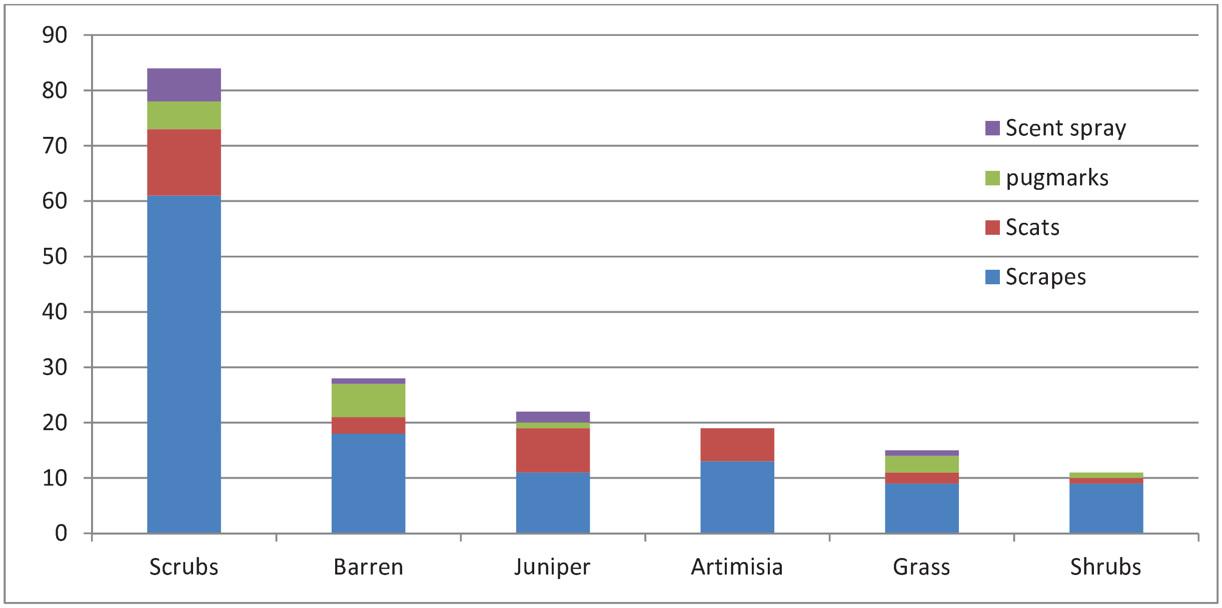

Figure 7. Relative frequency of snow leopard sign detected in different vegetation habitat categories during the occupancy sign surveys in Khunjerab National Park, November-December 2010.

The top model based on fresh scrapes and other fresh signs indicated that two covariates i.e. ridge and area as a various combinations had some effect on occupancy (ψ) estimates and detection probabilities (*P*) of snow leopards. When the models were run using only fresh scrapes, the top model (AIC= 156.99) was "psi(.),p(ridge)" (Table 1). The parameter estimate for ridge in this model was -7.105 (S.E. 1.1989), suggesting a strong negative impact on the detection probability. Therefore, likelihood of detecting scrapes on ridge is low. When models were run using “all combined fresh signs”, the top model (AIC= 145.74) was again "psi(.),p(ridge)" (Table 2). The ridge (-7.686, S.E. 1.219060) had strong negative impact on detection probability.

3.2. Camera trapping results

KNP Camera trapping was carried out for 31 days from 4 December 2010 to 3 January 2011 in KNP. Only six digital cameras were active and functioned properly throughout the study (i.e. 30

Table 1. Summary of various models run using all snow leopard fresh scrapes (<7 days) to estimate the effect of different site covariates (e.g. ridge and area) on detection probability (P) and occupancy (Psi) of snow leopard using PRESENCE 2.0 software in Khunjerab National Park, 2010**.**

Model	AIC	ΔAIC
"psi(.),p(ridge)"	156.99	0.00
"psi(area),p(ridge)"	165.11	8.12
"psi(.),p(area)"	175.45	18.46
"psi(area),p(area)"	180.29	23.30
"psi(ridge),p(area)"	185.29	28.30
"psi(.),p(.)"	193.67	36.68
"psi(area), p(.)"	196.16	39.17
"psi(ridge),p(.)"	201.03	44.04

Table 2. Summary of various models run using all snow leopard fresh signs (<7 days) to estimate the effect of different site covariates (e.g. ridge, valley and area) on detection probability (P) and occupancy (Psi) of snow leopard using PRESENCE 2.0 software in Khunjerab National Park, 2010.

Model	AIC	ΔAIC
"psi(.),p(ridge)"	145.74	0.00
"psi(area),p(ridge)"	147.74	2.00
"psi(ridge),p(area)"	161.21	15.47
"psi(.),p(area)"	169.84	24.10
"psi(area),p(area)"	169.97	24.23
"psi(ridge),p(.)"	178.77	33.03
"psi(area),p(.)"	187.50	41.76
"psi(.),p(.)"	187.61	41.87

days on average). These 6 functioning cameras recorded a total of 934 photographs (between 29 and 318 photos per camera). Captures included 606 images of snow leopards, 215 images of red foxes, 11 images of wolves, 29 images of hares, 5 images of pikas *(Ochotona princeps)*, 2 images of Himalayan stone martens *(Martes foina)*, 49 images of ibex and 17 images of birds (Fig. 8). Overall camera trap success rate for all species was 0.051 per 100 trap nights.

We excluded 52 empty photos and 3 photos of humans while setting the cameras and rebating.

Among 14 analog cameras, only 4 remained active for an initial couple of days and gave a few images and the remaining cameras failed to record photos. They recoded 1 image of livestock, 4 of fox and 3 images of ibex. It is generally believed that non-digital cameras do not have long-lasting batteries and they also do not function properly under cold climatic conditions. In KNP sometimes the temperature was dropped down to -12^{0}C. Camera traps did not detect brown bears, a known carnivore's species on the study area. Due to improper functioning of cameras it was difficult to calculate the number of days non digital cameras were active, so the detected success rate for non digital cameras could not be determined.

The most commonly photographed carnivore was the snow leopard (64% of the photographs) followed by the red fox (23% of photographs). In one capture event, 1 female snow leopard was detected playing with her two cubs (Fig. 9).

CGNP Using 20 analogue cameras during October 2009 in CGNP, a total of 25 photos (between 1 and 10 photos per camera) were made, including 10 of golden jackal, 9 of red fox, 1 of leopard cat, 1 of an un-identified carnivore (possibly a golden jackal or the result of a hybridization with a domestic dog), 2 markhor, 1 hare and 1 bird.

No snow leopard was trapped in CGNP. Only non-digital cameras (camTrekker) were used in CGNP and all remained functional throughout survey (23 days on average). Overall the camera traps success rate was 0.00053 per 100 trap nights for all species combined.

3.3. Regression results

We accepted a p value of 0.05 to consider that a regression model was statistically significant (at $P<0.05$). Various models with different variables were run to estimate the effect of lure for predators and canid species, but none showed significant effect except for canid species. It is possible that the small sample size was too small for other predators to obtain a significant difference. It was especially smaller for the snow leopard because no snow leopards were detected in CGNP in the 2009 survey, but they were detected in the KNP survey in 2010-2011.

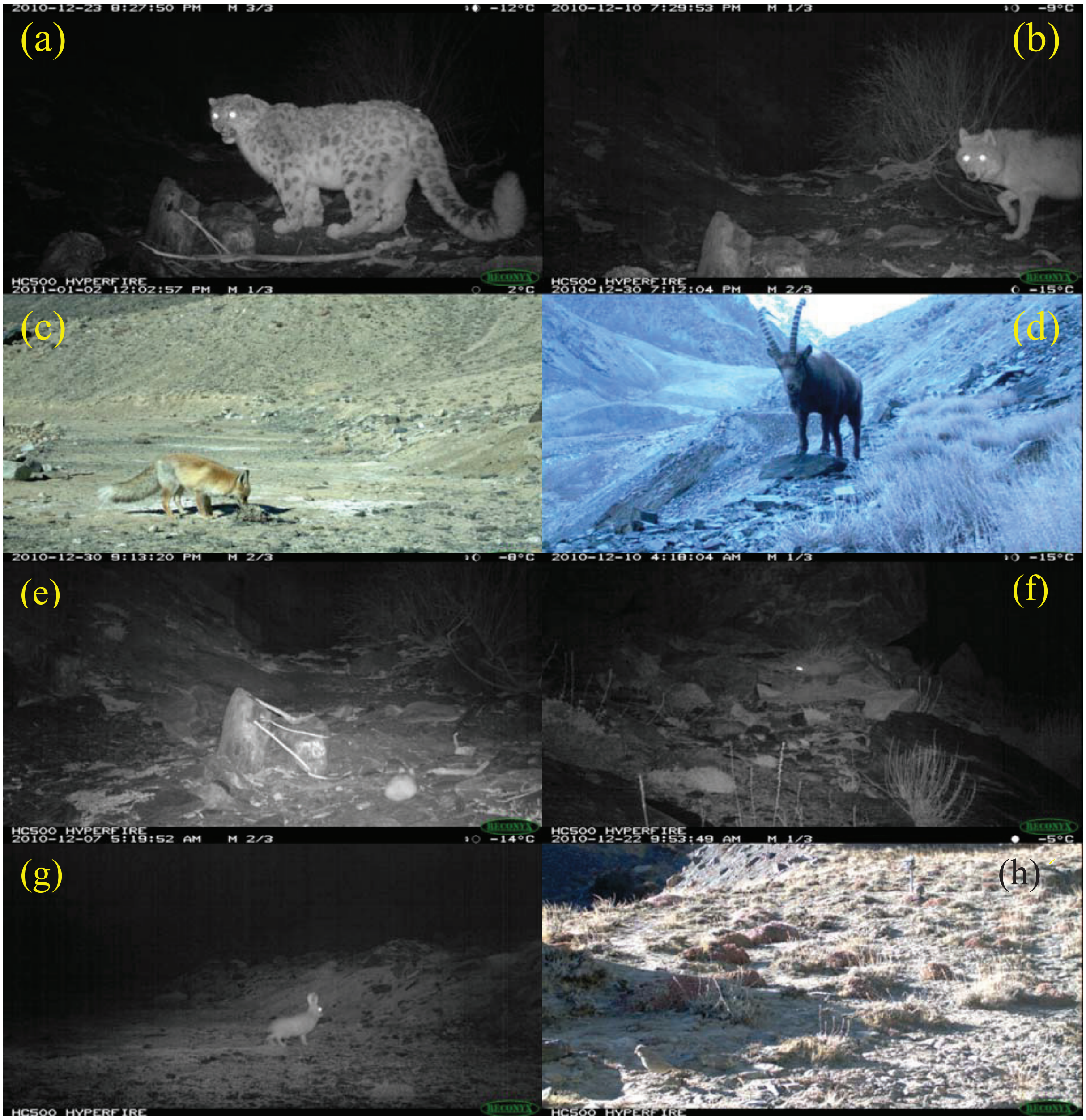

Figure 8. Examples of animals detected while camera trapping in KNP 2010. Photo (a) indicates, a snow leopard captured in Dhee Augh Valley, (b) indicates a wolf detected in Karchanai Valley, (c) red fox detected in Patkishk, (d) ibex detected in Patkishk, (e) pica detected in Karchanai, (f) stone marmot detected in Dhee Augh, (g) hare detected in Patkishk, (h) bird detected in Dhee Sar.

Figure 9. Both photos (a) and (b) indicate 1 female photographed with two cubs at SLF-5 digital camera traps above 3410 m in KNP (Karchnai valley 2010).

Since we have many factors that can influence over the response(s), which include lure, survey, treatment and ungulate detected. We have used a stepwise model selection approach for selection of best model. Different models together with AIC and adjusted AIC values are presented in (Table 3). We found the adjusted AIC i.e. ΔAIC for all the models that is less than 2, which indicates all models are equally explanatory. From this we have chosen the model with canid response and having lure, survey and ungulate detected explanatory variables, this is perhaps more informative model. The fitted model is presented here: Canid detected ~ Lure + Survey + Ungulate detected

Table 3. Logistic regression models developed to assess the effect of various variables on canid species detected while camera trapping in CGNP and KNP in 2009 and 2010-11. However another variable especially "predators detected" was also included but it has no significance effect on detection.

Model	Response	AIC	ΔAIC
Predators ~ Lure + Survey	Predators detected	30.65	0.00
Lure + Survey	Canid detected	31.47	0.82
Treatment + Survey	Canid detected	31.97	1.32
Lure + Survey + Ungulate detected	Canid detected	32.36	1.71
Lure * Survey	Canid detected	32.46	1.81

The fitted values from above model are presented in (Table 4), indicating on the average model performance where explanatory variable is taken as significant ($P<0.05$), while Lure True and Survey KNP also have significant impact in explaining variation of response ($P<0.1$). Ungulate detected True has no significant impact in explaining the response variation.

Table 4. Coefficients description of the fitted model with respect to the significance.

Coefficients	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-2.578	1.170	-2.203	0.0276 ($P<0.05$)
Lure True	2.342	1.248	1.877	0.0605($P<0.1$)
Survey KNP	2.772	1.637	1.693	0.0904 ($P<0.1$)
Ungulate Detected True	-1.868	1.898	-0.984	0.3252

Due to the small sample size (26 cameras, 2 studies), I considered only logistic regression models with a limited number of variables. “Lure” (with vs. without) and “survey” (KNP vs. CGNP) were retained in the final model. Camera stations with lures had a greater probability of capturing photos of carnivores than stations without lures (beta=2.351, se=1.187, z value =1.980, p=0.0477) (Fig. 8). The effect of study was not significant (beta=1.918, se=1.278, z value=1.501, p=0.1332), but was retained in the model to control for differences between study areas (study year, geographic location, use of digital vs. analogue cameras, etc.).

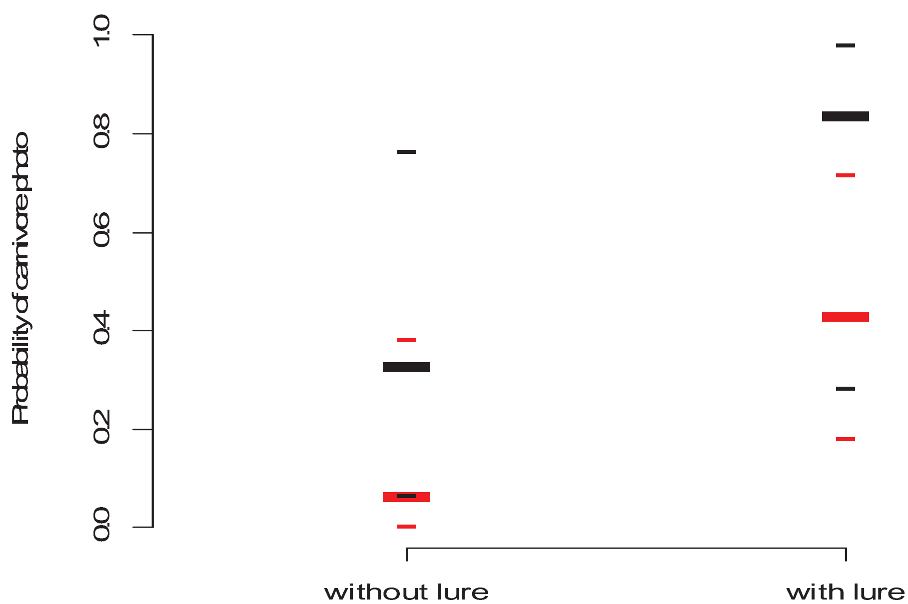

Figure 10. Probability of photo detection in relation to lure and without lure for carnivores in CGNP and KNP in 2009 and 2010. Red color represents CGNP camera trapping and black color indicates KNP camera trapping output. Each bar represents different species.

4. Discussion

4.1. Sign surveys and camera trap results discussion

The purpose of my research was to document the presence of the snow leopard and test the effect of scent lures in KNP and CGNP. Our results documented snow leopard sign and photographs from KNP but not from CGNP. The snow leopard's occupancy (ψ) in KNP was 0.849 close to "1" and detection probability (*P*) was 0.646. Many snow leopard signs were identified in KNP; among those scrapes was the most abundant (36%) sign. Also Fox (1989) found scrapes to be the most frequent snow leopard sign encountered in Central Ladakh, India. Ahlborn and Jackson (1988) also claimed that scrape signs are the most reliable sign for snow leopard presence. We may have found many scrapes because our study was conducted in the breeding season when snow leopards scrape sites regularly. After the breeding season the scrape frequency may be lower.

We ran various logistic regression models to determine the effect of different site co-variables on occupancy (ψ) "Psi" and detection (*P*) of fresh snow leopard signs (<7 days). The results demonstrated that both "area" and "ridge" have a combined effect on both occupancy and detection probability of snow leopard. It showed a positive effect of valley on occupancy and negative effect of ridge on detection probability. Therefore we conclude there is a greater chances that snow leopards are present in valleys but less detection is may be a result of inexpert observers. The negative results for ridges means that snow leopards are less likely to be present in ridge habitat but they still may have been present and not detected.

Our sign surveys indicated that it was a useful non invasive technique to obtain presence/absence data for low-density carnivores, especially the snow leopard. In the same way, successful sign surveys have also been carried out in Himalayan regions i.e. Pakistan, Nepal, Mongolia and India to determine snow leopard potential presence and absence habitat (Fox et al. 1991; Jackson et al. 2006). A few sign surveys also have been conducted in Big Pamir Wildlife Reserve, Wakhan, Afghanistan. There, successful sign surveys confirmed snow leopards were present in 10 valleys out of 11 surveyed (Habib 2006).

Our results show that camera traps are a viable technique to document the presence of individually recognizable species of rare mammals, as did McCarthy et al. (2008). We recoded many photographs of large and even small mammals. The snow leopard was captured more than all other species in KNP i.e. 606 (64%). (Jackson et al. 2006) used camera traps in Hemis National Park, India and recommended that it was a useful tool for snow leopard monitoring. In the Gobi Desert of Mongolia, camera trapping was used successfully to survey snow leopard (Janečka et al. 2011; McCarthy et al. 2010).

4.2. Hypothesis of using scent lures

Scent stations survey results should be considered to be preliminary, because of a limited number of scent stations functioning and small sample size. Logistic regression findings revealed that scent lure increased the no. of overall carnivores that were detected, and specifically canid species were detected both in KNP and CGNP survey areas. It confirms our hypothesis and applications of scent lure for predator detection. Also (Harrison 1997; Thorn et al. 2009) found that scent stations were effective to attract more visits by carnivores. Similarly also agreed that scent lures improve the detection rate of carnivores. Moreover, Sargeant et al. (1998) argued that a scent station is a suitable technique to detect wide-ranging and rarely observed carnivores.

Baited or scent camera stations are used to analyze habitat use, population estimation and distribution of low density carnivores (Harrison 1997). Using attractants entices the carnivores to visit scent stations for reasons that may include as hunger, sexual concern and curiosity. These lures attracts mammals towards camera stations and camera stations capture history contributed to affirm that scent station surveys are an effective tool for carnivore monitoring and conservation (Sargeant 1998). It is difficult to compare the efficiency of various baits for different species and types of field methods (McDaniel et. al. 2000). In some studies the scientists compare between food baits and scent lures and described that food baits are more efficient to attract mammals compare to the scent lures. Scent lures showed some results that are similar to ours not to attract felid species but towards canid species their results were opposite to ours and did not respond well for canid species (Espartosa et al. 2011). In another study, Mortillity and Boitani (2007) also used attractant for red foxes but it visited the scent stations only for few times inspite the abundance of red fox in the study area but Travaini et al. (1996) tested sent lures successfully for red fox and got more visits at scent stations.

In our study, we were targeting carnivores' more visit rate towards lure response but it showed only positive response to canid species rather than for overall carnivores. Our results contrast to some other studies like Thorn et al. (2009) studies; the lure based camera station significantly increase carnivores visits especially for targeting species i.e. hyena. Similarly another research demonstrated that using various lures, it attract more carnivores visit rate (McDaniel et. al. 2000). So it is concluded that some studies show similar results to ours and some opposite to ours. The variation in results may be due to difference in habitat conditions, targeting species and lure type used.

The possible variation in relationship of lure usage with predators' detection may involve some of potential reasons i.e. difference in habitat conditions, targeting species and lure type used.

The difference in results from KNP and CGNP suggests that detection and presence are not the same. According to Royle and Nicholes (2003) findings, it is also possible that the probability of detection is not always constant, because of differences in habitat, seasonality and predators' abundance etc. Similarly, in our studies, there might be many reasons for the difference, but it is possible that in KNP only 2 scent stations worked properly to capture predators. Moreover, some other factors may have influenced the results. We successfully documented abundant predators in the 2010 survey of KNP but fewer during 2009 survey in CGNP. It is possible that in CGNP, there are fewer predators compared to KNP. Similarly, the difference in number of images in both areas may be due to the biased survey and efficiency of cameras quality because in KNP some digital cameras have been used but not in CGNP. Habitat difference could also be important factor and KNP habitat may favors snow leopard. It is also firmly possible that snow leopard has reasonable population in KNP rather than in CGNP and also biased sign surveys for snow leopard may make it present in KNP.

4.3. General advantages and disadvantages of cameras

Using camera traps has some benefits and some problems. Major advantage of wildlife camera trapping over other techniques of tracking, trapping and direct observation is that it can record accurate data without capturing the animal even, when the researcher is not present in the field. This stored data is better than manually produced data by direct observations and can also be used for further research by other researchers (O'Connell et al. 2011). The problems include that it needs experienced technicians for installation and settings. The major issue involved is that data can be lost due to equipment failure itself. This can happen because of trigger mechanism failure to activate the camera or many photographs having no species image. Poor weather conditions, equipment damaged by the animals and badly engineered equipment also affect the performance of camera traps (O'Connell et al. 2011).

Our results indicated that cameras differ in their quality and capability to capture species. As we used paired camera stations to get maximum chances of getting animals photographs, but among pairs one of the cameras i.e. CamTrekker (non-digital) did not provide useful results to monitor carnivores, in spite of great efforts to set camera stations. Similar to Kelly and Holub (2008) studies, non-digital cameras' batteries don't work properly under severely cold temperature and in KNP, temperatures have low i.e. -12^{o}C. Only 4 CamTrekker remained active for a few days and provided few images. Camera traps did not detect brown bears; a known carnivore's species known to be in the study area.

It is also even harder to get information regarding non digital cameras because we did not know how many days they stayed active. Most problems were associated with the non-triggering of CamTrekkers. On the other hand, the other camera i.e. Reconyx camera performed brilliantly and provided hundreds of predator pictures. Reconyx performed as Kelly and Holub (2008) also reported and seemed to be more heat and motion sensitive, even to get images of small animals like pika and stone marten. During the whole survey, Reconyx had negligible malfunctions problems. These remarkable features of Reconys make it more attractive for scientists to use in rare and cryptic carnivores' studies in future.

4.4. Errors or limitations of our studies

There are various limitations associated with the implementation of my study. We have been more likely to find sign of mature male snow leopards rather than other age and sex classes, which has the biased occupancy estimates. If we try to find all signs even for cubs and females then there would be more chances for greater occupancy. During the surveys, only easily accessible cells have been explored that means that we didn't survey the study area representatively. Snow leopards probably use those unexplored cells and perhaps are even more abundant than explored areas. There might also be another factor of observers' difference in identifying signs. If observers fails to differentiate between snow leopard signs and other carnivores signs, than it would definitely affects the survey results. Utilization of non digital cameras was major drawback of this study. It certainly affected the results to test the hypothesis of lure response. Time selection of survey was also not suitable to get big sample size for data analysis and it caused less explored area.

4.5. What is new in our studies and future of our findings?

Our field work was the first to obtain photographs of a snow leopard and its family in Pakistan. Our study results can be used as the monitoring and presence of snow leopard on the basis of sign surveys and camera trapping. Camera trapping also distinguishes the individual species and can calculate the total no of individuals because of pelage patterns. These figures states the trend monitoring of snow leopard population status; either increasing or decreasing. This trend monitoring is a valuable method to know the status of snow leopard population and if its population is decreasing then it may create enthusiasm among management authorities to conserve its remaining population.

Both sign surveys and camera trapping can also be used for the presence of other wildlife and then ultimately for conservation status of the study areas biodiversity. Furthermore, this conservation can be used as a guideline to establish efficient management programs for endangered species i.e. snow leopard and ibex. It will definitely guide and help future researchers and scientists to reset camera stations at same locations where snow leopards have been captured. This future research can be used either for snow leopard population estimation or its habitat pattern variation in KNP. Successful sign surveys data can also be useful in further research for repeated survey to confirm the snow leopard presence. Digital cameras output is also significant to be used again in future research to detect individual species easily. Although sample size was limited, substantial results of lures to attract canid species indicates that it can also be used for further research on canid species.

4.6. Suggestions relevant to my research to improve

Occupancy sign surveys and camera trapping are effective tools for snow leopard monitoring and conservation. The availability of high-quality digital cameras allows camera trapping to be implemented at large spatial-scales for the observation, monitoring and conservation of snow leopard. Jackson et al. (2006) also suggested that camera trapping is a viable technique for snow leopard monitoring and conservation. Camera trapping provides baseline population demographic information and then this information is used for long term effectiveness of conservation measures. This data assures the identification of individual species with respect to their pelage patterns of all images obtained. For longer time study provides minimum no. of remaining individual and their residency time in study area. Capture data also easily identify known or likely present individuals vs. transient and dispersing individuals. Knowing the individual snow leopards and their abundance in the given area may promote the position of endangered species among stakeholders. These figures then ultimately give support for the management and conservation of this endangered carnivore, the snow leopard.

In the future, the use of non digital cameras should be avoided because it involves much effort and labor to set camera stations and if cameras do not function, than it affects the study results. Camera setting people must be trained properly to access and check the camera stations periodically so that camera performance can be improved. It is clear that two years data does not provide enough statistical power to detect predators' abundance. Therefore, repeated sign surveys and camera trapping is recommended to enhance the myth of predators presence especially snow leopard presence in both survey areas. Protecting the snow leopard being the flagship species; the entire ecosystem of the region can be protected.

5. Conclusion

It is concluded that both camera trapping and especially sign surveys are successful techniques to monitor snow leopard and other carnivores. Sign surveys discovered a lot of sign to confirm the presence of snow leopard and camera trapping produced solid proof for snow leopard presence. It presents that snow leopard occupancy is i.e. 0.855 (S-E 0.043) for fresh scrapes sign and for other fresh signs other than scrap the occupancy is 0.849 (S-E 0.100). The detection probability for fresh scrapes is 0.600 (S-E. 0.100) and for all other fresh sign the estimate was 0.646 (S-E. 0.041). Scent lures also indicated positive response to attract canid species but not for overall carnivores. The detection probability with respect to scented camera stations is higher than without scent lures. For future, these results are valuable in snow leopard monitoring. This data can also be used to evaluate the population trend of snow leopard. These capture histories then can be used for the conservation of snow leopard by knowing its individuals population.

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