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ORIGINAL ARTICLE

Carnivores' diversity and conflicts with humans in Musk Deer National Park, Azad Jammu and Kashmir, Pakistan

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Abstract Pakistan's northern expanses have rich diversity of mammalian carnivores, but majority of them are either threatened or endangered due to habitat degradation and conflict with humans. This study was conducted between May and June 2014 with the aim of determining the diversity of mammalian carnivores and their conflict with humans in Musk Deer National Park (MDNP), Azad Jammu and Kashmir (AJK). Forty motion-triggered cameras (Reconyx™) were installed in different watersheds of MDNP to determine carnivore species diversity. A human-carnivore conflict study was conducted through semi-structured questionnaires where 149 respondents were randomly selected from 18 villages in the park. A total of nine carnivore species were documented, namely snow leopard (*Panthera uncia*), common leopard (*Panthera pardus*), leopard cat (*Prionailurus bengalensis*), brown bear (*Ursus arctos*), Asiatic black bear (*Ursus thibetinus*), grey wolf (*Canis lupus*), red fox (*Vulpes vulpes*), stone marten (*Martes foina*), and yellow-throated marten (*Martes flavigula*). During the past year, a total of 817 livestock were lost to disease and carnivore predation. Carnivores were held responsible for 276 livestock losses which translated into an annual economic loss of USD 28,145 (USD 189 per household). Both Asiatic black bear and brown bear also damaged maize and potato crops causing economic losses of USD 16,330 (USD 110 per household). Depredation of livestock was greatly affected by four factors: prey type, season of depredation, location of depredation, and livestock guarding practices. Based on the responses, the people of Folwai village showed the most negative perception towards carnivores. Majority of the respondents declared grey wolf, brown bear, and Asiatic black bear to be the most dangerous carnivores in the park. Our results showed that MDNP has rich diversity of carnivores but their survival in the park is in danger due to conflict with humans over excessive livestock depredations and crop raiding. Active livestock guarding practices can reduce carnivore attacks. Educating local people, vaccinating their livestock, and compensating affected families can greatly reduce negative perceptions.

Keywords Carnivores · Camera trapping · Musk deer national park · Human-carnivore conflict · Livestock depredation

Introduction

Pakistan is home to 10 of 18 known mammalian orders, which reflects significant diversity matching overall trends (Sheikh and Molur 2004). The diversity of large mammals in northern Pakistan is high compared to other parts of the country, yet majority of these species is either threatened or endangered (Rao and Marwat 2003).

Neelum Valley in Azad Jammu and Kashmir (AJK), where two national parks (Ghamot National Park and Musk Deer National Park [MDNP]) are located, is known to have a rich diversity of large and small carnivores (Qamar et al. 2006). Although no empirical studies exist, the presence of thick forests, remoteness, low habitat degradation due to military presence, geographic location, and anecdotal evidence vouch for presence of a diverse carnivore guild in the area. The greater potential and lack of studies provided the motivation

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for this study; hence, the first study objective was to document the actual diversity of mammalian carnivores in the area.

Large carnivores are often considered keystone species, because as top predators, they play a role in regulating prey species, which in turn can potentially have significant impacts on habitats and other species via trophic cascades (Terborgh 2010; Ripple and Beschta 2012). Human-wildlife conflict is an emerging issue that has intensified with the passage of time. Many wildlife species have become threatened due to this conflict, especially large carnivores (Qamar et al. 2010). People living close to conflict areas possess negative attitudes towards carnivores and, as a result, make biodiversity protection a challenging task (Woodroffe et al. 2005). Large carnivores are more disposed to such conflicts due to two main factors: first, their large home ranges and food requirements overlap with humans (Linnell et al. 2001; Macdonald and Sillero-Zubiri 2002) and second, the killing of natural herbivore species by humans reduces the availability of natural prey resulting in attacks on livestock (Yalden 1993; Mishra 1997; Sillero-Zubiri and Laurenson 2001; Treves and Karanth 2003). Domestic livestock have no anti-predatory strategies, and carnivores are able to kill them with little effort (Vos 2000). Human-carnivore conflicts are exemplified by wolves (*Canis lupus*) in North America (Musiani et al. 2003), pumas (*Puma concolor*) and jaguars (*Panthera onca*) in South America (Mazzolli et al. 2002; Polisar et al. 2003), dingoes (*Canis lupus dingo*) in Australia (Allen and Sparkes 2001), hyenas (*Crocuta crocuta*) and lions (*Panthera leo*) in Africa (Patterson et al. 2004; Kolowski and Holekamp 2006), and snow leopards (*Panthera uncia*) in India and Pakistan (Hussain 2003; Jackson and Wangchuk 2004).

Human-carnivore conflicts have consequences both for wild carnivores and local communities. Human costs due to conflicts with carnivores are mostly in the form of economic losses to property and infrastructure, damage to crop, and depredation on livestock. Human-carnivore conflicts have large and unequal effects on pastoral communities because people living near carnivores tend to fall under the lowest income category. As a result, people have low tolerance toward carnivores, their conservation, and conservation of other non-conflict species. Humans often incorrectly identify offenders that cause the most losses (Naughton-Treves 1998; Linkie et al. 2007). Sometimes, large carnivores also attack humans causing injuries or even death (Conover et al. 1995; Packer et al. 2005; Lodhi 2007; White and Gehrt 2009). As a result of these losses, humans may take direct action against wildlife using poison, hunting, or shooting. Shooting and the actions of people depend on the tolerance level toward the damaging species (Frank et al. 2005).

There are limited studies describing human-carnivore conflicts in Pakistan (Dar et al. 2009; Din and Nawaz 2010, 2011; Bibi et al. 2013; Perveen and Abid 2013; Hameed et al. 2013; Kabir et al. 2014) despite wide prevalence of the issue, particularly in northern Pakistan where various large carnivores; common leopard (*Panthera pardus*), snow leopard, Asiatic black bear (*Ursus thibetinus*), brown bear (*Ursus arctos*), grey wolf, and lynx (*Lynx lynx*) often come into contact with humans and contribute to significant economic losses. The second objective of this study was to understand the nature and magnitude of human-carnivore conflicts and their bearing on both sides in the MDNP.

Materials and methods

Study area

MDNP (34.731456° N, 74.786682° E) is situated to the northeast of Muzaffarabad, the capital city of AJK. MDNP was legally notified in 2007 and covers an area of 52,815 ha. The elevation is in the range of 1942–4968 m above sea level. The park is located along the line of control (LoC) between Pakistan and Indian-administered Kashmir. Neelum River (Kishan Ganga River) enters MDNP from the east of Indian-administered Kashmir. There are 18 villages in the park (Fig. 1).

The maximum daily temperature varies from 20–30 °C during summer. The corresponding range for winter is 0–4 °C (Dar 2003). The area is outside the monsoon range and receives very little rainfall during summer. Precipitation usually occurs in the form of snowfall in winter. MDNP is rich in faunal diversity, and according to the Fisheries and Wildlife Department of AJK, mammal species found in the park include common leopard, leopard cat (*Prionailurus bengalensis*), brown bear, Asiatic black bear, grey wolf, red fox (*Vulpes vulpes*), yellow-throated marten (*Martes flavigula*), musk deer (*Moschus chrysogaster*), Kashmir stag (*Cervus Canadensis hanglu*), Kashmir marmot (*Marmota caudata*), and giant red flying squirrel (*Petaurista petaurista*).

Questionnaire survey

A survey was conducted in the communities residing in MDNP during May–June 2014 using semi-structured questionnaires. Overall 149 randomly selected households were interviewed from 18 villages, namely Taobut (15 households), Karimabad (9), Nikroon (4), Helmat (17), Shundas (2), Hunti (2), Sardari (6), Saonarr (5), Folwai (34), Marnat (11), Janwai (10), Buhi Nar (4), Dhooga (3), Jandar Seri (7), Chichal Mano (4), Jamghar (8), Dhaki (4), and Matchal (4). These households represent about 5 % of the total households within each village. Information was collected on household demographics, education, employment, livestock holdings, sightings, conflicts and perceptions of large carnivores. During the interviews, pictures of carnivores were shown in order to obtain reliable answers. The location of each

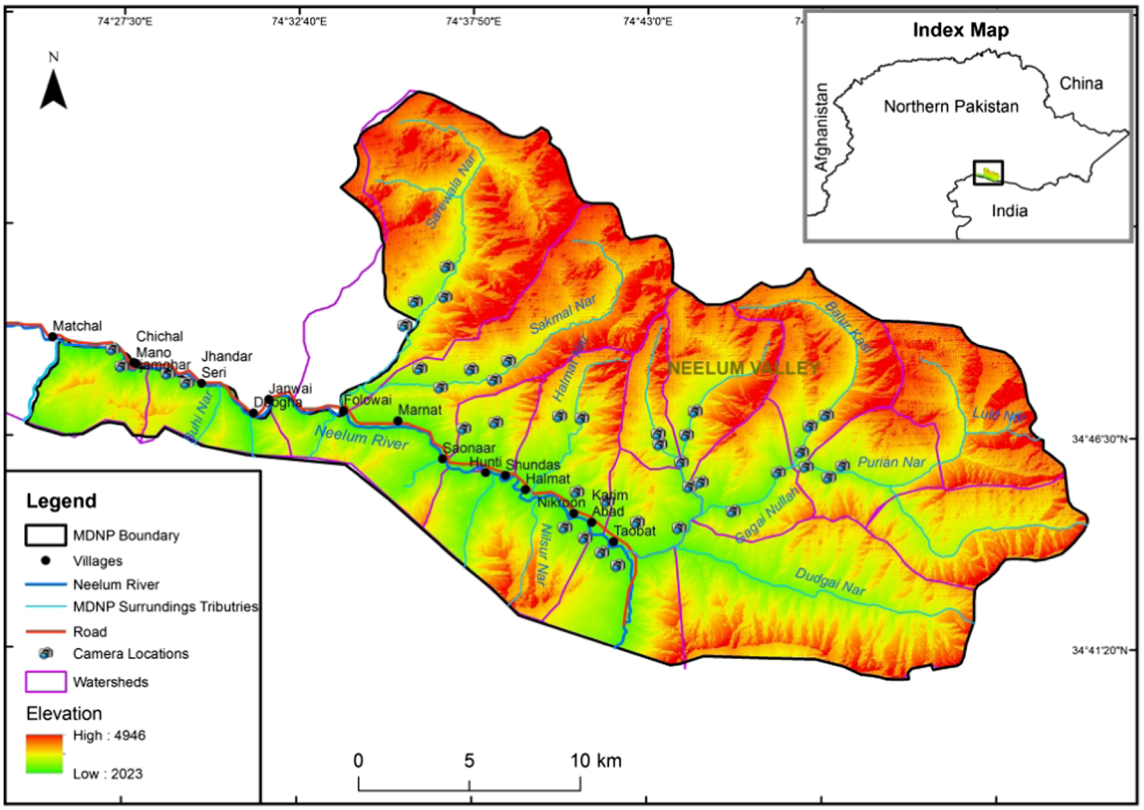

Fig. 1 Questionnaire survey sites (villages) and installed camera locations in MDNP

village was recorded and marked on a map (Fig. 1) using the global positioning system (GPS) (GPSMAP 62s Garmin).

Camera trapping

Camera trapping is being increasingly deployed to monitor shy and uncommon wildlife (Karanth and Nichols 1998; Jackson et al. 2006). The MDNP area was divided into watershed-based blocks having unequal size. Camera trapping was conducted during the period 10 May–26 June 2014. Forty motion-triggered Reconyx™ (HC500 HyperFire™ and PC900 HyperFire™; Reconyx, Holmen, WI, USA) cameras were deployed at different locations in different watersheds (Fig. 1).

Power to the cameras was supplied through nickel-metal hydride (NiMH) rechargeable batteries. The sites for camera installation were selected near tracks, scats, hairs, or other wild animal signs. A minimum aerial distance of 1 km was kept between the two nearest camera stations. Cameras were mounted on metal poles except for two that were fixed on trees. The height of each camera was kept at about 50 cm in order to capture small-, medium-, and large-sized animals. The cameras faced north or south to avoid direct sunlight (which could trigger false images). The camera sensors were placed such that there was no vegetation or grass in front of them as proposed in the previous studies (Jackson et al. 2006). Castor base scent lures were used (Bischof et al. 2014) to increase capture possibility and improve the capture of both flanks of animals (Guil et al. 2010). The lure was spread on stone or wood in front of the cameras. All of the cameras were set to take three consecutive photos after 1-s intervals each time they were triggered. The cameras' habitat, substrate, topography, terrain, altitude, and locations were noted on camera sheets. GPSMAP 62s Garmin was used for altitude and location reading.

Statistical analysis

Geographical information system (GIS) ArcMap10 was used to develop maps. Generalized linear models (GLMs) were run in R program (R-development core team 2013) in order to see the relationship between livestock depredation by carnivores and factors such as location, prey type, season, and whether or not livestock was guarded.

The perceptions of respondents were analyzed on the basis of village effect, respondents' age, household size, number of earning members, agricultural land, and domestic animals owned, using GLMs. Villages with less than 15 frequencies were merged to miscellaneous villages (groups of villages with less than 15 respondents) for GLM fitting. Fitting a statistical model requires sufficient amount of samples, i.e., respondents in our case. A small sample results in large variation in GLM model estimates, which makes the model estimation

unreliable. This problem is usually solved by merging small groups, which eventually introduces bias. As a result, there is variance-bias trade off; a small amount of bias is accepted to avoid large variations in parameter estimates. Other parameters like age, household size, earning members, agricultural land, and livestock owned were divided into two categories, 1 and 2 (Table 1).

Results

Carnivore diversity

Public sighting reports

A total of 149 locals were interviewed to document sighting records of large carnivores (snow leopard, common leopard, grey wolf, brown bear, Asiatic black bear, and lynx) in the area. Average annual sightings of Asiatic black bear were the most frequent followed by grey wolf and brown bear (Table 2).

Respondents had mixed views regarding the status of large carnivores. The majority (82 %) considered Asiatic black bear a common species in the area. Grey wolf and brown bear were also thought to be common in the area by 72 and 68 % of respondents, respectively. Snow leopard and common leopard were believed to be rare in the area by 50 and 36 % of respondents while 48 % thought lynx was absent from the area.

Photo-capture record

Four of the 40 deployed cameras were stolen. The cameras remained active in different watersheds for 1025 trap nights (trap nights were calculated from the time cameras were mounted until the date of the last photo or when the cameras were removed). During this period, 85,135 photos were recorded which included mammals, birds, humans, livestock, and false photos. Seven carnivore species were photo-captured, belonging to four families, namely felidae, ursidae, canidae, and mustelidae (Fig. 2). Felids captured in the photos included snow leopard and leopard cat. The ursidae family was represented by brown bear, canidae by grey wolf and red fox, and mustelidae by stone marten and yellow-throated marten (Table 3).

Table 1 Categories of various parameters used in GLM

Parameters	Category 1	Category 2
Respondents' age	<34	≥34
Household size	<7	≥7
Earning members	1	>1
Agricultural land	<5 kanals	≥5
Domestic animals	<20	≥20

Human-carnivore conflict

Livelihood system in MDNP

The livelihood system in MDNP is predominantly agro-pastoral where livestock plays a crucial role. Surveyed households ($n = 149$) reared a total of 2547 livestock with an average herd size of 17.09 (range 1–71) per household. Sheep accounted for the largest percentage of livestock (37.42 %), followed by cattle (31.10 %), goat (27 %), and others (yak, horse, donkey, and mule) (4.79 %).

In 2013, 149 respondents sold 287 livestock for PKR 3,081,400 (USD 30,814) which yielded an average annual income of PKR 20,700 (USD 207) per household.

Livestock depredation and economic valuation of loss

The respondents reported 817 livestock losses to depredation and disease during the previous year. Carnivores were held responsible for 276 livestock losses while disease accounted for 541. Snow leopard was blamed for 88 (31.9 %) livestock losses. Common leopard, grey wolf, brown bear, and Asiatic black bear predated on 18 (6.5 %), 51 (18.5 %), 72 (26.1 %), and 47 (17.0 %) heads of livestock, respectively. No lynx-related depredation was reported. The most favorable prey species for snow leopard was sheep (45 % of snow leopard hunt) followed by goat (32 %), others (17 %), and cattle (6.0 %). Common leopard's prey species consisted of goat (50.0 %), others (39 %), and cattle (11 %). Grey wolf prey species were sheep (75 %), goat (24 %), and cattle (1 %). Most favorable prey species for brown bear was sheep, which accounted for 63 % of its total killings. Other prey species were goat (25 %), cattle (8 %), and others (4 %). Asiatic black bear predated on sheep and goat (40 % each), cattle (13 %), and others (7 %).

The reported figure of 817 livestock losses constituted an economic loss of PKR 8,890,100 or USD 88,901 (PKR 59,665 or USD 597 per household) to 149 households. Of the total loss, carnivores were blamed for an annual economic loss of USD 28,145 (USD 189 per household per year) while disease contributed an annual loss of USD 60,756 (USD 408 per household per year) (Table 4).

Respondents also reported crop damage by the two bear species in 2013. The annual economic loss incurred was PKR 1,633,000 or USD 16,330 (PKR 10,960 or USD 110 per household per year). Bears were the only carnivores responsible for crop damage, attacking crops in autumn when maize and potatoes are fully grown. Brown bear crop damage caused a loss of PKR 84,000 or USD 840 (PKR 564 or USD 6 per household per year). The corresponding figure for the Asiatic

Table 2 Reported sightings of carnivore species in MDNP, AJK, Pakistan, in 2013

Carnivores	Total annual sightings	Average annual sightings per respondent
Asiatic black bear	489	3
Brown bear	256	2
Common leopard	47	0.32
Grey wolf	270	2
Lynx	30	0.2
Snow leopard	74	0.5

black bear was higher; PKR 1,549,000 or USD 15,490 (PKR 10,396 or USD 104 per household per year).

Factors affecting livestock depredation

The top GLM model (Table 5) suggested that livestock depredation was influenced by four factors: prey type, season of depredation, location of depredation, and livestock guarding. Depredation of others, sheep, and goat were 3.77, 2.52, and 2.22 times higher than that of cattle (Table 5). The highest depredation was in summer (1.90 times higher than autumn) while lowest depredation was recorded in winter. Depredation of livestock in pastures and villages was 2.74 and 1.06 times less than depredation of livestock in forests, respectively. Depredations of livestock were four times higher when not guarded.

The interaction between type of prey and livestock guarding indicated inconsistent effect of guarding practice

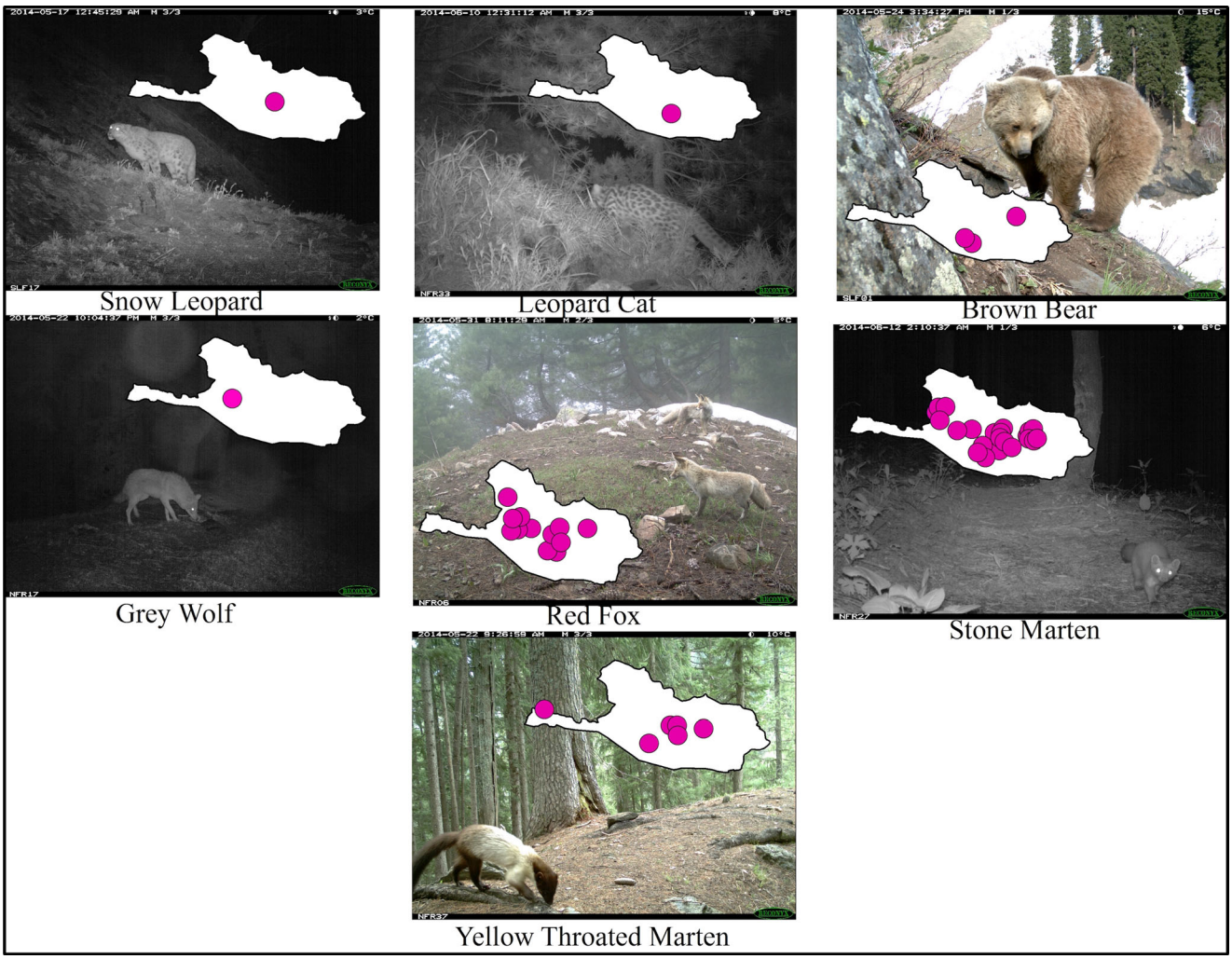

Fig. 2 Spatial distribution of photo-captures of carnivore species in MDNP, AJK. The *pink dots* represent successful captures

Table 3 Photo-capture details of carnivore species in MDNP, AJK, Pakistan, in 2014

Family	Species	Capture stations	Capture events[a]	Capture rate[b]	No. of photos	Percentage
Felidae	Snow leopard	1	1	0.1	21	2.0
	Leopard cat	1	1	0.1	3	0.3
Ursidae	Brown bear	3	7	0.7	118	11.2
Canidae	Red fox	12	64	6.2	623	58.9
	Grey wolf	1	1	0.1	4	0.4
Mustelidae	Stone marten	23	56	5.5	219	20.7
	Yellow-throated marten	6	13	1.3	69	6.5
Total					1057	100

[a] Where we captured an individually identifiable animal (McCarthy et al. 2008)

[b] No. of different, identifiable individuals' captured/100 trap-nights (McCarthy et al. 2008)

on livestock groups. Predation on goats and others is higher than cattle in general; however, when guarded, predation declined to half of that in cattle. Contrary to goats, predation on sheep did not appear to decline much with guarding.

Consequences of conflict for carnivores

The perception of locals regarding carnivores was diverse. Majority of respondent had negative perception, while few did not respond. The views of locals were categorized into positive and negative. Respondents who wanted to maintain or increase carnivore population in MDNP were included in the positive category while those who wanted to eliminate or decrease their population were included in the negative category (Fig. 3).

Respondents had mixed views about the perceived danger of carnivores for livestock. They were asked to assign a number from one to six (low to high) for six predators on the basis of threat intensity to their livestock. The grey wolf was rated to be the most dangerous (average score 4.8), followed by brown bear (3.9), Asiatic black bear (3.4), snow leopard (3.4), common leopard (2.1), and lynx (0.2) (Fig. 4).

In village Folwai, respondents had 17.5 times more negative attitude towards snow leopards as compared to other villages. Villages Helmat and Taobat had 1.75 and 1.09 times more positive perceptions as compared to other villages. Families with more than one earning member had 2.35 times more positive perceptions than families with one earning member (Table 6).

The most negative perception regarding common leopard was observed in village Folwai (29.64 times more than other villages). Villages Taobat and Helmat had 2.89 and 1.53 times

Table 4 Economic loss (in US Dollars) due to depredation and disease in Musk Deer National Park, in 2013

Livestock	UV	SL	CL	GW	BB	ABB	Total predation loss	Disease loss	Total Loss
Goat	55	1,534	493	657	986	1,041	4,710	11,832	16,542
		(28)	(9)	(12)	(18)	(19)	(86)	(216)	
Sheep	55	2,189	0	2,080	2,463	1,041	7,772	11,328	19,100
		(40)		(38)	(45)	(19)	(142)	(207)	
Cattle	321	1,606	642	321	1,927	1,927	6,423	35,006	41,429
		(5)	(2)	(1)	(6)	(6)	(20)	(109)	
Others	280	4,830	2,450	0	910	1,050	9,240	2,590	11,830
		(15)	(7)		(3)	(3)	(28)	(9)	
Total loss		10,159	3,585	3,058	6,285	5,058	28,145	60,756	88,901
		(88)	(18)	(51)	(72)	(47)	(276)	(541)	
Average loss/ HH		68	24	21	42	34	189	408	597

The numbers in parenthesis represent the number of livestock killed

PKR 100 = USD 1

UV unit value, *SL* snow leopard, *CL* common leopard, *GW* grey wolf, *BB* brown bear, *ABB* Asiatic black bear, *HH* household

Table 5 Livestock depredation as a function of circumstances in MDNP. β represents estimates of parameters, retained by top GLM model

Coefficients	β	EXP (β)	SD	Z value	P value
Intercept	−3.952	−52.075	0.552	−7.156	8.28e-13***
Spring	−0.825	−2.2821	0.959	−0.860	0.38975
Summer	0.644	1.905	0.660	0.977	0.32853
Winter	−15.636	−6,177,350	805.910	−0.019	0.98452
Pasture	−1.009	−2.743	0.484	−2.083	0.03729*
Village	−0.067	−1.069	0.367	−0.184	0.85439
Guarded: yes	−1.490	−4.440	0.644	−2.314	0.02069*
Prey: goat	0.798	2.222	0.633	1.261	0.20744
Prey: other	1.327	3.770	0.596	2.227	0.02598*
Prey: sheep	0.926	2.524	0.605	1.529	0.12630
Guarded yes: goat	−0.601	−1.823	0.837	−0.718	0.47280
Guarded yes: other	−0.800	−2.226	0.986	−0.812	0.41704
Guarded yes: sheep	0.768	2.155	0.725	1.058	0.28988

β = beta, *EXP* (β) = exponent, *SD* = standard error and *P value* = value of significance

Signif. codes: 0***, 0.001**, 0.01*, 0.05, 0.1, 1, AIC: 1067.8

more positive perceptions than other villages, respectively. Illiterate and school education members had 4.9 and 3.7 times more negative views than members of college education, respectively. Respondents owning agricultural land ≥5 kanals had 2.37 times more negative views than respondents owning agricultural land <5 kanals. For grey wolf, miscellaneous villages possessed 6.09 times more negative views as compared to other villages (Table 6).

Concerning brown bear, respondents having ≥20 heads of livestock had 2.76 times more positive views as compared to respondents having <20 domestic animals. In the case of Asiatic black bear, villages Taobat and Helmat had 5.33 and 1.93 times more positive perceptions than other villages, respectively. Village Folwai had 4.50 times more negative views than other villages (Table 6).

Discussion

Present camera trapping and questionnaire study records a rich diversity of carnivore species in MDNP. Nine carnivore species (snow leopard, common leopard, leopard cat, brow bear, Asiatic black bear, grey wolf, red fox, stone marten, and yellow-throated marten) belonging to four families (felidae, ursidae, canidae, and mustelidae) were documented from the park, of which seven carnivore species has been confirmed through photo-captured record (Fig. 2). Snow leopard, common leopard, brown bear, Asiatic black bear, and grey wolf are considered conservation icons nationally (Sheikh and Molur 2004).

Camera trapping technique has proven its effectiveness in detecting elusive and rare carnivore species in the highly dense forests of MDNP. This demonstrates the usefulness of camera trapping in mountain landscapes (Trolle and Kéry 2005; Rovero and Marshall 2009; Treves et al. 2010; Jiménez et al. 2010).

Snow leopards were photo-captured at one location, and camera trapping study confirmed their presence in MDNP for the first time since Roberts (1997) claimed their presence in the Neelum Valley. Leopard cat in Pakistan is categorized as a "data deficient" species by the IUCN as no information exists about its occurrence, extent, habitat, population, or occupancy (Sheikh and Molur 2004). Leopard cat was captured at one location and locals of the park had not been aware of its presence. No

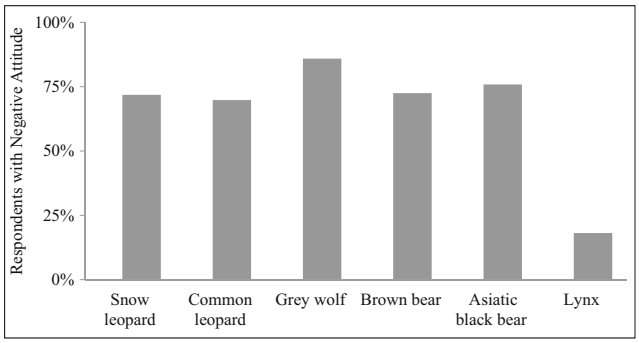

Fig. 3 Attitude of respondents towards carnivores in MDNP

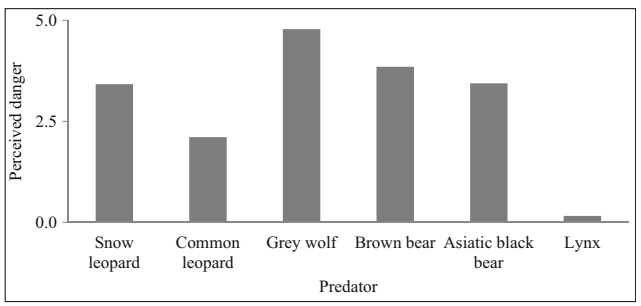

Fig. 4 Danger of carnivores perceived by respondents in MDNP, perception is ranked 1–6 (least dangerous to most dangerous)

Table 6 Effects of socio-economic factors on perception of community toward carnivores in MDNP, AJK

Coefficient	Snow leopard					Common leopard					Grey wolf		
	β	ESP (β)	SD	Z value	P value	β	ESP (β)	SD	Z value	P value	β	ESP (β)	SD
Village miscellaneous	−1.097	−2.99	0.289	−3.793	0.000149 ***	0.695	2.00	0.660	1.052	0.29283	−1.807	−6.09	0.235
Village Folwai	−2.861	−17.48	1.052	−2.718	0.006567**	−3.389	−29.63	1.105	−3.066	0.00217**	–	–	–
Village Helmat	0.559	1.74	0.585	0.957	0.338548	−0.430	−1.53	0.635	−0.677	0.49865	–	–	–
Village Taobut	0.095	1.09	0.609	0.156	0.87612	−1.064	−2.89	0.767	−1.386	0.1657	–	–	–
Earning member >1	0.854	2.34	0.416	2.051	0.040254*	0.799	2.22	0.459	1.741	0.08164	–	–	–
Education illiterate	–	–	–	–	–	−1.595	−4.92	0.717	−2.223	0.02619*	–	–	–
Education school	–	–	–	–	–	−1.302	−3.67	0.635	−2.05	0.04036*	–	–	–
Agriculture land >5 kanals	–	–	–	–	–	−0.865	−2.37	0.520	−1.663	0.09629	–	–	–
Livestock >20	–	–	–	–	–	–	–	–	–	–	–	–	–

Coefficient	Grey wolf		Brown bear					Asiatic black bear				
	Z value	P value	β	ESP (β)	SD	Z value	P value	β	ESP (β)	SD	Z value	P value
Village miscellaneous	−7.677	1.6314 ***	−1.276	−3.58	0.230	−5.529	3.2308 ***	−1.268	−3.55	0.266	−4.755	1.9906***
Village Folwai	–	–	–	–	–	–	–	−1.504	−4.49	0.776	−1.938	0.0526.
Village Helmat	–	–	–	–	–	–	–	0.662	1.93	0.573	1.155	0.248
Village Taobut	–	–	–	–	–	–	–	1.674	5.33	0.590	2.834	0.0046 **
Earning member >1	–	–	–	–	–	–	–	–	–	–	–	–
Education illiterate	–	–	–	–	–	–	–	–	–	–	–	–
Education school	–	–	–	–	–	–	–	–	–	–	–	–
Agriculture land >5 kanals	–	–	–	–	–	–	–	–	–	–	–	–
Livestock >20	–	–	1.018	–	0.397	2.566	0.0103*	–	–	–	–	–

Signif. codes: 0***, 0.001**, 0.01*, 0.05, 0.1, 1

one reported conflict with this species. Brown bear was captured at three locations, and trap history shows that brown bear populations in MDNP are restricted along the LoC where public interference is minimal as the Pakistan Army does not allow frequent human movement in the area. Grey wolf was captured at one location although respondents cited it as a common species in the park area. This study helped in refining the geographic range of this species as grey wolf was captured about 15 km away from the nearest IUCN range. Red fox was the second most captured species after the stone marten. Red fox and stone marten were evenly distributed throughout the park. Yellow-throated marten was photo-captured at six locations and its captures were 13 km away from the nearest IUCN range.

Respondents reported the highest average annual sightings (three) of Asiatic black bear, but it was not captured at any camera station. This was likely due to the season as locals reported that Asiatic black bear mostly visits MDNP in late summer and autumn from the lower parts of the Neelum Valley when the potato and maize crops are fully grown whereas our camera trapping was done in spring. Concerning common leopard, locals declared it a rare species in the park and it was not captured at any camera stations either. We attribute this to the fact that common leopard visits the area during autumn as indicated by livestock killings (15 of 18). In addition, its population is low in AJK. During the past 4 years, humans killed about 60 common leopards in different parts of AJK (personal communication, Director General, Wildlife, AJK 2015). In the case of lynx, the majority of respondents reported its absence in MDNP. Respondents did not blame this species for livestock losses.

This study shows that disease is the main agent responsible for livestock losses in northern Pakistan. This fact is rarely reported in scientific literature pertaining to human-wildlife conflicts, and dispels the notion that predators are always responsible for livestock losses (Dar et al. 2009). In the present study, disease had caused an economic loss of more than two times than from carnivores and was higher than cash income on average each household gains from livestock selling. A study in the Sanjiangyuan region of China (Li et al. 2013a, b) reported 809 disease-related livestock losses with an annual economic loss of USD 375,031 (USD 2604 per household per year). Interviews with locals revealed that most livestock deaths were caused by common and treatable diseases that could not be cured due to the unavailability of veterinary services in MDNP.

One of the most common sources of human-wildlife conflict worldwide is the killing of livestock by mammalian carnivores and is common in and around reserves in the developing world (Distefano 2005). In Himalaya and Hindu-Kush mountains, increased livestock depredation by large carnivores has been attributed to increasing population of livestock (Jackson and Hunter 1996; Mishra 1997; Hussain 2003). It is generally believed that over the past 20 years, human-carnivore conflict in AJK has increased due to a 17–26 % increase in domestic livestock populations (Dar et al. 2009). Locals reported 276 livestock losses due to carnivores in 2013 with economic losses of USD 28,145 (USD 189 per household). The current observed livestock loss of 276 attributed to predators is higher than the predation rate reported from other parts of Pakistan. The predation losses reported from other area are 27 per year (Din and Nawaz 2010), 99 (Dar et al. 2009), 216 (Bibi et al. 2013), and 261 (Din et al. 2013). Corresponding figures for India are 57 (Ahmed et al. 2012) and 23 (Singh et al. 2015). In China, reported numbers are 258 (Li et al. 2013a, b) and 76 for Bhutan (Wang and Macdonald 2006). The higher losses in MDNP may be due to co-occurrence of multiple predators in the park. Furthermore, several studies have shown that thin natural prey densities may be a strong contributor to high depredation rates (Meriggi and Lovari 1996; Kolowski and Holekamp 2006). Such losses, when combined with restrictions on the use of natural resources, are likely to generate aggressive attitudes towards conservation and may provoke retaliatory action by farmers (Conforti and de Azevedo 2003).

Locals blamed Asiatic black bear and brown bear for crop damages leading to economic losses of USD 104 and USD 6 per household, respectively. Bear species raid crops in MDNP because locals cut and store grasses and fodder in late summer causing a major drop in the amount of natural food available to bears. Food availability for bears is also affected by nomads' excessive livestock grazing in pastures and forested areas during the summer.

Livestock depredation in MDNP was significantly affected by four factors: type of prey, season, location, and whether or not livestock is guarded. GLM analysis showed that predators killed medium-sized livestock (goat, sheep) in greater numbers as compared to cattle and others. Similar studies conducted in Machiara National Park (Dar et al. 2009; Kabir et al. 2014) and India (Suryawanshi et al. 2013) reported greater percentages of goat and sheep being killed by predators as compared to larger livestock. Medium-sized livestock (25–45 kg) are the most vulnerable to predation because large carnivores can easily kill and drag them to safety (Bibi et al. 2013; Dar et al. 2009).

Livestock predation usually follows seasonal patterns (Oli et al. 1994; Dar et al. 2009; Sogbohossou et al. 2011). In this study, the majority of livestock depredation occurred in summer. This was followed by autumn, winter, and spring. Dar et al. (2009) reported higher (56 %) depredation in summer for common leopard in Machiara National Park. In Africa, low wild prey availability—which was often linked with rainfall patterns and seasonal movements of these prey species—has been found to increase predators attack on domestic animals (Patterson et al. 2004; Kolowski and Holekamp 2006). In MDNP, snow melt in the summer makes surrounding pastures and forest areas suitable spots for livestock grazing. Locals graze their domestic livestock here. As a result, unattended livestock always has higher predation risk. In winter,

predation by carnivores was low due to heavy snowfall, restricting livestock grazing.

GLM analyses show that forests are the most vulnerable sites for livestock depredation as compared to pastures and villages. The greater numbers of livestock depredation in forests and pastures are due to the fact that local villagers move with their livestock to their summer huts (*baigs*) in upward areas in the summer. These *baigs* have no protective fences, so livestock gather in herds at night in the surrounding forests or pastures. This increases their risk of predation.

Active defense and herd guarding are necessary in animal husbandry. Predation is generally lower when herdsmen are present (Breitenmoser 1998). In parts of Europe, changes in animal husbandry now means that domestic livestock are rarely guarded and are thus more vulnerable to predation (Sillero-Zubiri and Laurenson 2001). In France and Italy, the highest predation of domestic sheep by wolves occurred among free grazing and unattended flocks (Espuno et al. 2004). Unattended livestock in MDNP are at higher risk of predation and various authors blame poor herding practices for attacks on livestock throughout the Himalayan region (Oli et al. 1994; Mishra 1997; Ikeda 2004; Namgail et al. 2007). Our results also support the effectiveness of active guarding and show that livestock depredation by carnivores was four times less when herds were guarded.

Despite snow leopard's high predation, respondents declared grey wolf, brown bear, and Asiatic black bear to be the most dangerous carnivores in the park. Locals in the study area were of the opinion that grey wolf was a major livestock killer, and they also assumed it to be a serious risk to human life. High negative perception about grey wolf is because it is considered a sign of cruelty, tyranny, and cowardice in the region. The snow leopard, on the other hand, is tolerated—despite causing heavy livestock losses (higher than grey wolf)—because it is professed as a sign of bravery and beauty. Children are often named after snow leopard in this region. Brown bear and Asiatic black bear were disliked for their predations and the economic loss associated with crop raids.

The perceptions of predators among villages varied. People of village Folwai possessed more negative perceptions than any other village. This is likely due to their close contact with predators and the fact that they had opposed the declaration of the area as a national park (because it set restrictions on natural resource use). It was also revealed that perceptions about carnivores became positive when the number of earning members was more than one in a household. Larger numbers of domestic animals in a household also had a positive effect on perceptions, but larger amounts of agricultural land created negative perceptions. The results also showed that poorly educated people were more negative towards carnivores. This showed that education appears to play an important role in shaping attitudes towards carnivores (Røskaft et al. 2007). Education can actually increase local people's tolerance towards wildlife (Ogada et al. 2003; Lindsey et al. 2005). Similar to our findings, Holmern et al. (2006) reported that respondents with primary or secondary school education were more tolerant of depredation as compare to the respondents with no education.

Conclusion and recommendations

MDNP has an exceptionally rich diversity of carnivores. Nine carnivore species have been reported of which seven were confirmed through photo captures. Stone marten and red fox had the highest photo-capture frequency. This was followed by yellow-throated marten and brown bear. The presence of large carnivores has a large economic bearing on local communities and causes a huge economic loss which is why park communities do not support carnivore conservation with more than 70 % of locals wanted to eliminate carnivores from the park area. Compensation and environmental education are required to promote the coexistence of carnivores and humans in MDNP (Mishra et al. 2003). Additional studies need to be carried out in different seasons to maximize carnivore photo captures. Livestock or crop damage by carnivores should be verified in the future.

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