Journal of Arid Environments 182 (2020) 104241

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Patterns of Livestock Depredation and Large Carnivore Conservation Implications in the Indian Trans-Himalaya

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ARTICLE INFO

Keywords:
Large carnivores
Livestock depredation
Participatory approach
Snow leopard
Kargil
Himalaya

ABSTRACT

Livestock is one of the major sources of livelihood for the agro-pastoral communities in central and south Asia. Livestock depredation by large carnivores is a wide-ranging issue that leads to economic losses and a deviance from co-existence. We investigated the grass root factors causing livestock depredation in Kargil, Ladakh and tested the findings of diet analysis in validating reported livestock depredation. Globally vulnerable snow leopard (*Panthera uncia*) and more common wolf (*Canis lupus*) were the two main wild predators. A total of 1113 heads of livestock were reportedly killed by wolf (43.6%) followed by unknown predators (31.4%) and snow leopard (21.5%) in the study site from 2009 to 2012, which comes to 2.8% annual livestock losses. Scat analysis also revealed a significant amount of livestock in the diet of snow leopard (47%) and wolf (51%). Poor livestock husbandry practices and traditional livestock corrals were found to be the major drivers contributing in the livestock depredation. Based on the research findings, we worked with the local communities to sensitize them about wildlife conservation and extended limited support for predator proof livestock corrals at a small scale. Eventually it helped in reducing conflict level and conserving the globally threatened carnivores. We conclude that a participatory approach has been successful to generate an example in reducing large carnivore-human conflict in the west Himalaya.

1. Introduction

Traditional agro-pastoral communities are primarily dependent on natural resources, but such systems have undergone dramatic changes in recent decades in the central and southern Asian mountain ecosystems (Central Asian Mountain Partnership, 2008; ADB, 2010; Kerven et al., 2011). Such dependence leads to decline in the unique wildlife in these mountains (Mishra et al., 2004; Maheshwari, 2016). For instance, increasing livestock may lead to declines in the populations of wild ungulates such as Tibetan argali (*Ovis ammon hodgsoni*), markhor (*Capra falconeri)*, blue sheep (*Pseudois nayaur),* and ibex (*Capra ibex sibirica),* consequently reducing natural prey of snow leopards (*Panthera uncia*) and wolf (*Canis lupus*) (Mishra et al., 2004; Jumabay-Uulu et al., 2013; Lovari et al., 2013). This forces wild predators to prey on livestock which at times leads to retaliatory killing of globally threatened carnivores and results in an escalation of large carnivore-human conflict (Treves and Karanth, 2003; Jackson et al., 2010; Maheshwari et al., 2014). Livestock depredation by snow leopard and wolf has been reported throughout the predators' range (Maheshwari et al., 2010; Li et al., 2013; Jackson, 2015; Din et al., 2017; Farrington and Tsering, 2019; Rashid et al., 2020). For instance, about 3–18% of local livestock holdings are reportedly lost to snow leopards annually (Oli et al., 1994; Jackson and Wangchuk, 2001; Namgail et al., 2007; Maheshwari et al., 2010; Alexander et al., 2015; Chetri et al., 2017; Farrington and Tsering, 2019; Rashid et al., 2020). Such livestock loss can amount to as much as 56% of an average per capita income (Ikeda, 2004; Alexander et al., 2015; Chen et al., 2016; Li et al., 2013; Farrington and Tsering, 2019; Maheshwari and Sathyakumar, 2019).

Inadequate knowledge about wild predators and understanding of ecological and social issues of livestock depredation makes the resolution of such conflict critical (Maheshwari et al., 2014; Rashid et al., 2020). In this context, we attempted to evaluate the extent of large carnivore-human conflict in Kargil, Ladakh. To address this, we quantified livestock depredation by large carnivores through questionnaire surveys, and validated responses through diet analysis (Bhatnagar et al., 1999; Anwar et al., 2011; Jackson, 2015).

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https://doi.org/10.1016/j.jaridenv.2020.104241
Received 18 September 2019; Received in revised form 29 May 2020; Accepted 8 June 2020

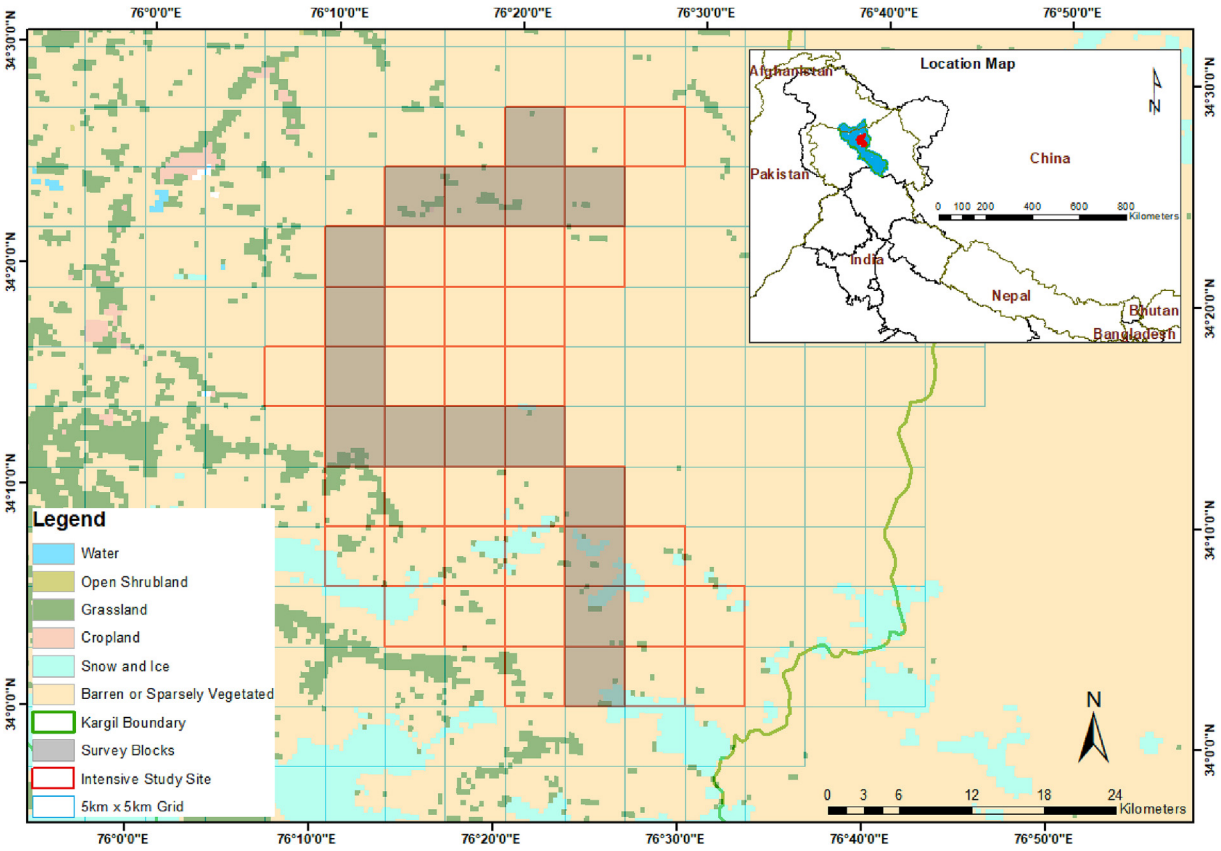

Fig. 1. Study area: Location of survey grid cells in Kargil District, India.

2. Materials and methods

2.1. Study area

We conducted the study in the Suru, Wakha, Mulbek and Kanji Valleys, of which together approximately 1000 km^2 of area was covered in Kargil district spread over an area of 14,000 km^2 (Fig. 1). Kargil is an area in the disputed state of Jammu and Kashmir and was the site of high-altitude combat between Pakistan and India in the summer of 1999. The area is a mountainous cold desert in Ladakh region with little or sparse vegetation. Elevation ranges between 2934 m and 7410 m, with an average elevation of 3400 m. Kargil is located on the rain shadow of the Himalaya. Annual precipitation (around 15 cm) is mainly in the form of snow. During winters, temperatures drop to −48 °C (Maheshwari, 2016). Local communities are primarily agro-pastoral and cultivate the land within drainage system.

2.2. Sampling design

Being a politically sensitive region, at the time of the present study (November 2012), civil movement was restricted in Kargil and systematic sampling was not realistic. Therefore, to understand the general scenario of large carnivore-human conflict in Kargil, we, first gathered secondary information on general occurrence of large carnivores and their interactions with locals through discussions with staff of the Department of Wildlife Protection, Government of Jammu & Kashmir. Through informal interviews, we selected areas for a reconnaissance survey (April–May 2009) and placed a 5 × 5 km grid over Kargil district to validate the feasibility of the identified sampling grids (Fig. 1). We excluded the grids with i) more than 50% of glaciers or high and inhospitable mountain peaks, (ii) areas falling in large human settlements because of high anthropocentric disturbance and (iii) areas with restricted movement because of the presence of bombs and landmines. We then selected 12 villages covering 1000 km^2 in the Suru, Wakha, Mulbek and Kanji areas and fieldwork was carried out from June 2009 to November 2012.

We covered every households in 12 villages. At each household, the eldest member of the family was interviewed to gather following information: (i) livestock number and composition, (ii) number and type of livestock depredation by large carnivores, (iii) time and site of attack: e.g. corral in the village or *doksa* (summer camp), (iv) current livestock guarding practices and willingness to improve corrals (poorly constructed corrals are more vulnerable for predator's attack and would be replaced with predator-proof closed corrals), (vi) perception about the large carnivores (a) positive – locals have no issues with carnivores and in general they like them, b) negative – locals have strong dislike for the carnivores, or c) neutral) and (vii) wildlife awareness level amongst the locals particularly about wildlife laws and legislation. We also interviewed villagers living in *doksa* to collect information. With the permission from livestock owners, we conducted a total head count of livestock in each village and *doksa* during evening hours when all livestock were corralled for the night. We classified the livestock in three groups: (i) Cow, yak, *dzo/dzomo* (hybrid of cow and yak) (bovids), (ii) sheep and goat (caprins), (iii) horse and donkey (equids). To reduce and avoid overestimation of livestock depredation, we employed Participatory Rural Appraisal (PRA), a standardised approach for collecting data on large carnivore–human conflict using the semi-structured interview technique of PRA (Maheshwari et al., 2014).

2.3. Food habits of snow leopard and wolf

Scat analysis reveals the contribution of wild and domestic prey in the predator's diet (Maheshwari et al., 2014). During the study period, we collected scats of wild carnivores from the sampling grids (Anwar et al., 2011; Lovari et al., 2013). Scats were segregated based on size, position and presence of pugmarks to decrease the risk of collecting

scats of red foxes and dogs (Mukherjee et al., 1994; Lovari et al., 2013; Maheshwari, 2016). A total of 217 scats were sun dried and preserved in polyethylene bags for further analysis. After DNA-based genetic confirmation of the type of predator (Karmacharya et al., 2011; Janečka et al., 2008), (snow leopard, n = 59; wolf, n = 53) scats were analyzed for diet through identification of prey species' hair found in the scat samples (Mukherjee et al., 1994; Bagchi and Mishra, 2006; Lovari et al., 2013; Maheshwari, 2016; Chetri et al., 2017). These hairs were identified on the basis of structural differences like medullary portion, cuticle, cortex and pigmentation in the cells (Mukherjee et al., 1994; Maheshwari, 2016).

3. Results

3.1. Livestock demography

Total livestock holdings in surveyed villages was 13,356 animals. Sheep and goats were dominant contributing at 59.6%, while cow, yak, *dzo/dzomo* (30.3%) and horse and donkey (10%) constituted the remainder of livestock. *Doksa* were the site of large herds of caprins, bovids, and equids during the snow-free period (May to September) where they were corralled nightly. In winter, livestock were kept in the village in loosely open night shelters or corrals located beneath or attached to the houses and stall-fed by forage collected from the mountain pastures during the snow-free period.

3.2. Livestock depredation

In total, 664 households reported 532 livestock depredation incidents with a total of 1113 head of livestock killed by large carnivores from 2009 to 2012 (Fig. 2). The majority of these incidents occurred at traditional corrals (54.5%), followed by open pastures (36.7%) and open fields (8.8%). Out of total livestock losses, wolf accounted for 43.6% of losses followed by unknown predators (31.5%), snow leopard (21.6%) and brown bear (3.3%) (Table 1). Amongst the three livestock categories, we found 77.9% of losses were caprins, 12.9% were bovids and 9.2% were equids (Fig. 3). In addition to the above, villagers reported red fox (*Vulpes vulpes*) depredation on sheep, juvenile goats and small chickens. In total, respondents reported 74 sheep and juvenile goats and over 100 chickens killed by red fox from 2009 to 2012 (Maheshwari, 2018).

3.2.1. Food habits of snow leopard and wolf

Of 138 scat samples collected that were believed to be snow leopard, only 59 were genetically determined to be snow leopard. Scat analysis of these samples revealed a total of nine prey species in the diet of snow leopards in Kargil. Of the 59 scat samples, 32 were comprised of single prey, 19 of two prey and eight of three prey species. Ibex constituted 23% of the diet, followed by long tailed marmot (*Marmota caudata*) (9%), rodents (8%) and Ladakh urial (*Ovis orientalis vignei*) (5%). Domestic livestock made up almost 47% of snow leopard diet. There were also some unidentified vegetation and animal material (8%) found in the snow leopard scat samples (Table 2).

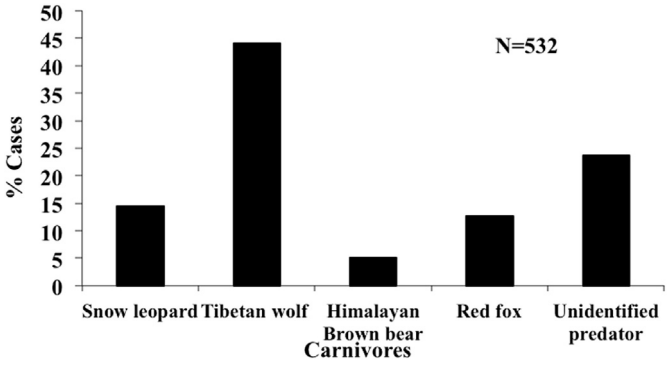

Fig. 2. Cases of livestock depredation (%) by large carnivores reported in Kargil from 2009 to 2012.

Of 79 scat samples collected that were believed to be, 53 were genetically determined to be wolf. A total of nine prey species were identified in these samples, and 26 contained a single prey species, 18 contained two prey species and nine had three prey species. Wolf diet was comprised of domestic sheep and goats (19%), followed by rodents (18%), Ladakh urial (13%), long tailed marmot (9%) and Asiatic ibex (3%) (Table 2). Similar to snow leopard, 6% of diet consisted of vegetation, while insects were also recorded in the wolf scats.

3.3. Local perceptions of carnivores and wildlife conservation awareness level

Of the 664 respondents we interviewed, 46% had a negative perception followed by neutral (33%) and positive (21%) towards large carnivores. Households that suffered highest livestock losses (12 sheep and goats were killed by snow leopard) due to large carnivores expressed their concerns negatively for predators and stated that such large carnivores need to be confined and managed in the wilderness areas, away from the villages. They also said they needed monetary compensation and mitigatory tools to minimise livestock depredation. Similarly, those, who suffered marginal loss (1 yak calf killed by a wolf) or have some knowledge of wildlife conservation showed positive attitudes towards large carnivores. We did not find a high level of awareness of wildlife conservation and law enforcement issues, with only 16% of respondents being aware of legislation prohibiting poaching of wildlife.

4. Discussion

Being a war zone in the late 1990s, Kargil had been neglected with respect to detailed wildlife research and follow-up conservation activities (Maheshwari, 2016). Local communities are primarily agro-pastoral and livestock is the major source of their incomes. Losses of valuable livestock to wild predators leads to retaliatory killing of large carnivores (Oli et al., 1994; Jackson and Wangchuk, 2004). We compared our results with similar studies documenting livestock depredation in the snow leopard habitat (Oli et al., 1994; Namgail et al., 2007; Li et al., 2013; Din et al., 2017) and found that our results are similar with the neighbouring Leh District, where livestock loss was reported at 2.9% per annum (Namgail et al., 2007) (Table 3).

Scat analysis revealed that livestock contributed 47% and 51.2% in the diet of snow leopard and wolf respectively, whereas respondents attributed lower rate of livestock depredation to snow leopard (21.6%) and wolf (43.6%). Similarly, the 21% of equids that have been reported by respondents to have been killed by snow leopard was not corroborated by findings of the scat analysis. This may be due to: i) response bias in reporting livestock loss (Maheshwari, 2016), ii) topography of the habitat which restricted scat collection efforts ii) and/or iii) snow leopard scats which might have contained horse or donkey remains were not positively determined to be snow leopard and thus were not analyzed for diet. Similarly, Bagchi and Mishra (2006), reported higher livestock in snow leopard diet (58%) through scat analysis compared to questionnaire responses 42% of the local communities in Spiti region of Himachal Pradesh. Further, all depredation incidents occurred on grazing pastures and none in villages in Spiti. On the contrary, in our study, 54.5% of livestock depredation cases occurred within the villages and 45.5% in the grazing pastures. This clearly highlights poor livestock guarding practices in Kargil, which leads to severe livestock loss to carnivores. This is probably also due to the low density of wild prey accessible to the wild predators in Kargil (Maheshwari, 2016).

Since, livestock depredation by large carnivores was identified as the root cause of the large carnivore-human conflict in Kargil,

Table 1
Total livestock depredation by large carnivores in the study area, Kargil (2009–2012) as reported by survey respondents.

Large carnivores	Goat/sheep	Yak, cow/*dzo/dzomo*	Horse/donkey	Total livestock loss
Snow leopard	198	21	21	240
Wolf	386	32	68	486
Himalayan brown bear	37	0	0	37
Unidentified carnivores	246	49	55	350
Total	**867**	**102**	**144**	**1113**

retaliatory killing of large predators can't be ruled out. However, we did not find any evidence of snow leopard poaching during the study period. A comparable situation exists with many central and southern Asian mountain regions, where both snow leopard and wolf are persecuted for livestock depredation and also for illegal trade (Jackson, 2015; Din et al., 2017; Maheshwari and Niraj, 2018). Such situations are common in a number of developing nations and mitigation efforts (present study) should be considered a biological system support fee to be paid by global societies or governments for promoting coexistence of humans and wildlife. Hence, we emphasize participatory models where local communities play a key role in wildlife conservation programs (Jackson and Lama, 2016).

5. Conclusion

In general, there are three conservation strategies in practice to mitigate the large carnivore-human conflict in the central and southern Asian mountain regions, 1. Predator proof corrals and fence around stone corral (Bhatnagar et al., 1999; Jackson and Wangchuk, 2004; Jackson, 2015; Farrington and Tsering, 2019; Samelius et al., 2020), 2. Livestock insurance scheme (Mishra et al., 2003) and 3. Sensitizing local communities and raising their awareness for wildlife conservation (Jackson and Wangchuk, 2004; Maheshwari et al., 2010; Jackson, 2015). We investigated carefully the effectiveness of each of the tools in conflict management (Samelius et al., 2020) and implemented two of the management strategies in Kargil and combined predator proof corrals with education awareness initiatives. It is remarkable to note here that there was no depredation reported in 2012 and later till 2016 after building the livestock corrals. Moreover, Jackson (2015) also stressed upon the participatory approach for wildlife conservation in the high-altitude regions and it is a matter of perspective that how locals have shared the space with large carnivores over time. We conclude that results of predator-proof corrals and conservation awareness programmes have been striking in reducing the livestock depredation.

Table 2
Percentage frequency of prey in scats of snow leopard and wolf.

Species	Snow leopard (n = 59) Percentage frequency in scats (%)	Wolf (n = 53) Percentage frequency in scats (%)
Asiatic ibex	23.4	2.6
Ladakh urial	4.7	12.8
Long tailed marmot	9.4	9
Rodent	7.8	17.9
Goat	9.4	19.2
Sheep	17.2	12.8
Cow	14.1	5.1
Yak/*dzo/dzomo*	6.3	0
Horse/donkey	0	14.1
Insects	0	23.1
Unidentified and vegetative material	7.8	6.4

Author contributions

AM and SSK designed the study. AM carried out fieldwork, analysed data and wrote the manuscript. SSK and AM reviewed the manuscript.

Ethical statement

All permissions to carry out the field research were obtained from the Department of Wildlife Protection, Jammu and Kashmir and livestock counts were conducted with permission from their owners without any coercion.

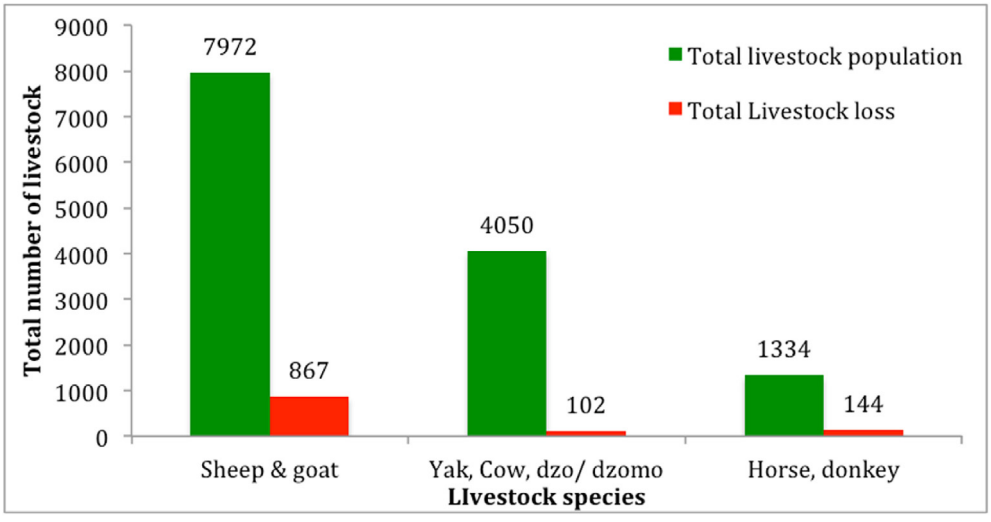

Fig. 3. Livestock loss against total livestock population due to large carnivores from 2009 to 2012 in Kargil (of the livestock holding of 13,356 animals at the start of our survey, villagers reported that 1113 were killed by predators during 2009–2012).

Table 3
Comparison of livestock depredation by carnivores in 1 year in different sites" is the correct table caption.

Site	Percent of livestock depredation[a]				Data source
	Snow leopard	Wolf	Unknown	Total	
Annapurna Conservation area, Nepal[b]	2.6			2.6	Oli et al. (1994)
Gya-Miru Wildlife Sanctuary, India	1.08	1.72		2.9	Namgail et al. (2007)
Sanjiangyuan, Qinghai, China	1.3	5	0.13	3.7	Li et al. (2013)
Pamirs (Afghanistan, Pakistan and Tajikistan)	1.5	1.6		3.5	Din et al. (2017)
Kargil, Ladakh, India	1.8	3.6	2.6	2.8	Present study

[a] Some of these numbers were calculated by dividing total livestock depredation with the number of years reported data in previous studies.
[b] This study did not report livestock depredation by wolf.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Our gratitude to the Rufford Foundation for financially supporting our research and later conservation initiatives in Kargil. We extend our gratitude to the locals of Kargil who shared their valuable and painful experiences of livestock losses. Kazim is thanked for providing all the assistance in the field and staff of the Department of Wildlife Protection is thanked for their permission and support during the study. Mukesh and Arun are particularly thanked for assisting us in improving the manuscript. The Wildlife Institute of India and Banda University of Agriculture and Technology, Banda are thanked for their support and encouragement while writing the manuscript. We are grateful to the anonymous reviewers who also helped us in refining the manuscript in publishable form.

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