Living with leopards: an assessment of conflict and people's attitudes towards the common leopard *Panthera pardus* in a protected area in the Indian Himalayan region

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Abstract Protected areas are important for wildlife conservation but they are also used by many local communities for livelihood activities. This often leads to conflicts and erodes the tolerance of local people for wildlife, particularly towards carnivores that prey on livestock. To enhance conservation success and improve the social carrying capacity of carnivores, it is essential to understand the factors influencing such conflicts and the attitudes of people interacting with carnivores. We used structured questionnaire surveys to assess the extent of livestock mortality and community responses to common leopards *Panthera pardus* in Kishtwar National Park, a relatively understudied protected area in the Greater Himalayan region of India. The mountainous Park and its surroundings have historically served as a haven for the local agro-pastoralists and transhumant pastoralists, resulting in complex human–wildlife interactions across the larger landscape. Our results showed that leopards were responsible for high livestock depredation (71 incidents in 2 years), and households with larger livestock holdings experienced a higher predation rate compared to those with smaller livestock holdings. An ordinal logistic regression model revealed that respondents' age and period of activity in the Park significantly influenced their opinions regarding leopards. Large losses suffered by otherwise low-income households resulted in more negative attitudes towards these predators. Our study indicates that financial compensation for livestock losses is a key factor in improving human–leopard coexistence. A comprehensive, cross-sector collaborative approach would help to improve conflict resolution and promote favourable attitudes towards these predators.

Keywords Conflict management, human–wildlife conflict, Kishtwar National Park, livestock depredation, questionnaire approach, transhumant pastoralists

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Introduction

Protected areas, where the conservation of wildlife including predators is a top priority, are used by many local communities for their livelihoods. Because of growing rural populations in and around wildlife habitats, people and carnivores are increasingly sharing habitats and activity periods (Linnell et al., 2002; Jhala, 2003). Carnivores often visit human-dominated landscapes to take advantage of the available cover, easy prey availability and food provisioning by people (Athreya et al., 2015; Suryawanshi et al., 2017; Naha et al., 2018). Forest fragmentation, habitat heterogeneity (Acharya et al., 2017) and a lack of natural prey (Gurung et al., 2008; Goodrich, 2010) are all significant predictors of predation attempts by carnivores. This results in negative human–carnivore interactions (Seoraj & Pillay, 2017; Wilkinson et al., 2020), especially in multi-use landscapes, with serious consequences (Bombieri et al., 2023) including potential human injury and death (Penteriani et al., 2016, 2017; Bombieri et al., 2018). To effectively manage human–carnivore coexistence under various conditions, a deeper understanding of the factors driving negative interactions is necessary (Chapron et al., 2014; Penteriani et al., 2017; Bombieri et al., 2018).

The compromised livelihoods of marginalized communities erode human tolerance for wildlife, particularly towards carnivores that prey on livestock (Mishra, 1997; Treves & Karanth, 2003; Graham et al., 2005; Inskip et al., 2016). Globally, a significant proportion of large felid mortality is a result of human–carnivore conflict (Inskip & Zimmermann, 2009). The killing of carnivores in retaliation for livestock predation is amongst the most serious, pervasive and direct threats to carnivores (Inskip et al., 2014) and has long-term consequences for their conservation (Treves, 2009). To ensure sustainable livestock production in pastoral communities and the continued survival of carnivore populations, mitigation of conflicts involving livestock depredation is key (Khanal et al., 2020).

Although many studies have focused on various aspects of the ecology of large mammals in the protected areas of

India, information on where they share space with people is limited (Karanth et al., 2012; Odden et al., 2014; Miller et al., 2016). The common leopard *Panthera pardus* is one of the most adaptable and widely distributed large felids (Gubbi et al., 2020), occupying a diverse range of habitats ranging from pristine protected forests to urban edges (Athreya et al., 2013; Kumbhojkar et al., 2021). Leopards have adapted to living along the interface between forests and rural settlements on the outskirts of human habitations (Naha et al., 2018). Conflict between people and leopards is a complicated issue that is influenced by species biology, political and social attitudes, and management practices (Athreya & Belsare, 2007). Livestock depredation is one of the principal causes of such conflicts (Graham et al., 2005), and can be significant where communities live near protected areas (Mishra, 2000; Linnell et al., 2001; Conforti & Azevedo, 2003) and wild prey is displaced by domestic livestock (Patterson et al., 2004). There have been numerous studies reporting trends of human–leopard interactions in India (Pandey et al., 2016; Crown & Doubleday, 2017; Naha et al., 2020; Ankit et al., 2021). However, despite reliable accounts of negative human–leopard interactions in various parts of Jammu and Kashmir, scientific reports on this matter are lacking for the region (Ahmed, 2021).

Kishtwar (High Altitude) National Park, the largest protected area in Jammu and Kashmir, is one of the least explored protected areas in India (Kichloo & Sharma, 2021). Located in the Greater Himalaya and bordering the Zanskar range in the north, the Park serves as a haven for the Bakerwals, who are nomadic pastoralists. The livestock driven by these transhumant pastoralists and the local livestock that accompanies them to the higher reaches of the Park during summer seasons are easy prey for predators, mostly leopards, creating complex human–wildlife interactions. To analyse the economic impact of livestock depredation, the resulting negative attitudes of people towards carnivores and the conservation implications, we interviewed local people in and around Kishtwar National Park. Specifically, we aimed to understand the spatial patterns of livestock depredation by leopards, the practices employed to mitigate such depredation and the factors governing people's attitudes towards leopards.

Study area

Kishtwar National Park is the largest national park in Jammu and Kashmir, covering 2,191.5 km² across an elevational range of 2,224–6,293 m (Fig. 1). The Park is well drained by four major streams: Kibber, Nanth, Kiyar and Rinae, which join the Marusudhar River, a part of the Chenab catchment. The Park is characterized by vast and narrow valleys, rugged mountains, broken cliffs, snow-clad peaks, permanent glaciers and a vast drainage network. The vegetation primarily comprises moist, temperate, broad-leaved and coniferous forests, which give way to sub-alpine scrub, alpine meadows and rocky outcrops farther northwards. The climate is cold and arid with short summers and long winters. Temperature varies considerably with elevation and drops below 0 °C in winter. Precipitation, largely in the form of snow in winter and rainfall in summer, is determined by the elevation.

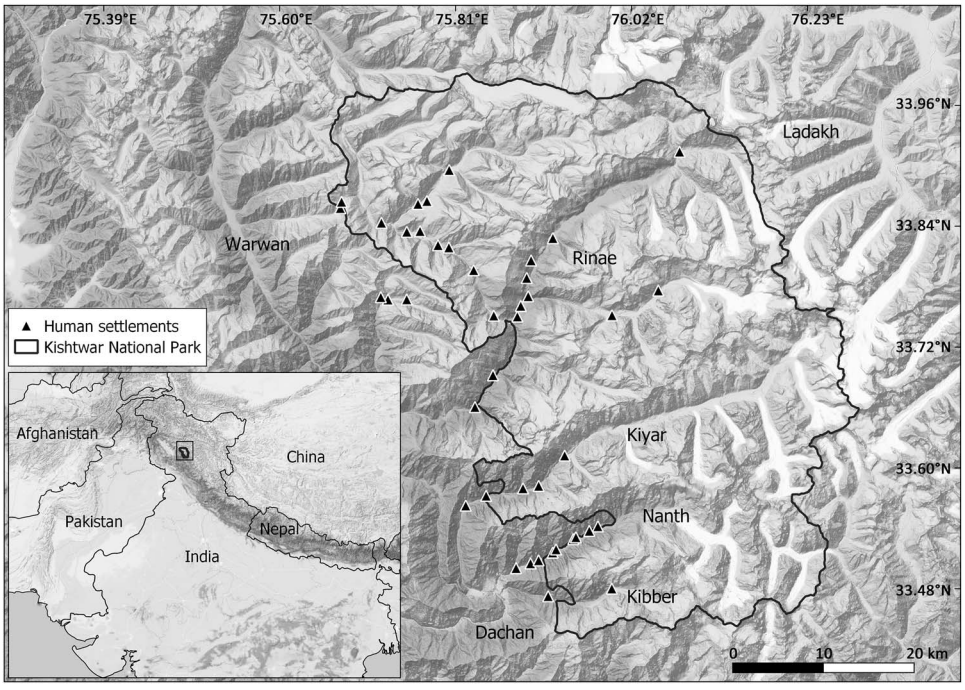

FIG. 1 Kishtwar National Park in the Indian Himalaya, Jammu and Kashmir, India, showing the names of valleys and the locations of human settlements (both local and tribal) in the area where we carried out the survey.

The wide array of habitats across the landscape supports a large population of carnivores and their prey base. The major carnivores in the region, apart from the common leopard, include the snow leopard *Panthera uncia*, Asiatic black bear *Ursus thibetanus* and Himalayan brown bear *Ursus arctos isbellinus*. The main prey species include the Himalayan goral *Naemorhedus goral*, Himalayan musk deer *Moschus leucogaster*, Himalayan ibex *Capra sibirica*, hangul *Cervus hanglu hanglu*, various smaller animals and numerous species of Galliformes (Hilaluddin & Naqash, 2013). Agriculture and livestock herding are the primary sources of income for the majority of the population in the area. The Bakerwals inhabit the National Park along with their large herds of sheep, goats, cows and horses that graze along the forest edges and meadows through the summer (April–September).

Methods

Sampling design

We conducted questionnaire-based interviews with select members of local communities and Bakerwals over a 2-year time period, during 2017–2019. The questionnaire (following Oli et al., 1994; Supplementary Material 1), comprised three parts: (1) socio-demographic data (name, age, gender, occupation and community) and respondent knowledge of wildlife, (2) details regarding livestock depredation as well as the practices used to mitigate such predation, and (3) data regarding people's perceptions towards carnivores on a five-point Likert scale (strong like, slight like, indifferent, slight dislike and strong dislike). We approached the respondents and introduced ourselves as students conducting a study on human–wildlife interactions in the National Park and its surroundings. We included in the study only those individuals who could correctly identify the common leopard from a series of pictures of different wild animals. Before the start of each interview, we obtained informed verbal consent from each respondent and we kept their identity confidential. To faciliate communication with respondents in their local language, the interviewing team was often accompanied by local people who were knowledgeable about wildlife, and by staff from the local wildlife department. We conducted the interviews (lasting a mean of 6 min) in local languages including Kashmiri, Gojri and Urdu. We provided no financial incentives or monetary benefits to the respondents who participated in the survey.

Data analysis

We used descriptive statistics to analyse data on livestock mortality and depredation patterns. We examined the relationship between livestock holdings, predation control practices and respondent attitudes towards these practices using Spearman's correlation. We measured the predation control practices as ranks and considered the Likert score to be an ordinal variable. For each predation control practice, we computed the correlation coefficient and related P-value with livestock holdings and Likert score as dependent variables, whereby livestock holdings equalled animal counts. We used an ordinal logistic regression to determine the key factors (e.g. age, gender, occupation, region, activity duration and livestock holdings) that influence the attitudes of people towards leopards. We performed all statistical and graphical analysis in *R 4.1.1* (R Core Team, 2022). We carried out the regression analysis using the *clm* function in the *ordinal* package in *R* (Christensen, 2022), and assessed the overall measure of model fit using the function *anova*. We calculated pseudo-R^2 values to test the goodness of model fit using the function *nagerkerke* from the package *rcompanion* (Mangiafico, 2023). We calculated the statistical significance of the livestock holdings for the groups of respondents who had and had not experienced livestock depredation using a Mann–Whitney U test after we had checked the samples for normality using a Shapiro–Wilk test. We used a rank biserial correlation to calculate the effect size of the results using the function *rank_biserial* from the package *effectsize* (Ben-Shachar et al., 2020).

Results

We interviewed 102 respondents (98 men, 4 women) in various villages/locations in the Dachan and Marwah regions of the National Park. Most of the respondents (52%) were aged 46–65 years, with a mean age of 49.7 years (Table 1). The principal occupation of the majority of the respondents was livestock rearing (52%) followed by agriculture/small landholders (32%) and government employees (forest and wildlife officials; 10%), and 6% of respondents practiced mixed occupations. Most of the interviewees were long-time users of the Park, and the mean activity period of respondents (i.e. the number of years during which they had visited the Park regularly) was 30.5 years (Table 1). Many of the respondents (42%) had visited the Park on a regular basis for more than 30 years, followed by those with activity periods of 21–30 years (25%) and 10–20 years (31%). Only two respondents (2%) had regularly accessed the Park for less than 10 years.

Of the total 102 respondents, 68 reported mixed livestock holdings comprising sheep, goat, cows, oxen and horses. Amongst these, 43 respondents reported livestock predation by leopards on 71 separate occasions over a span of 2 years (during 2017–2019). Participants from the Rinae valley reported the highest number of depredation cases (30), followed by those from the Kiyar (22), Kibber (15) and

TABLE 1 Socio-demographic profile of respondents (n = 102) involved in the survey in Kishtwar National Park, Jammu and Kashmir, India (Fig. 1), including their principal occupation and activity period (i.e. the number of years during which respondents regularly accessed the National Park).

Variable	n	%
Gender		
Male	98	96
Female	4	4
Age		
< 18 years	0	0
18–25 years	1	1
26–45 years	39	38
46–65 years	53	52
> 65 years	9	9
Principal occupation		
Forest/wildlife protection/other government service	10	10
Farmer/smallholder	33	32
Shepherd	53	52
Other	6	6
Activity period		
< 10 years	2	2
10–20 years	32	31
21–30 years	25	25
> 30 years	43	42
Religious affiliation		
Hindu	21	21
Muslim	81	79

Nanth (4) valleys (Fig. 2). The majority of these incidents occurred during the day, in forests and pastures far from settlements. Livestock holdings comprised a mean of 273 ± SD 200 animals, and this figure was higher amongst the respondents who reported predation (mean 307 ± SD 33) than those who reported no predation (mean 96 ± SD 17). This difference was statistically significant (rank biserial coefficient = −0.65; Table 2). Respondents in the surveyed area incurred a total financial loss of USD 5,693 because of livestock depredation by leopards during 2017–2019. Mean loss per household was USD 132 over this period.

TABLE 2 Statistical significance of the relationship between the size of respondents' livestock holdings and whether or not they had experienced livestock depredation during 2017–2019. Statistical significance was tested using a Mann–Whitney U test after the samples had been checked for normality using a Shapiro–Wilk test.

Shapiro–Wilk test for normality	Statistic (W)	P-value
Predation	0.91	< 0.001
No predation	0.64	< 0.001
Mann–Whitney U test		
Predation – no predation	450	< 0.001

In general, the respondents had a negative attitude towards leopards. Only 13 people had a favourable opinion of leopards, and they were mostly forest and wildlife officials or affiliated with the government. Most of the respondents expressed a negative attitude (slight dislike = 34, strong dislike = 31); people in this group had a mean livestock holding of 217 ± SD 209 animals and had experienced at least one instance of livestock depredation by leopards (Fig. 3). The 24 respondents who showed a neutral (indifferent) attitude towards leopards had a mean livestock holding of 161 ± SD 165 animals and mostly had experienced minimal or no livestock predation by leopards.

Age, activity period and livestock holdings significantly influenced respondent attitudes ($P < 0.001$) towards common leopards (Table 3). Age increased the likelihood of a positive response by 0.18 ± SD 0.04; however, a longer activity period decreased the likelihood of having a positive response by −0.21 ± SD 0.04. The goodness of fit (McFadden R^2) for the model was 10%.

All 68 respondents who owned livestock believed that livestock depredation by common leopards could be reduced or compensated in some way. The majority of the respondents (58%) thought that financial compensation

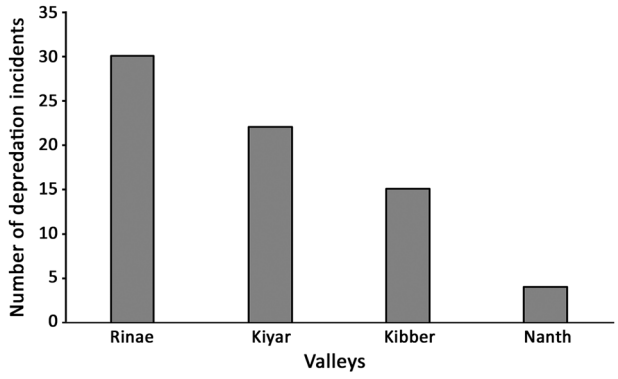

FIG. 2 Number of livestock depredation incidents by common leopards *Panthera pardus* that were reported during 2017–2019 by survey respondents in the various valleys in Kishtwar National Park, Jammu and Kashmir, India.

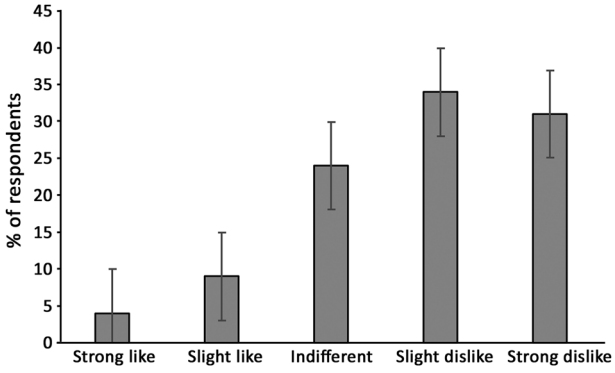

FIG. 3 Per cent of respondents involved in the survey in Kishtwar National Park, Jammu and Kashmir, India, showing different attitudes towards the common leopard on a five-point Likert scale. The error bars represent the standard errors.

TABLE 3 Key variables influencing the attitudes of people towards the common leopard in Kishtwar National Park, Jammu and Kashmir, India, using logistic regression. We used P-values to determine significance, with highly significant values marked with an asterisk (*).

Variable	Estimate ± SE	*z*-value	P-value
Age	0.18 ± 0.04	4.55	0.000*
Gender	0.82 ± 0.77	1.06	0.288
Activity duration	−0.21 ± 0.04	−5.05	0.000*
Livestock holdings	0.003 ± 0.00	2.73	0.006*
Region	−0.62 ± 0.40	−1.52	0.127

would be the most effective strategy for dealing with wildlife depredation, followed by avoidance of high-risk areas (31%; high-risk areas were based on respondents' perceptions of where leopard attacks on livestock may occur) and improving animal husbandry practices (29%). The selective removal of problematic leopard individuals and eradication of all leopards were the least favoured approaches to predation control. The rating of improved husbandry practices and financial compensation for livestock losses showed weak but significant positive correlations with the size of livestock holdings, implying that larger livestock holdings increased demand for both compensation and improved husbandry practices. Eradication of wild animals showed a significant inverse correlation with the size of livestock holdings (i.e. as livestock holdings increased, the ranking of eradication decreased; Table 4).

Discussion

People's perception of conflict with predators is likely to be influenced by the physical and behavioural characteristics of the carnivore, by cultural and historical associations (Kellert et al., 1996; Kleiven et al., 2004; Suryawanshi et al., 2013; Pahuja & Sharma, 2021) and people's attitudes towards the species in question (Suryawanshi et al., 2014). The existence of leopards near human settlements has frequently resulted in negative human–leopard interactions (Karanth et al., 2018), leading to the creation of a negative narrative about these interactions (Ankit et al., 2021). Livestock depredation is one of the leading causes of economic losses in the affected communities, resulting in negative perceptions of predators (Bagchi & Mishra, 2006; Chen et al., 2016; Farrington & Tsering, 2019). We aimed to understand the persistence of this human–carnivore conflict and the attitudes of people towards common leopards in Kishtwar National Park in India. Although no human deaths have been reported in the Park, the leopard is perceived as the most infamous predator in the Kashmir region (Bombieri et al., 2023). In Kishtwar National Park, leopards dominate the low-lying, broad-leaved forests, treelines and sub-alpine pastures that are used by livestock during different seasons (Ahmed, 2021). Livestock belonging to local people and nomadic communities are mostly left unattended in the upper reaches of the National Park, serving as easy prey for wild predators. Our findings indicate that leopards caused damage to these communities through livestock depredation, with households that reported predation having larger livestock holdings (mean: 307 ± SD 33) than those reporting no predation (mean: 96 ± SD 17). The high economic losses suffered by low-income households result in more negative attitudes towards the predator (Bagchi & Mishra, 2006; Suryawanshi et al., 2014; Bhatia et al., 2017). However, age seemed to improve the attitudes of people towards the common leopard, indicating that older people were more tolerant of this predator.

TABLE 4 Spearman correlation between predation control practices and total livestock holdings of respondents involved in the survey in Kishtwar National Park, Jammu and Kashmir, India. For each predation control practice, we provide the correlation coefficient and corresponding P-value.

Predation control practice	Correlation coefficient	P-value
Animal husbandry improvements	0.34	0.01
Avoidance of high-risk areas	0.14	0.25
Compensation for damages caused	0.35	0.00
Selective removal of problem animals	−0.09	0.45
Eradication of predator species	−0.34	0.01

The long-term success of a protected area depends upon the support of local communities, whose contribution to wildlife conservation is driven by their attitudes towards wildlife (Gusset et al., 2009; Krishnakumar et al., 2020). Our study indicates that financial compensation for livestock losses is a fundamental component in improving human–wildlife coexistence, as was reported by 58% of the respondents, followed by avoidance of high-risk areas (31%) and improving animal husbandry practices (29%). This is in contrast to previous findings (Oli et al., 1994) showing that the majority of respondents (60%) thought that total eradication of problematic animals was the only solution worth considering.

Of the many recommendations that have been proposed previously (Pettigrew et al., 2012; Clark & Rutherford, 2014; Jackson, 2015; Karanth et al., 2018), financial compensation has been identified as one of the most effective approaches to address human–carnivore conflict (Jackson et al., 2010; Dickman et al., 2011; Suryawanshi et al., 2013; Chen et al., 2016). Proponents of compensation contend that it increases tolerance for wildlife, decreases retaliatory killings and strengthens community support for conservation (Agarwala et al., 2010; Pettigrew et al., 2012; Rosen et al.,

2012; Persson et al., 2015; Chen et al., 2016; Krishnakumar et al., 2020). Despite the government mandate supporting compensation payments in India, the evaluation, implementation and payment procedures vary across the Indian states (Karanth et al., 2018). The public perception of predators could be altered through the implementation of an effective, cross-sector and collaborative financial compensation scheme for livestock losses, which is currently lacking in Jammu and Kashmir, but such schemes have been implemented in 26 other states across India (Karanth et al., 2018). In light of the rising incidence of negative human–wildlife interactions in the region and throughout Jammu and Kashmir, effective mechanisms for reporting and responding to depredation and providing compensation should be developed with community participation. The sustainability of financial compensation can be ensured through insurance schemes, or with full or partial funding by the Department of Wildlife Protection or an external agency, processes that have been adopted in other states across India. These schemes can achieve positive conservation outcomes when tailored to local settings.

Achieving carnivore conservation whilst preserving human well-being in human-dominated landscapes has become a major challenge for conservationists (Athreya et al., 2015). Conflict reduction in nations such as India, where human–wildlife coexistence is mostly involuntary, will necessitate not just educating people but also changes to the social and economic setting (Bombieri et al., 2023). Together with a carefully designed financial compensation programme, improved animal husbandry practices (e.g. guarded corrals, fenced livestock yards, guard dogs and kraaling livestock during night time; McManus et al., 2015; Naha et al., 2020) could have a significant impact on the management of human–wildlife conflict in Kishtwar National Park. In addition, a sustained education and awareness programme regarding the significance of conserving carnivores and their prey base, particularly amongst younger stakeholders, is required to raise the social carrying capacity of wildlife in the protected area. The insights from our study have implications for such a conflict management programme and could help determine the future of human–carnivore conflict in the region.

Author contributions Study design: MAK, NS; data collection: MAK; data analysis: MAK, AS; writing: MAK; revision: all authors.

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Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards. In the absence of a local institutional research ethics committee we describe in the Methods how the research met appropriate ethical standards. We obtained permission for carrying out the research from the Department of Wildlife Protection, Government of Jammu and Kashmir (letter no. WLP/Res/2017-18/659-62, dated 12 October 2017). We obtained informed verbal consent from all respondents prior to the interviews and we anonymized the data obtained.

Data availability The data that support the findings of this study include information obtained through interviews with individuals. To uphold privacy and ethical standards, these data are available on request from the corresponding author.

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