Building evidence for conservation globally

Journal of Threatened Taxa

10.11609/jott.2024.16.6.25283-25494
www.threatenedtaxa.org

26 June 2024 (Online & Print)
16(6): 25283-25494
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Open Access

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

For Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scope
For Article Submission Guidelines, visit https://threatenedtaxa.org/index.php/JoTT/about/submissions
For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: Emperor Tamarin *Saguinus imperator*: a look into a better world through the mustache lens – mixed media illustration. © Maya Santhanakrishnan.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 June 2024 | 16(6): 25283–25298

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.8567.16.6.25283-25298

#8567 | Received 02 June 2023 | Final received 22 May 2024 | Finally accepted 31 May 2024

OPEN ACCESS

ARTICLE

Measuring people's attitude towards conservation of Leopard *Panthera pardus* (Mammalia: Carnivora) in the foothills of Himalayan region

Megha Rani [1], Sujeet Kumar Singh [2], Maximilian L. Allen [3], Puneet Pandey [4] & Randeep Singh [5]

[1,2,5] Amity Institute of Forestry and Wildlife, Amity University, Gautam Buddha Nagar, Uttar Pradesh 201301, India.
[3] Illinois Natural History Survey, University of Illinois, 1816S, Oak Street, Champaign, IL, 61820, USA.
[4] Conservation Genome Resource Bank for Korean Wildlife (CGRB), Research Institute for Veterinary Science and College of Veterinary Medicine, Seoul National University, Seoul, Republic of Korea.
[1] smegha808@gmail.com, [2] btsujeet@gmail.com (corresponding author), [3] maxallen@illinois.edu, [4] puneet.pandey09@gmail.com, [5] randeep04@rediffmail.com

Abstract: Measuring people's attitudes about the large carnivores involved in human-wildlife interface, also termed conflict or interaction, is an essential aspect of developing effective conservation and management planning for human-carnivore coexistence. Human-leopard (*Panthera pardus*) interaction is widespread and one of the most pressing conservation issues within the global range of leopards. However, there is a scarcity of information on local people's opinions and attitudes concerning carnivores in human-dominated areas. Our current study focused on understanding the human dimensions of human-leopard interactions in the multi-purpose landscape situated in the foothills of Shiwalik Himalaya, Uttarakhand, India. Between January and May 2022, we conducted a semi-structured questionnaire survey (N = 266) to understand how socio-demographic factors impact the attitudes of local people toward leopard conservation in the Rajaji Tiger Reserve, Uttarakhand, India. Overall, 61.7% of respondents had positive attitudes toward leopards and supported leopard conservation, primarily attributed to the aesthetic value of leopards. Using ordinal logistic regression models, we found that male respondents and individuals with higher education had a positive attitude towards leopard conservation. The majority of respondents who conveyed positive attitudes towards leopard conservation belonged to the more educated socio-demographic groups. As a follow-up, specific studies need to be conducted on local people's attitude about compensation or compassionate payments, often disbursed as compassionate payments, the response of the forest department to prevailing conflict, and current awareness programs. These can be crucial factors towards shaping the attitude of local respondents and promote human-leopard coexistence.

Keywords: Coexistence, economic loss, felid-conservation, human-leopard conflict, human-leopard interaction, human-leopard interface, people's attitude, socio-demographic factors, Uttarakhand.

Editor: L.A.K. Singh, Bhubaneswar, Odisha, India.

Date of publication: 26 June 2024 (online & print)

Citation: Rani, M., S.K. Singh, M.L. Allen, P. Pandey & R. Singh (2024). Measuring people's attitude towards conservation of Leopard Panthera pardus (Mammalia: Carnivora) in the foothills of Himalayan region. *Journal of Threatened Taxa* 16(6): 25283–25298. https://doi.org/10.11609/jott.8567.16.6.25283-25298

Funding: None.

Competing interests: The authors declare no competing interests.

Author details: Megha Rani pursuing PhD on human-wildlife interaction at the corridor of Rajaji- Corbett Tiger Reserve, Uttarakhand at Amity University. Her research focuses on human-wildlife conflict and its spatio-temporal pattern. Dr. Sujeet Kumar Singh, assistant professor at Amity University has more than 13 years of research experience in conservation genetics and wildlife forensics of large carnivores. Dr. Randeep Singh, associate professor, at Amity University, has more than 18 years of experience in ecology, environment science remote sensing, and GIS (forestry and ecology) from the Indian Institute of Remote Sensing. Dr. Puneet Pandey, senior researcher at Seoul National University is a wildlife scientist, educator, and conservationist, with more than 13 years of experience in research, and teaching of conservation genetics, wildlife crime investigation. Dr. Alllen Maxmillan is a carnivore biologist at the University of Illinois and Illionis Natural History Survey. His primary research focus is using camera trapping to understand solitary carnivores and ecological interactions.

Author contributions: Conceptualization: Megha Rani, Sujeet Kumar Singh, Randeep Singh; Writing - original draft preparation: Megha Rani; Methodology: Megha Rani, Sujeet Kumar Singh, Randeep Singh; Formal analysis and investigation: Megha Rani; Writing - review and editing: Megha Rani, Sujeet Kumar Singh, Randeep Singh, Maximilian L. Allen, Puneet Pandey; Funding acquisition: NA; Supervision: Sujeet Kumar Singh, Randeep Singh

Ethics declaration: We obtained permission to conduct the survey from the principal chief conservator of forest, Uttarakhand Forest Department, (letter no. 2380/5-6 dated 9-2-2021, letter no 2949/5-6, date 17-05-2022,). We obtained verbal consent from the respondents who were interviewed, and they were briefed about the purpose of collecting the information. Additionally, informed consent was obtained from all individual participants included in the study before conducting the surveys, and all respondent information was protected to ensure that the right to privacy was not violated.

Acknowledgements: We are grateful to the director, Amity Institute of Forestry and Wildlife, Amity University, Noida, for their encouragement. We appreciate all the respondents for their active participation in the survey. For assistance with conducting a survey and providing human-leopard conflict data, we thank forest officials, forest guards, UK Forest Department.

INTRODUCTION

Humans have had an impact on the terrestrial ecosystem for millennia by converting a large portion of the earth's surface to anthropogenic land usage (Barnosky et al. 2012; Ellis et al. 2013). An increasing number of large carnivore species have been forced to coexist with humans in altered landscapes as a result of landscape change (Galán-Acedo et al. 2019). This habitat sharing at the human-wildlife interface has led to a greater number of conflicts between large carnivores and people in many areas, with negative effects on both local people's livelihoods and biodiversity conservation (Biset et al. 2019; Lamb et al. 2020). Across the world, approximately 82% of the total distributional ranges of carnivores fall outside of protected areas and are threatened by different human activity all over the world (Braczkowski et al. 2023). These threats are mostly related to competition with humans for habitat, prey, and livestock (Graham et al. 2005; Treves et al. 2006; Wang & Macdonald 2006). This is important because habitat loss, prey depletion, and the illegal killing of carnivores are the main causes of the decline of carnivore populations globally (Ripple et al. 2014).

Over the past few decades, tigers *Panthera tigris* and leopards have been among the species involved in human-wildlife conflict, associated with increased incidence of attacks on people and livestock in India (Naha et al. 2018). Among both predators, leopards are quite often seen in the human-wildlife interface (outside of protected areas on the outskirts of human settlements), where the transition between people and forest areas makes them more prone to interaction with humans (Rahalkar 2008; Athreya et al. 2013; Naha et al. 2018). Globally, human-leopard interaction revolves around livestock depredation (Ogada et al. 2003; Katel et al. 2014; Pena Mondragon et al. 2017) or attacks on humans (Athreya et al. 2011; Kshettry et al. 2017; Packer et al. 2019). As a result, leopards are often killed in retaliation, placing them at greater risk and increasing the vulnerability of their populations (Mishra et al. 2003; Treves & Karanth 2003; Nyhus & Tilson 2004), as mortalities from human-wildlife interaction can contribute to declines in carnivore populations (Fuller 2001; Nowell & Jackson 1996; Butchart et al. 2010). Leopard numbers are decreasing globally because of habitat degradation, decline in prey base, retaliatory killing, and poaching for body parts (Jacobson et al. 2016; Stein et al. 2020). The International Union for the Conservation of Nature recently changed the classification of the leopard from 'Near Threatened' to 'Vulnerable' in 2016 due to exploitation, a decrease in its habitat, and loss of prey base (Stein et al. 2020). The leopard is the most adaptive and widely dispersed large carnivore in both Asia and Africa (Jacobson et al. 2016), distributed across many ecosystems ranging from tropical forests, desert savannah, and alpine ranges (Nowell & Jackson 1996) to the outskirts of cities (Odden et al. 2014).

Human-leopard negative interaction is a serious management and conservation issue because of opposition to and intolerance for large carnivores by people in human-dominated landscapes (MacLennan et al. 2009). Identification of interface areas can help to develop management strategies to reduce negative interactions, but it is crucial to have the support of local communities for any conservation efforts (Pooley et al. 2021). During the past several decades, India's population has increased by more than double, leading to increased interactions between humans and leopards who live close to protected areas (Jhala et al. 2020). As a result, leopards have attacked and killed people in different areas throughout India, and leopards were also killed in retaliation (Mishra et al. 2003; Treves & Karanth 2003; Nyhus & Tilson 2004; Chauhan et al. 2000; Badola et al. 2021; Ahmed & Khan 2022). Due to attacks and fear, conservation measures to protect apex predators can be contentious and may face opposition from local communities (Graham et al. 2005). In response to these emerging threats and due to the ecological importance of species, different strategies have been implemented to promote human-leopard coexistence. These include establishing conservation incentives (Woodroffe et al. 2005; Dickman et al. 2011), livestock insurance schemes (Morrison et al. 2009; Mishra et al. 2016), and incorporating local people in conservation governance.

Understanding human attitudes toward leopards is an essential aspect of human-leopard coexistence in shared landscapes (Marchini 2014; Verdade et al. 2014). Recent studies have highlighted many factors with respect to sociocultural and socioeconomic aspects, such as local community identity and values, social positioning, political influence, and cultural viewpoints (Manfredo et al. 2009; Dickman et al. 2013; Pooley et al. 2017) influencing people's attitude towards large carnivore conservation in shared landscapes, for example, age, gender, education levels, and family size (Yosef 2015; Mekonen 2020; Merkebu & Yazezew 2021; Penjor et al. 2021), livestock depredation, husbandry practices (Biru et al. 2017; Mkonyi et al. 2017; Teixeira et al. 2021), type of human-carnivore interaction, diversity of livelihoods, size of the land owned, and the number of livestock owned (Gebresenbet et al. 2018; Biset et

al. 2019; Western et al. 2019). It is evident that social, political, and cultural variables influence big carnivore persistence (Aiyadurai 2016; Redpath et al. 2017; Athreya et al. 2018). One such example associated with cultural viewpoint was presented in the study conducted by Ghosal (2013) which reported that in Maharashtra large carnivores like tigers and leopards are worshiped as 'Waghoba/Waghya dev', for both fear and respect. In the political aspect, one such reason is the lack of lethal control of carnivore populations in India, which may have contributed to opinionated perception of the shared landscapes (Majgaonkar et al. 2019). Unfortunately, the cultural and socio-political aspects of people-carnivore interactions cannot be measured in the same way that ecological evaluations can (Karanth et al. 2009). In India, the conservation of large carnivores, particularly occurring outside of protected areas, is still challenging. Leopards have coexisted with humans in multiple-use landscapes for centuries (Athreya et al. 2015), but studies on factors influencing their coexistence mechanism like the people's attitude towards leopard conservation are scarce.

Our current study focused on understanding the human dimensions of human-leopard interactions in the multiuse landscape situated in the foothills of Shiwalik Himalaya, Uttarakhand India. The purpose of this study was to identify the components that account for human attitude toward leopards, their conservation, and the motivations for these attitudes. This includes (1) examining local people's attitudes toward leopard conservation and (2) identifying the determinants (demographic, socioeconomic, and previous encounters with leopards such as attacks on humans and/or livestock) influencing local people's attitudes toward leopard conservation in the vicinity of Rajaji Tiger Reserve. We formulated three hypotheses to address the study objectives: (1) Men would more likely support leopard conservation as women are less exposed to carnivores than males, and they are less tolerant of them (Røskaft et al. 2003; Mir et al. 2015); (2) Educational status would affect the attitude toward leopard conservation. Highly educated people being more favourable towards leopard conservation, education can improve carnivore tolerance by rationalizing attitudes (Woodroffe et al. 2005) and enhancing people's perspectives on predator conservation, and shaping their attitudes (Espinosa & Jacobson 2012); and (3) People who lost humans and/or livestock to wildlife in the past were expected to have negative attitudes towards such animals (Mir et al. 2015), and that past leopard experience would negatively affect the attitude towards leopard conservation.

MATERIALS AND METHODS

Study area

We conducted the household survey in two ranges (Motichur range and Shyampur range) of Rajaji Tiger Reserve (Figure 1). We selected two study sites based on high density of leopard (16.90 ±1.44/100 km^2; Jhala et al. 2021), (45 leopard (35–36 95% HPD level) /100 km^2; Yadav et al. 2019) and a human-leopard negative interaction hotspot region (Harihar et al. 2011). The Motichur and Shyampur range of the Rajaji Tiger Reserve (820 km^2), covers an area of 113 km^2 and 101 km^2 (Figure 1). The Rajaji Tiger Reserve (RTR) is situated in the lesser Himalayan zone and the upper Gangetic plains biogeographic zone (Rodgers & Panwar 1988). The climate is subtropical type with three distinct seasons winter, summer, and rainy with a temperature range that varies 23–46 °C in summer and a minimum of 5 °C during winter. The annual rainfall varies 1,200–1,500 mm. Within a 5-km radius of RTR, there are over 100 settlements, but our study area consists of 13 villages with a total population of 28,449 with 13,170 male and 15,279 female (Uttarakhand Population census 2011), and many of the population rely on adjacent forest resources such as fuelwood, fodder, grass, livestock foraging ground, and locally available non-timber forest products (Badola 1997; Chandola et al. 2007). The vegetation consists of northern tropical moist and dry deciduous forests with species such as *Shorea robusta, Mallotus philippensis, Kydia calycina, Dalbergia sissoo, Acacia catechu, Ougeinia oojeinensis*, and *Terminalia* spp. The dominant vegetation of the area is comprised of Sal *Shorea robusta*, Rohini *Mallotus philippensis*, Khair *Acacia catechu*, Haldu *Adina cordifolia*, Bahera *Terminalia bellirica*, Bargad *Ficus benghalensis*, and Shisham *Dalbergia sissoo*. Prime mammalian fauna of the park consists of tiger, leopard, Sloth Bear *Melursus ursinus*, Striped Hyaena *Hyaena hyaena*, Barking Deer *Muntiacus muntjak*, Goral *Nemorhaedus goral*, Chital *Axis axis*, Sambar *Cervus unicolor*, Wild Boar *Sus scrofa*, and among reptilian fauna the Mugger Crocodile *Crocodylus palustris* and King Cobra *Ophiophagus hannah* (Joshi 2016). Motichur and Shyampur ranges were chosen based on the recommendations of forest department employees and local key informants, who reported a high prevalence of conflict in these two ranges. Most of the communities in this area are (1) Garhwalis and Kumaonis, hill inhabitants who are marginal farmers and also engaged in private jobs, and (2) Gujjars, the transhumance pastoralists who live inside the forest and breed cattle.

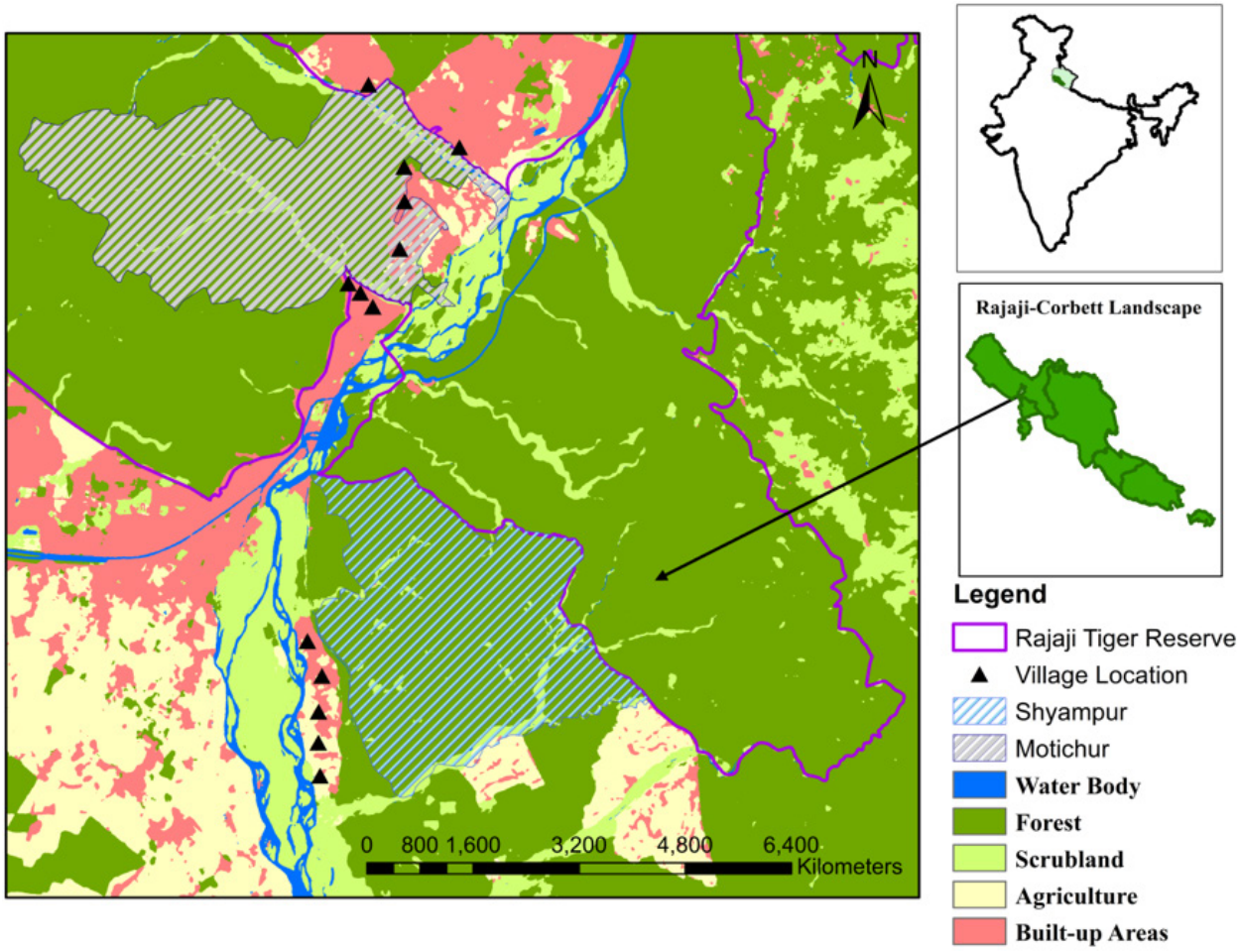

Figure 1. Study area location with the location of surveyed villages in Rajaji Tiger Reserve, Uttarakhand, India from January 2022 to May 2022 (N = 266).

Data collection

We first collected the reported conflict incidents involving livestock predation and human casualties by leopards from the year 2010 to 2021 from the Uttarakhand Forest Department and our survey (for the details regarding methodology see Supplementary Material Text S1). Thereafter, we collected the resident's attitudes on human-leopard negative interaction along with their response to the conservation of leopards in the RTR. The literature analysis helped to construct the questionnaire for the survey (Naha et al. 2018; Yadav et al. 2019) (Appendix 1). The questionnaire was pre-tested with 30 respondents before being surveyed. A local forest guard was present initially at the start of each interview for a formal introduction about the subject matter and to increase the community acceptance. Prior informed consent was obtained verbally from all participants. Their responses were later translated into English during analysis. Each interview lasted for 40–45 minutes. A total of 266 randomly selected households were interviewed during a survey from 13 villages in both study sites (Motichur and Shyampur range) of RTR between January to May 2022 using a semi-structured questionnaire (a standard set of questions that included both open and close-ended questions) in the local language (Hindi), with a systematic sample of 10% of families per village and maintaining an average distance of 500-800m between each residence in the corresponding village. The questionnaire comprised three sections: (i) sociodemographic (gender, age, family size, education, occupation, income, livestock head) and experience of the respondent with leopards (any human casualties or livestock depredation by these animals in respondents' family in the last 10 years); (ii) question on attitude toward leopard conservation – to what extent do you agree that leopard conservation is important? The latter qualitative questions were recorded on a five-point Likert scale as strongly disagree (-2), disagree (-1), neutral (0), agree (1),

and strongly agree (2), while the prior questions were recorded on nominal scales (Supplementary Material Table S1). Thereafter, we identified a total of eight predictor variables (Table 1), chosen from attitude-based studies done in the past on wildlife conservation (Krester et al. 2009; Mkonyi et al. 2017).

Data analysis

We quantified and analyzed all eight predictor variables that could potentially impact people's attitudes toward the conservation of leopards. We checked the independent variables for multicollinearity and found all the variables had generalized variance inflation factor (GVIF) <5 (Fox & Monette 1992), indicating the absence of collinearity among the predictor variables (Supplementary Material Table S2). We used Ordinal Logistic Regression (OLR) to model ordinal dependent variables as a function of continuous or categorical predictor variables (Warner 2008; Adejumo & Adetunji, 2013) using the 'MASS' package with 'polr' function against all independent variables (Eboli & Mazzulla 2009; Mutanga et al. 2016; Auster et al. 2019; Liang et al. 2020). We used this initial global model to understand the importance and significance of each variable. Thereafter, we formulated 12 potential models using the 'AICcmodavg' package using all eight predictor variables (Johnson & Omland 2004) to understand drivers of attitudes. We used the Akaike information criterion corrected for small sample sizes (AICc) to select the most plausible models (ΔAICc <2) to describe the people's attitude toward leopard conservation (Burnham & Anderson 2004). We computed the measure of association between different explanatory variables and outcomes using the odds ratio (Auster et al. 2019). We performed all statistical analysis for data collected on different parameters of human-leopard negative interactions in R v. 4.2.1 (R Development Core Team 2022) and the statistical software IBM SPSS Statistics 26.0 (IBM SPSS 2019).

RESULTS

Socio-economic condition of locals

Out of all respondents (N = 266), 62% were male (N = 165) (Figure 2). Most of the people had primary education (42%; N = 112), followed by secondary education, graduation, and illiterate status (Figure 2). Based on the questionnaire survey, 44% of people were mid-d (41–60 years age class), with an average age of 47 (±SE 0.9) (Figure 2). Out of all occupations, service and daily wage labour were the two major occupations, employing nearly 74% (N = 196) of the people (Figure 2). Out of all the respondents, 41% (N = 110) of annual income ranged between INR 100,000–500,000 (Figure 2). The average livestock owned per household was 3.45 (±SE 0.34). The average landholding size per household was 0.03 (±SE 0.005 ha). The average family size was found to be 6.36 (±SE 0.19). Approximately, 58% (N = 154) of households reported being dependent on forest resources for their livelihood (i.e., for fuelwood, non-timber forest product (NTFPs), and grass). Out of all the respondents 44% (N = 117) were dependent on fuelwood as well as alternate fuel; 26% (N = 68) alone were dependent on fuelwood and 29% (N = 78) were dependent on commercial fuel. Most of the respondents (70%, N = 186) owned livestock which included cattle (74%), goats (18%), and poultry (8%).

The overall attitude towards conservation

From the survey, significantly most of the respondents had positive attitudes towards leopards (61.7%), then

Table 1. Variables at the village level used in regression models to predict the attitude of people towards leopard conservation in Rajaji Tiger Reserve, Uttarakhand.

Theme	Variable (Abbreviation)	Description	Data scale
Socio-economic	Gender (Gen)	Gender of the respondent. Two levels: Male and Female.	Nominal
	Employment (Emp)	Occupation of the respondents.	Nominal
	Past leopard experience (PLE)	Experience of losses incurred due to leopards such as human casualty (attack/death), and livestock depredation. Two levels: Yes or No	Nominal
	Annual income (INR)	Dependence of respondents on income-generating activities. Four levels: <50,000, 50,000–100,000, 100,000–500,000, >500,000	Nominal
	Age in years	The age group of the respondent. Three levels: 18–40, 41–60, >60.	Nominal
	Family Size (Fs)	Number of family members in a household. Three levels: 0–3, 4–6, >6	Nominal
	Livestock-head (LH)	Number of livestock in each respondent household. Four levels: 0–5, 6–10, 11–15, >15	Nominal
	Education (Edu)	Education received at the time of the interview. Four levels: Illiterate, Primary School (1–10), Secondary (10–12), Graduate and above.	Nominal

neutral (20.7%) or negative (17.7%) attitudes ($\chi 2 = 19.75$, df = 2, p <0.005) (Figure 3). There was also a significant difference in degree to which respondents agreed on the conservation of leopards ($\chi 2 = 17.76$, df = 4, p <0.005). Out of all the respondents, 33% (N = 88) strongly agreed with conserving leopards in the surrounding landscape, while 26% (N = 69) strongly disagreed (mean = 0.3, ± SE 0.09) (Figure 4). The positive attitude of local communities towards leopard presence in their surrounding environment indicated that respondents found leopards to be important in the environment. Out of all the respondents who had faced livestock death (10%) due to predation along with human injury and death (5%) had a marginal negative attitude towards leopards which accounted for (4%), and thought that leopard predation on livestock occurred due to the easy availability in the surrounding vicinity. Out of all the reported human casualties, most of these occurred inside PAs while collecting fuelwood. Sixty-one percent of the people in the study area were not aware of the role of leopards, 25% believed their primary role was to kill livestock whereas 9% stated that they helped maintain ecological balance (Supplementary Material Figure S1). Fifty-nine percent of respondents believed that availability of domestic prey, i.e., livestock attracted leopards towards human habitation and 26% of respondents stated that the decline of wild prey was the primary reason for leopard predation (Supplementary Material Figure S2).

Socio-economic drivers of people's attitude towards leopards and their conservation

The ordinal logistic regression resulted that, the persons having a positive attitude toward the importance of leopard conservation were positively related to gender (male) (ß = 0.75, p = 0.004) and high literacy (ß = 0.82, p = 0.06) (Table 2). Thereafter, people with very few livestock-head (ß = −0.27) and moderate annual income (ß = −0.17) had a negative influence but did not significantly affect the people's attitude toward inference on the importance of leopard conservation (Table 2). However, employment (ß = 0.97), and households experiencing livestock predation or human casualties (ß = 0.17) were found to have a positive but non-significant influence on the support of leopard conservation.

In our model comparison analyses predicting the socio-economic drivers of leopard conservation, we obtained three top models based on ΔAICc values (ΔAICc <2) (Table 3; Supplementary Material Table S3). The first top model signified that the predictor variables including gender (ß = 0.40), age (ß = 0.05), and education of people (ß = 0.26) influenced the attitude of people on leopard conservation (ΔAICc = 0.00, *w* = 0.28; Table 3). While in the second top model, gender (ß = 0.43), family size (ß = -0.10), livestock head (ß = 0.18), and education (ß

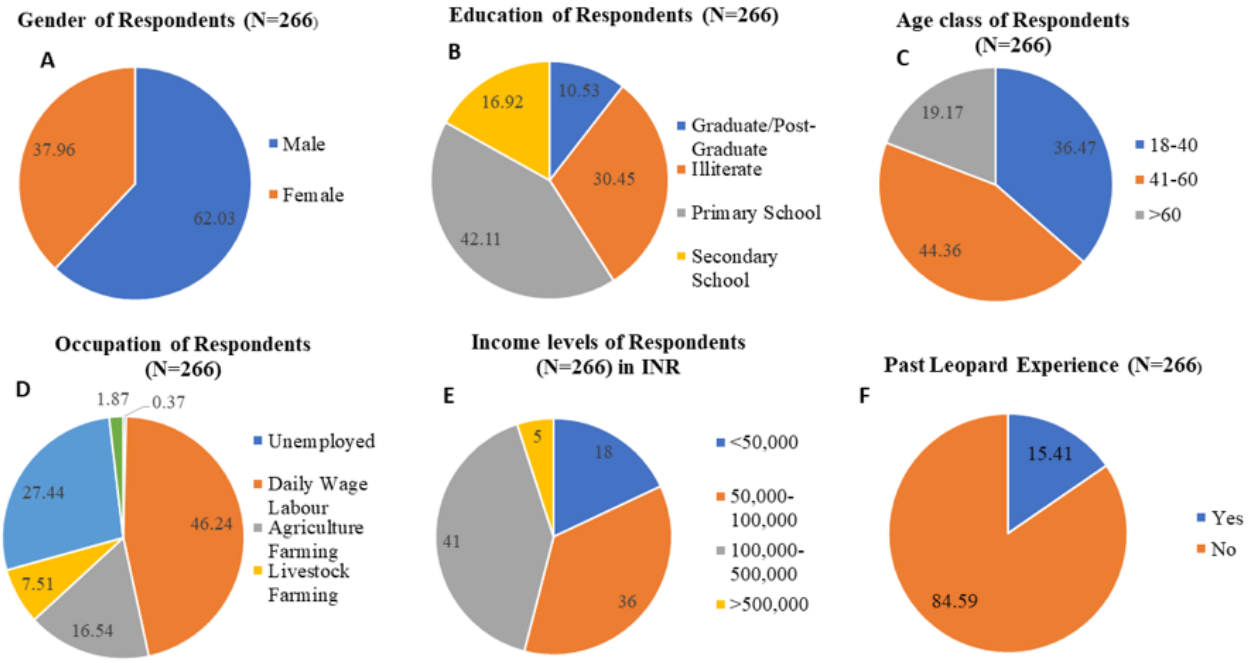

Figure 2. Socio-demographic attributes (gender, education, age, occupation, and income) and past leopard experience of respondents (N = 266) in Rajaji Tiger Reserve, Uttarakhand.

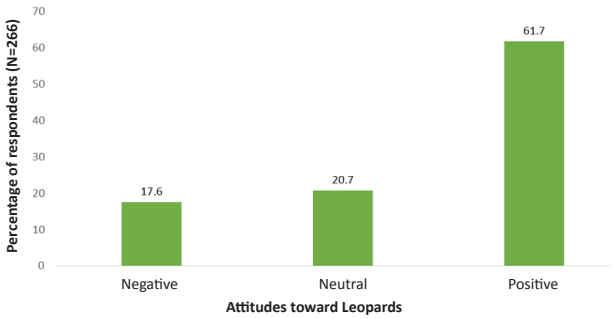

Figure 3. Attitude of people (N = 266) towards leopards in Rajaji Tiger Reserve, Uttarakhand.

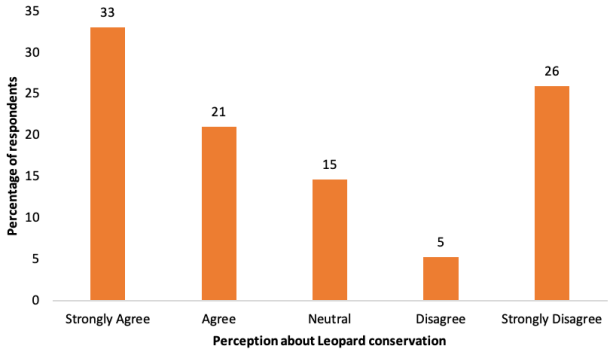

Figure 4. Attitude of people (N = 266) towards leopard conservation in Rajaji Tiger Reserve, Uttarakhand.

= 0.26) were the predictors of people's attitude toward leopard conservation (ΔAICc = 0.26, *w* = 0.25; Table 3). In the third top model, gender (ß = 0.39), age (ß = 0.06), employment (ß = 0.03), and education (ß = 0.28) were the best predictors of people's attitude toward leopard conservation (ΔAICc = 1.94, *w* = 0.11; Table 3).

DISCUSSION

Conflicts between people and large felids (including tigers and leopards) are common, especially where people reside in proximity to forests in human-dominated landscapes (Inskip & Zimmermann 2009; Malviya & Ramesh 2015). An excellent example of this is the Rajaji-Corbett landscape, where there have been many human-feline conflicts in and around the parks, with disputes being recorded by numerous households, villages, and Gujjar communities (Malviya & Ramesh 2015). Our study highlights the factors (i.e., the gender and education of respondents) that play a significant role in the attitude of local people toward leopards' conservation in the Rajaji landscape. Specifically, we found males were more likely to support leopard conservation, and the person with higher education (i.e., graduate and post-graduate people) at the household level was more likely to influence support toward leopard conservation. These factors play an important role in influencing the attitudes of local people and the success of human-felid coexistence.

The attitude of local people is an important consideration for the conservation of leopards (Kshettry et al. 2017). The majority of respondents in our study area were in favour of leopard conservation. One possible explanation for our findings, as expressed by the local community, was that the habitat would get conserved to assist protection and existence of the species. Permanent human habitation is connected with increasing exposure to large carnivores. Ericsson & Heberlein (2003) proposed this to explain public attitudes towards mesopredators, which was later demonstrated by Røskaft et al. (2003) for the people exposed to large carnivores in Norway. Our study highlighted that the respondents had differentiated opinions positive (61.7%) as well as negative attitudes (17.7%) about leopards. Most of the respondents generally had a positive attitude towards leopards, which may be attributed to the financial incentives dispensed to locals following human/livestock loss due to leopard predation (Badola et al. 2021); in some cases, financial incentives may even promote coexistence (Mishra et al. 2003; Dickman et al. 2011). However, programmes whose primary goal is to provide large compensation payouts typically fail to build tolerance towards predators (Bautista et al. 2019) which may be reflected in our study area as some people had a negative attitude toward leopards.

Our results are consistent with research on conflicts with wild animals (Davenport et al. 2010; Thornton & Quinn 2010) that show a mix of attitudes toward coexistence with wildlife (Szinovatz 1997; Gidey et al. 2011). After the recovery of tigers in the Rajaji Tiger Reserve, leopards shifted their distribution and diet, indicating that leopards were forced to inhabit the peripheral habitats along the park boundary since livestock are only available in the villages located in the surrounding forested areas (Harihar et al. 2011). Therefore, a significant increase in the occurrence of domestic prey in the diet of leopards from 7% to 32% over the four years (Harihar et al. 2011) reflects the shift in dietary habits of leopards. It appears that leopards started killing livestock and attacking people because of frequent visits near to human settlements. This may have led to some negative human-leopard interactions and negative attitudes among local people. Similar studies

Table 2. Ordinal Logistic Regression analysis of variables affecting attitude towards leopard conservation, Rajaji Tiger Reserve, Uttarakhand. We note significant values as: *p <0.05, **p <0.01, and ***p <0.001.

						97.5% CI for odds ratio		
Independent variable	**Category**	**β**	**S.E.**	**t**	**Odds Ratio**	**Lower**	**Upper**	**P**
Gender	Male	0.75	0.27	2.82	2.12	1.25	3.56	0.004*
	Female (reference)	0.00						
Age	41–60	0.21	0.28	0.73	1.23	0.71	2.12	0.46
	>60	-0.003	0.35	-0.01	0.99	0.49	2	0.99
	18–40 (reference)	0.00						
Family Size	4–6	-0.142	0.49	-0.29	0.87	0.33	2.27	0.77
	>6	-0.14	0.51	-0.27	0.87	0.32	2.36	0.78
	0–3 (reference)	0.00						
Livestock-head	6–10	-0.27	0.38	-0.71	0.76	0.36	1.60	0.47
	11–15	-0.64	0.75	-0.86	0.52	0.11	2.28	0.38
	>15	0.12	0.65	0.18	1.13	0.31	4.09	0.84
	0–5(reference)	0.00						
Education	Primary	0.01	0.28	0.06	1.01	0.58	1.77	0.95
	Secondary	0.49	0.36	1.36	1.64	0.80	3.34	0.17
	Graduate and above	0.82	0.44	1.84	2.27	0.94	5.45	0.06·
	Illiterate (reference)	0.00						
Employment	Service	0.97	1.57	0.61	2.63	0.11	57.64	0.54
	Agriculture	0.41	1.54	0.26	1.50	0.07	31.08	0.79
	Daily wages	0.63	1.55	0.41	1.87	0.09	39.59	0.68
	Livestock farming	2.19	1.61	1.36	8.97	0.38	211.75	0.17
	Others	0.45	1.80	0.25	1.58	0.04	54.28	0.79
	No source of Income (reference)	0.00						
Past leopard experience	Yes	0.16	0.31	0.54	1.18	0.64	2.18	0.58
	No (reference)	0.00						
Income	50,000–100,000	-0.16	0.36	-0.47	0.84	0.41	1.70	0.64
	100,000–500,000	-0.18	0.36	-0.49	0.83	0.41	1.70	0.62
	>500,000	0.06	0.65	0.09	1.06	0.29	3.85	0.92
	<50,000 (reference)	0.00						

in Uttarakhand also reported that livestock predation by leopards tends to create a negative attitude (Naha et al. 2018; Mukeka et al. 2019). We observed that households having more livestock held positive attitudes toward leopard conservation but did not play a significant role in shaping conservation attitudes toward leopards. This is similar to other studies where people's attitude is positively associated with the number of livestock owned and negatively associated with livestock lost to predators (Naughton-Treves et al. 2003; Kideghesho et al. 2007).

Our results indicate that the employment status of people did not have any significant negative effect on leopard conservation. But in our study area, unemployed people with no or low formal education primarily depend on NTFPs (Non-timber forest products) from the forest in the form of fodder grasses, dry and fallen twigs and branches, leaf litter, and leaves, fiddlehead, locally known as lingda which has some medicinal properties and edible. This resource dependency is mainly due to free access to forest resources for the poor or low-income groups for their livelihood (Islam et al. 2015). Most of the respondents in the interview mentioned: 'Alternative fuels are expensive for me, and it has become a compulsion to visit the forest and collect fuelwood to

Table 3. Model comparison using Akaike information criterion corrected for small sample sizes (AICc) showing best top three models (ΔAICc <2) and β coefficient values to identify factors influencing the attitude of local people towards leopard conservation in Rajaji Tiger Reserve, Uttarakhand. We also report the number of parameters (k), the change in AICc scores (ΔAICc), the AIC weight (w), and the loglikelihood (LL). We note significant values as: *p <0.05, **p <0.01, and ***p <0.001.

Models	K	AIC_c	ΔAICc	w	LL	Adjusted R^2	Parameters	B	SE	P
Gender+Age+ Education	5	1001.00	0.00	0.28	-495.39	0.030	Intercept	-0.75	0.39	0.060
							Gender	0.40	0.20	0.052
							Age	0.05	0.14	0.686
							Education	0.26	0.10	0.011*
Gender+ Family Size+ Livestock Head+ Education	6	1001.26	0.26	0.25	-494.47	0.033	Intercept	-0.67	0.50	0.182
							Gender	0.43	0.20	0.030*
							Family Size	-0.10	0.16	0.510
							Livestock Head	0.18	0.14	0.204
							Education	0.26	0.10	0.009**
Gender+Age+ Employment+ Education	6	1002.95	1.95	0.11	-495.31	0.027	Intercept	-0.84	0.47	0.073
							Gender	0.39	0.21	0.065
							Age	0.06	0.14	0.642
							Employment	0.03	0.09	0.70
							Education	0.28	0.10	0.010*

meet my daily needs'. These factors tend to develop positive attitudes of people, who visit forests and collect non-timber forest products (Krishnakumar & Nagarajan 2020), toward leopard conservation.

Our results illustrated that men have a more positive attitude towards leopard conservation in our study area than women. In previous studies, gender also played a substantial role in predicting local people's perceptions of wildlife (Teixeira et al. 2021). Women are more involved in forest-based chores, so they are more prone to negative interaction with wildlife than men, as has been found in other studies (Mkonyi et al. 2017; Trajçe et al. 2019). Previous research studies around RTR (Wildlife Institute of India 2005) reported that the women's participation in the eco-development committees was low and they were more involved in accomplishing everyday chores (Chandola et al. 2007). The finding of our study has been consistent with other studies which showed the negative attitude of women due to greater fear of dangerous carnivores (Roskaft et al. 2003; Kaltenborn et al. 2010; Prokop & Tunnicliffe 2010). Possibly it is the result of less exposure to leopards than in men, who frequently confront them in defense of their families and livestock (Roskaft et al. 2003; Goldman et al. 2010).

Although it is believed that education broadens people's perspectives (Carter et al. 2012). Poverty, low literacy, and meagre money are also thought to contribute to negative perceptions of carnivores, such as the Sundarban Tiger (Inskip et al. 2013). Education and awareness about predators can sometimes ameliorate negative attitudes (Bruskotter & Wilson 2014; Lyngdoh et al. 2017) and mitigate conflict due to improved knowledge of the risks and drivers of conflict (Treves & Karanth 2003). Our results showed that respondents with formal education (i.e., graduates and post-graduates) expressed a more positive attitude toward leopard conservation than those without any formal education. Our finding confirms those of previous studies that showed that formal education can improve attitudes and increase tolerance levels for large carnivores (Lindsey et al. 2005; Woodroffe et al. 2005; Parker et al. 2014). We did not find any significant association between age and family size with an attitude of locals toward leopards' conservation.

We acknowledge some limitations of our study. Our study only focused on the sociodemographic, and economic factors affecting people's attitude toward the conservation of leopards. But we did not quantify the wildlife values, interest in animals, empathy, norms, habits, and other ecological variables in our analysis. Other limitations were representativeness. It is especially in relation to accessibility to victims' households related to human casualties by leopards, gender biases, and our constraints with manpower time. In spite of these limitations, our study highlights the effectiveness of coexistence among the local community in mitigating human-leopard conflicts in and around RTR. This study could be further used for future research on leopards and also on the management and conservation of

leopards in the area. Since the conservation of leopards involves and affects the local population of RTR, the factors that foster such positive perceptions of leopards should be acknowledged and linked ecologically for further research on mitigating leopard-human negative interaction. In our study area 47% of the respondents proposed solar fencing as an effective mitigating tool leading to coexistence (Supplementary Material Figure S3).

CONCLUSIONS AND RECOMMENDATIONS

Our findings have implications for leopard conservation in and around Rajaji Tiger Reserve. Despite attacks on humans and livestock, our research findings demonstrate that there is crucial local support for leopard conservation, which could aid in the survival of leopard populations. However, the villagers who expressed prejudice toward leopards (26%) should not be ignored because it may lead to retaliatory killing. Women and people with low education levels have been reported to have negative attitudes toward leopards' conservation; this cohort should be recognized and offered a particular conservation programme. A specific study based on local perception about compensation payments and the response of the forest department to a prevailing conflict should also be conducted as it can be a crucial factor in shaping the attitude of local respondents. Awareness programs should focus more on people who are less positive, less educated, and less knowledgeable about wildlife. These measures would improve people's attitudes toward wildlife in general and increase community awareness of wildlife conservation (Lindsey et al., 2005). Park management should put effort towards refuting the existing perception and better foster ties between the park and the community. Multiple strategies could be used to target impacted communities, and deciding the ones that are most suited should be done together with the participation of concerned communities so that they represent their cultural environment and are more likely to draw community support.

The finding of our study suggests that the local communities play a vital role as major stakeholders in effective conservation of leopards, and they promote coexistence with carnivore together with the support of government officials. These partnerships can not only help shape an individual attitude towards species conservation but also can increase community engagement towards awareness programs for knowledge of leopard importance. Sensitizing the local community about the need to conserve wildlife can help develop tolerance towards carnivores (Woodroffe et al. 2005), but it is sometimes difficult to develop a positive attitude among the community who are intolerant towards large carnivores due to lacking interest (Kaczensky 2003). Therefore, it is recommended that to address the negative as well as positive attitude, there be widespread community awareness, the development of alternative livelihood options that lessen the pressure on wildlife, and the development of efficient HWC mitigation measures in designated areas of RTR. The Forest department at RTR has installed solar power fencing at some places along village boundaries. It serves as an effective measure to reduce HWC incidents (Krishnaswamy et al. 2022) and minimise encroachment on forest land until management authorities take necessary action. Such conservation and management inputs need to be further installed and repaired, as most of the time fencing is damaged due to the frequent movement of elephants at places where no boundary is demarcated between villages and PAs (Jasmine et al. 2015).

Data availability

The data used in this study are provided in Supplementary Information.

REFERENCES

Adejumo, A.O. & A.A. Adetunji (2013). Application of ordinal logistic regression in the study of students' performance. *Mathematical Theory and Modeling* 3: 10–19.

Ahmed, T. & A. Khan (2022). Economics of carnivore depredation: A case study from the northern periphery of Corbett Tiger Reserve, Uttarakhand, India. *Acta Ecologica Sinica* 42(2): 68–73. https://doi.org/10.1016/j.chnaes.2021.03.007

Aiyadurai, A. (2016). 'Tigers are Our Brothers' Understanding Human-Nature Relations in the Mishmi Hills, Northeast India. *Conservation and Society* 14(4): 305–316. https://doi.org/10.4103/0972-4923.197614

Athreya, V., M. Odden, J.D.C. Linnell & K.U. Karanth (2011). Translocation as a tool for mitigating conflict with leopards in human-dominated landscapes of India. *Conservation Biology* 25: 133–141.

Athreya, V., M. Odden, J.D.C. Linnell, J. Krishnaswamy & K.U. Karanth (2013). Big cats in our backyards: persistence of large carnivores in a human dominated landscape in India. *Public Library of Science One 8*(3): e57872. https://doi.org/10.1371/journal.pone.0057872

Athreya, V., A. Srivathsa, M. Puri, K.K. Karanth, N.S. Kumar & K.U. Karanth (2015). Spotted in the News: Using Media Reports to Examine Leopard Distribution, Depredation, and Management Practices outside Protected Areas in Southern India. *Public Library of Science One* 10(11): e0142647. https://doi.org/10.1371/journal.pone.0142647

Athreya, V., S. Pimpale, A.S. Borkar, N. Surve, S. Chakravarty, M. Ghosalkar, A. Patwardhan & J.D.C. Linnell (2018). Monsters or gods? Narratives of large cat worship in western India. Cat News 67: 23–26.

Auster, R.E., A. Puttock & R. Brazier (2020). Unravelling perceptions of Eurasian beaver reintroduction in Great Britain. *Area* 52: 364–375. https://doi.org/10.1111/area.12576

Badola, R. (1997). Economic Assessment of Human-Forest

Interrelationship in the Forest Corridor Linking the Rajaji and Corbett National Parks. Ph.D. Thesis, Jiwaji University, Gwalior (India), Department of Economics. Wildlife Institute of India, Dehradun.

Badola R., T. Ahmed, A. K. Gill, P. Dobriyal, G.C. Das, S. Badola & SA. Hussain (2021). An incentive-based mitigation strategy to encourage coexistence of large mammals and humans along the foothills of Indian Western Himalayas. *Scientific Reports* 11(1): 5235. https://doi.org/10.1038/s41598-021-84119-7

Barnosky, A.D., E.A. Hadly, J. Bascompte, E.L. Berlow, J.H. Brown, M. Fortelius, W.M. Getz, J. Harte, A. Hastings, P.A. Marquet & N.D. Martinez (2012). Approaching a state shift in Earth's biosphere. *Nature* 486(7401): 52–58. https://doi.org/10.1038/nature11018

Bautista, C., E. Revilla, J. Naves, J. Albrecht, N. Fernández, A. Olszańska, M. Adamec, T. Berezowska-Cnota, P. Ciucci, C. Groff & S. Härkönen (2019). Large carnivore damage in Europe: Analysis of compensation and prevention programs. *Biological Conservation* 235: 308–316. https://doi.org/10.1016/j.biocon.2019.04.019

Biru, Y., Z.K. Tessema & M. Urge (2017). Perception and attitude of pastoralists on livestock-wildlife interactions around Awash National Park, Ethiopia: implication for biodiversity conservation. *Ecological Processes* 6: 1–13. https://doi.org/10.1186/s13717-017-0081-9

Biset, A., G. Mengesha & Z. Girma (2019). Human-wildlife conflict in and around Borena Sayint National Park, northern Ethiopia. *Human-Wildlife Interactions* 13(1): 111–124. https://doi.org/10.26076/fk60-mp27

Braczkowski, A.R., C.J. O'Bryan, C. Lessmann, C. Rondinini, A.P. Crysell, S. Gilbert, M. Stringer, L. Gibson & D. Biggs (2023). The unequal burden of human-wildlife conflict. *Communications Biology* 6(1): 182. https://doi.org/10.1038/s42003-023-04493-y

Bruskotter, J. T. & Wilson, R.S (2014). Determining where the wild things will be: using psychological theory to find tolerance for large carnivores. *Conservation Letters* 7(3): 158–165. https://doi.org/10.1111/conl.12072

Burnham, K.P. & D.R. Anderson (2004). Multimodel inference: Understanding AIC and BIC in model selection. *Sociological Methods and Research* 33: 261–304. https://doi.org/10.1177/0049124104268644

Butchart, S.H., M. Walpole, B. Collen, A.V. Strien, J.P. Scharlemann, R.E. Almond, J.E. Baillie, B. Bomhard, C. Brown, J. Bruno & K.E. Carpenter (2010). Global biodiversity: indicators of recent declines. *Science* 328(5982): 1164–1168. https://doi.org/10.1126/science.1187512

Carter, N.H., S.J. Riley & J. Liu (2012). Utility of a psychological framework for carnivore conservation. *Oryx* 46(4): 525–535. https://doi.org/10.1017/S0030605312000245

Chandola, S., R. Badola & S.A. Hussain (2007). Factors Affecting Women's Participation in Conservation Programmes in and Around Rajaji National Park. *Journal of the Indian Anthropological Society* 42: 11–21.

Chauhan, D.S., S.P. Goyal, M. Agarwal & R. Thapa (2000). A study on distribution, relative abundance and food habits of Leopard (Panthera pardus) in Garhwal Himalayas". Technical Report – 1999–2000, Wildlife Institute of India, Dehradun, India.

Davenport, M.A., C.K. Nielsen & J. Mangun (2010). Attitudes toward mountain lion management in the Midwest: Implications for a potentially recolonizing large predator. *Human Dimensions of Wildlife* 15(5): 373-388.

Dickman, A.J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation* 13(5): 458–466. https://doi.org/10.1111/j.1469-1795.2010.00368.x

Dickman, A.J., E.A. Macdonald & D.W. Macdonald (2011). A review of financial instruments to pay for predator conservation and encourage human-carnivore coexistence. *Proceeding of National Academy of Science* USA 108: 13937–13944. https://doi.org/10.1073/pnas.1012972108

Dickman, A.J., S. Marchini & M. Manfredo (2013). The human dimension in addressing conflict with large carnivores, pp. 110–126. https://doi.org/10.1002/9781118520178.ch7

Eboli, L. & G. Mazzulla (2009). An ordinal logistic regression model for analysing airport passenger satisfaction. *European-Mediterranean Journal of Business*. 4. 40-57. https://doi.org/10.1108/14502190910956684

Ellis, E.C., D.Q. Fuller, J.O. Kaplan & W.G. Lutters (2013). Dating the Anthropocene: Towards an empirical global history of human transformation of the terrestrial biosphere. *Elementa* 1: 000018. https://doi.org/10.12952/journal.elementa.000018

Ericsson, G. & T.A. Heberlein (2003). Attitudes of hunters, locals, and the general public in Sweden now that the wolves are back. *Biological Conservation* 111: 149–159. https://doi.org/10.1016/S0006-3207(02)00258-6

Espinosa, S. & S. Jacobson (2012). Human-wildlife conflict and environmental education: Evaluating a community programme to protect the Andean bear in Ecuador. *The Journal of Environmental Education* 43: 55–65. https://doi.org/10.1080/00958964.2011.579642

Fox, J. & G. Monette (1992). Generalized collinearity diagnostics. *Journal of the American Statistical Association* 87(417): 178–183.

Fuller, T.K. & P.R. Sievert (2001). Carnivore demography and the consequences of changes in prey availability, pp. 163–178. In: Gittleman, J.L., S.M. Funk, D.W. Macdonald & R.K. Wayne (eds.). *Carnivore Conservation*. Cambridge University Press, London.

Goldman, M.J., J.R. de Pinho & J. Perry (2010). Maintaining complex relations with large cats: Maasai and lions in Kenya and Tanzania. *Human Dimensions of Wildlife* 15: 332–346. https://doi.org/10.1080/10871209.2010.506671

Galán-Acedo, C., V. Arroyo-Rodríguez, E. Andresen, L. Verde Arregoitia, E. Vega, C.A. Peres & R.M. Ewers (2019). The conservation value of human-modified landscapes for the world's primates. *Nature Communications* 10(1): 152. https://doi.org/10.1038/s41467-018-08139-0

Gebresenbet, F., H. Bauer, J.M. Vadjunec & M. Papes (2018). Beyond the numbers: Human attitudes and conflict with lions (*Panthera leo*) in and around Gambella National Park, Ethiopia. *Public Library of Science One* 13(9): 1–17. https://doi.org/10.1371journal.pone.0204320

Graham, K., A.P. Beckerman & S. Thirgood (2005). Human–predator–prey conflicts: ecological correlates, prey losses and patterns of management. *Biological Conservation* 122(2): 159–171.

Harihar, A., B. Pandav & S.P. Goyal (2011). Responses of leopard Panthera pardus to the recovery of a tiger Panthera tigris population. *Journal of Applied Ecology* 48(3): 806–814.

IBM Corp. Released (2019) IBM SPSS Statistics for Windows, Version 26.0. Armonk, IBM Corp., NY.

Inskip, C. & A. Zimmermann (2009) Human-felid conflict: a review of patterns and priorities worldwide. *Oryx 43*(1): 18–34. https://doi.org/10.1017/S003060530899030X

Inskip, C., M. Ridout, Z. Fahad, R. Tully, A. Barlow, C.G. Barlow, M.A. Islam, T. Roberts, & D. MacMillan (2013). Human–tiger conflict in context: risks to lives and livelihoods in the Bangladesh Sundarbans. *Human Ecology* 41: 169–186. https://doi.org/10.1007/s10745-012-9556-6

Islam, M.A., R. Rai, S.M.S. Quli & M.S. Tramboo (2015). Socio-economic and demographic descriptions of tribal people subsisting in forest resources of Jharkhand, India. *Asian Journal of Bio Science* 10(1): 75–82. https://doi.org/10.15740/HAS/AJBS/10.1/75-82

Jacobson, A.P., P. Gerngross, J.R. Lemeris Jr, R.F. Schoonover, C. Anco, C. Breitenmoser-Würsten, S.M. Durant, M.S. Farhadinia, P. Henschel, J.F. Kamler & A. Laguardia (2016). Leopard (*Panthera pardus*) status, distribution, and the research efforts across its range. *PeerJ* 4: e1974 (eCollection 2016). https://doi.org/10.7717/peerj.1974

Jasmine, B., D. Ghose & S.K. Das (2015). An attitude assessment of human-elephant conflict in a critical wildlife corridor within the Terai Arc Landscape, India. *Journal of Threatened Taxa* 7(2): 6843–6852. https://doi.org/10.11609/JoTT.o3914.6843-52

Jhala, Y.V., Q. Qureshi & A.K. Nayak (2019). Status of tigers, copredators and prey in India, 2018. National Tiger Conservation Authority, Govt.

of India, New Delhi and Wildlife Institute of India, Dehradun. TR No./2019/05.

Jhala, YV., Q. Qureshi & S.P. Yadav (2020). Status of leopards, co-predators, and megaherbivores in India, 2018. In National Tiger Conservation Authority. Government of India, New Delhi, and Wildlife Institute of India, Dehradun. Technical Report TR/2020/16.

Johnson, J.B. & K.S. Omland (2004). Model selection in ecology and evolution. *Trends in Ecology and Evolution* 19: 101–108.

Joshi, R. (2016). Mammalian fauna of Rajaji National Park, India: a review on ecological observations and checklist. *Check List* 12(3): 1892–1892. https://doi.org/10.15560/12.3.1892

Kaltenborn, BP., T. Bjerke & J. Nyahongo (2010). Living with problem animals: Selfreported fear of potentially dangerous species in the Serengeti region, Tanzania. *Human Dimensions of Wildlife* 11: 397–409.

Karanth, K.K., J.D Nichols, J.E. Hines, K.U. Karanth, & C. Norman L (2009). Patterns and determinants of mammal species occurrence in India. *Journal of Applied Ecology* 46(6): 1189–1200.

Katel, O.N., S. Pradhan & D. Schmidt-Vogt (2014). A survey of livestock losses caused by Asiatic wild dogs, leopards and tigers, and of the impact of predation on the livelihood of farmers in Bhutan. *Wildlife Research* 41: 300–310. https://doi.org/10.1071/WR14013

Kideghesho, J., E. Røskaft & B. Kaltenborn (2007). Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. *Biodiversity and Conservation* 16: 2213–2230. https://doi.org/10.1007/s10531-006-9132-8

Kretser, H.E., P.D. Curtis, J.D. Francis, R.J. Pendall & B.A. Knuth (2009). Factors affecting perceptions of human–wildlife interactions in residential areas of northern New York and implications for conservation. *Human Dimensions of Wildlife* 14(2): 102–118.

Krishnakumar, B.M. & R. Nagarajan (2020). Living with Leopard Panthera pardus fusca (Mammalia: Carnivora: Felidae): livestock depredation and community perception in Kalakkad-Mundanthurai Tiger Reserve, southern Western Ghats. *Journal of Threatened Taxa* 12(10): 16210–16218. https://doi.org/10.11609/jott.5206.12.10.16210-16218

Krishnaswamy, V., N. Singh, M. Sharma, N. Verma & A. Verma (2022). Application of CRISP-DM methodology for managing human-wildlife conflicts: an empirical case study in India. *Journal of Environmental Planning and Management* 1–27. https://doi.org/10.1080/09640568.2022.2070460

Kshettry, A., S. Vaidyanathan & V. Athreya (2017). Leopard in a tea-cup: a study of leopard habitat-use and human-leopard interactions in north-eastern India. *Public Library of Science One* 12: 1–15. https://doi.org/10.1371/journal.pone.0177013

Lamb, C.T., A. T. Ford, B. N. McLellan, M. F. Proctor, G. Mowat, L. Ciarniello, S. E. Nielsen & S. Boutin (2020). The ecology of human–carnivore coexistence. *Proceedings of the National Academy of Sciences* 117(30): 17876–17883. https://doi.org/10.1073/pnas.1922097117

Liang, J., G. Bi & C. Zhan (2020). Multinomial and ordinal Logistic regression analyses with multi-categorical variables using R. *Annals of Translational Medicine* 8(16):982. https://doi.org/10.21037/atm-2020-57

Lindsey, P.A., J.T. Du Toit & M.G.L. Mills (2005). Attitudes of ranchers towards African wild dogs Lycaon pictus: Conservation implications on private land. *Biological Conservation* 125: 113–121. https://doi.org/10.1016/j.biocon.2005.03.015

Lyngdoh, S., V.B. Mathur & B.C. Sinha (2017). Tigers, tourists and wildlife: visitor demographics and experience in three Indian Tiger Reserves. *Biodiversity and Conservation* 26: 2187–2204. https://doi.org/10.1007/s10531-017-1352-6

Maclennan, S.D., R.J. Groom, D.W. Macdonald & L.G. Frank (2009). Evaluation of a compensation scheme to bring about pastoralist tolerance of lions. *Biological Conservation* 142(11): 2419–2427.

Majgaonkar, I., S. Vaidyanathan, A. Srivathsa, S. Shivakumar, S. Limaye & V. Athreya (2019). Land-sharing potential of large carnivores in human-modified landscapes of western India. *Conservation Science and Practice* 1(5): e34. https://doi.org/10.1111/csp2.34

Manfredo, M.J., T.L. Teel & K.L. Henry (2009). Linking society and environment: a multilevel model of shifting wildlife value orientations in the Western United States. *Social Science Quaterly* 90(2): 407–427. https://doi.org/10.1111/j.1540-6237.2009.00624.x

Malviya, M. & K. Ramesh (2015). Human–felid conflict in corridor habitats: implications for tiger and leopard conservation in Terai Arc Landscape, India. *Human-Wildlife Interactions* 9(1): 5. https://doi.org/10.26077/x9tx-gb97

Marchini, S. (2014). Who's in Conflict with Whom? Human Dimensions of the Conflicts Involving Wildlife. In: Verdade, L., Lyra-Jorge, M., Piña, C. (eds) Applied Ecology and Human Dimensions in Biological Conservation. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-54751-5_13

Merkebu, S. & D. Yazezew (2021). Assessment of human-wildlife conflict and the attitude of local communities to wild animal conservation around Borena Sayint National Park, Ethiopia. *International Journal of Ecology* Vol. 2021:1–8. https://doi.org/10.1155/2021/6619757

Mekonen, S. (2020). Coexistence between human and wildlife: The nature, causes and mitigations of human wildlife conflict around Bale Mountains National Park, Southeast Ethiopia. *BioMed Central Ecology* 20(1): 51. https://doi.org/10.1186/s12898-020-00319-1

Mir, Z.R., A. Noor, B. Habib & G.G. Veeraswami (2015). Attitudes of local people toward wildlife conservation: A case study from the Kashmir Valley. *Mountain Research and Development* 35: 392–400. https://doi.org/10.1659/MRD-JOURNAL-D-15-00030.1

Mishra, C., B. Rutherford, T. Thinkley, K. Sonam, A. Bijoor & R. Timbadia (2016). Setting up mechanisms to offset wildlife-caused economic damage: community-based livestock insurance. *The PARTNERS Principles for Community-Based Conservation* Snow Leopard Trust, Seattle, USA.

Mishra, C., P. Allen, T.O.M. McCarthy, M.D. Madhusudan, A. Bayarjargal & H.HT. Prins (2003). The role of incentive programmes in conserving the snow leopard. *Conservation Biology* 17: 1512–1520.

Mkonyi, F.J., A.B. Estes, M.J. Msuha, L.L. Lichtenfeld & S.M. Durant (2017). Socio-economic correlates and management implications of livestock depredation by large carnivores in the Tarangire ecosystem, northern Tanzania. *International Journal of Biodiversity Science, Ecosystem Services and Management* 13(1): 248–263. https://doi.org/10.1080/21513732.2017.1339734

Morrison, K., R. Victurine & C. Mishra (2009). Lessons learned, opportunities and innovations in human wildlife conflict compensation and insurance schemes.

Mukeka, J.M., J.O. Ogutu, E. Kanga & E. Røskaft (2019). Human-wildlife conflicts and their correlates in Narok County, Kenya. *Global Ecology and Conservation* 18: e00620. https://doi.org/10.1016/j.gecco.2019.e00620

Mutanga, C.N., E. Gandiwa, N. Muboko & S. Vengesayi (2016). Prospects for wildlife conservation: Local community views and factors influencing conservation relationships in Zimbabwe. *Annals of Social and Behavioural Science* 2: 57–75.

Naha, D., S. Sathyakumar & G.S. Rawat (2018). Understanding drivers of human-leopard conflicts in the Indian Himalayan region: spatio-temporal patterns of conflicts and perception of local communities towards conserving large carnivores. *Public Library of Science One* 13: e0204528. https://doi.org/10.1371/journal.pone.0204528

Naughton-Treves, L.I.S.A., R. Grossberg & A. Treves (2003). Paying for tolerance: Rural citizens' attitudes towards wolf depredation and compensation. *Conservation Biology* 17: 1500–1511. https://doi.org/10.1111/j.1523-1739.2003. 00060.x

Ghosal, S. (2013). Intimate beasts: exploring relationships between humans and large carnivores in Western India (Ph. D. thesis.). *Norwegian University of Life Sciences*, Ås, Norway.

Nowell, K & P. Jackson (eds.) (1996). *Wild Cats: Status Survey and Conservation Action Plan* (Vol. 382). IUCN, Gland.

Nyhus, P.J. & R. Tilson (2004). Characterizing human–tiger conflict in Sumatra, Indonesia: implications for conservation. *Oryx* 38: 68–74.

Ogada, M.O., R. Woodroffe, N.O. Oguge & L.G. Frank (2003). Limiting depredation by African carnivores: the role of livestock husbandry. *Conservation Biology* 17: 1521–1530.

Odden, M., V. Athreya, S. Rattan & J.D. Linnell (2014). Adaptable neighbours: movement patterns of GPS-collared leopards in human-dominated landscapes in India. *Public Library of Science One* 9(11): e112044. https://doi.org/10.1371/journal.pone.0112044

Packer, C., S. Shivakumar, V. Athreya, M.E. Craft, H. Dhanwatey, P. Dhanwatey, B. Gurung, A. Joshi, H. Kushnir, J.D. Linnell & N.M. Fountain-Jones (2019). Species-specific spatiotemporal patterns of leopard, lion and tiger attacks on humans. *Journal of Applied Ecology* 56(3): 585–593. https://doi.org/10.1111/1365-2664.13311

Parker, D.M., B.M. Whittington-Jones, R.T.F. Bernard & H.T. Davies-Mostert (2014). Attitudes of rural communities towards dispersing African wild dogs in South Africa. *Human Dimensions of Wildlife* 19: 512–522. https://doi.org/10.1080/10871209.2014.926575

Peña-Mondragón, J.L., A. Castillo, A. Hoogesteijn & E. Martínez-Meyer (2017). Livestock predation by jaguars Panthera onca in south-eastern Mexico: the role of local peoples' practices. *Oryx* 51: 254–262. https://doi.org/10.1017/S0030605315001088

Penjor, U., S. Wangdi, T. Tandin & D.W. Macdonald (2021). Vulnerability of mammal communities to the combined impacts of anthropic land-use and climate change in the Himalayan conservation landscape of Bhutan. *Ecological Indicators* 121: 107085. https://doi.org/10.1016/j.ecolind.2020.107085

Pooley, S., M. Barua, W. Beinart, A. Dickman, G. Holmes, J. Lorimer, A.J. Loveridge, D.W. Macdonald, G. Marvin, S. Redpath, C. Sillero-Zubiri, A. Zimmermann & E.J. Milner-Gulland (2017). An interdisciplinary review of current and future approaches to improving human–predator relations. *Conservation Biology* 31(3): 513–523. https://doi.org/10.1111/cobi.12859

Pooley, S., S. Bhatia & A. Vasava (2021). Rethinking the study of human–wildlife coexistence. *Conservation Biology 35*(3): 784–793. https://doi.org/10.1111/cobi.13653

Prokop, P. & S.D. Tunnicliffe (2010). Effects of keeping pets on children's attitudes toward popular and unpopular animals. *Anthrozoös* 23: 21–35.

Rahalkar, K. (2008). Attitudes of local people to conflict with leopards (*Panthera pardus*) in an agricultural landscape in Maharashtra, India. M.Sc. thesis, Centre for Wildlife Studies and National Centre for Biological Sciences, University of Agricultural Sciences, GKVK Campus, Bangalore, India, vi + 37 pp.

Redpath, S.M., J.D. Linnell, M. Festa-Bianchet, L. Boitani, N. Bunnefeld, A. Dickman & E.J. Milner-Gulland (2017). Don't forget to look down–collaborative approaches to predator conservation. *Biological Reviews 92*(4): 2157– 2163. https://doi.org/10.1111/brv.12326

Ripple, W.J., J.A. Estes, R.L. Beschta, C.C. Wilmers, E.G. Ritchie, M. Hebblewhite, J. Berger, B. Elmhagen, M. Letnic, M.P. Nelson & O.J. Schmitz (2014). Status and ecological effects of the world's largest carnivores. *Science* 343(6167): 1241484. https://doi.org/10.1126/science.1241484

Rodgers, W.A. & H.S. Panwar (1988). *Planning a wildlife protected area network in India, Vols. I and II*. Dehradun: Wildlife Institute of India.

Røskaft, E., T. Bjerke, B. Kaltenborn, J.D. Linnell & R. Andersen (2003). Patterns of self-reported fear towards large carnivores among the Norwegian public. *Evolution and Human Behavior* 24(3): 184–198. https://doi.org/10.1016/S1090-5138(03)00011-4

RStudio Team (2022). RStudio: Integrated Development Environment for R. RStudio, PBC, Boston, MA. http://www.rstudio.com/

Singh, S.K., V. Sharma, S. Mishra, P. Pandey, V.P Kumar & S.P. Goyal (2015). Understanding Human–Tiger Conflict around Corbett Tiger Reserve India: A Case Study Using Forensic Genetics. *Wildlife Biology in Practice* 11(1): 1. https://doi.org/10.2461/wbp.2015.11.1

Stein, A.B., V. Athreya, P. Gerngross, G. Balme, P. Henschel, U. Karanth, D. Miquelle, S. Rostro-Garcia, J.F. Kamler, A. Laguardia, I. Khorozyan & A. Ghoddousi (2020). Panthera pardus, Leopard. The IUCN Red List of Threatened Species e.T15954A163991139. https://doi.org/10.1007/978-1-4615-6424-9_34. Accessed on 20 March 2023

Szinovatz, V. (1997). Attitudes of the Norwegian public toward bear and lynx. Diploma Thesis at the Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, Austria.

Teixeira, L., K.C. Tisovec-Dufner, G.D.L. Marin, S. Marchini, I. Dorresteijn & R. Pardini (2021). Linking human and ecological components to understand human–wildlife conflicts across landscapes and species. *Conservation Biology* 35(1): 285–296. https://doi.org/10.1111/cobi.13537

Thornton, C. & M. Quinn (2010). Risk perceptions and attitudes toward cougars in the southern foothills of Alberta. *Human Dimensions of Wildlife* 15(5): 359–372. https://doi.org/10.1080/10871200903582626

Trajçe, A., G. Ivanov, E. Keçi, A. Majić, D. Melovski, K. Mersini, S. Mustafa, T. Skrbinšek, A. Stojanov, A. Todorovska & M. von Arx (2019). All carnivores are not equal in the rural people's view. Should we develop conservation plans for functional guilds or individual species in the face of conflicts?. *Global Ecology and Conservation* 19: e00677. https://doi.org/10.1016/j.gecco.2019.e00677

Treves, A & K.U. Karanth (2003). Human–carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology* 17: 1491–1499.

Treves, A., R.B. Wallace, L. Naughton-Treves & A. Morales (2006). Co-managing human-conflicts: A review. *Human Dimensions of Wildlife* 11: 383–396.

Uttarakhand Population Census, India Village wise-Population (2011). https://censusindia.gov.in/ Accessed Jan 25 2023.

Verdade, L.M., M.C. Lyra-Jorge, C.I. Piña (2014). Redirections in conservation biology, pp. 3–17. In: Luciano M. Verdade, L.M., M.C. Lyra-Jorge & C.I. Piña (eds.). Applied ecology and human dimensions in biological conservation. Springer, viii + 228 pp.

Wang, S.W. & D.W. Macdonald (2006). Livestock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. *Biological Conservation* 129(4): 558–565.

Warner, P. (2008). Ordinal logistic regression. *Journal of Family Planning and Reproductive Health Care* 34(3): 169.

Western, G., D.W. Macdonald, A.J. Loveridge & A.J. Dickman (2019). Creating landscapes of coexistence: Do conservation interventions promote tolerance of lions in human-dominated landscapes? *Conservation and Society* 17(2): 204–217. https://doi.org/10.4103/cs.cs_18_29

WII (2005). The relationships among large herbivores, habitats, and peoples in Rajaji-Corbett national parks: a study in Uttaranchal, India. Wildlife Institute of India, Dehradun.

Woodroffe, R., S. Thirgood & A. Rabinowitz (eds.) (2005). *People and wildlife, conflict or co-existence?* (Vol. 9). Cambridge University Press, xviii + 497 pp. https://doi.org/10.1017/CBO9780511614774.003

Yosef, M. (2015). Attitudes and perceptions of the local people towards benefits and conflicts they get from conservation of the Bale Mountains National Park and Mountain Nyala (*Tragelaphus buxtoni*), Ethiopia. *International Journal of Biodiversity and Conservation* 7(1): 28–40. https://doi.org/10. 5897/ijbc2014.0792

Yadav, S., M. Mohan, D. Sandilaya, P. Boro, A. Sharma, S. Sanatan & K. Ramesh (2019). *Human-Wildlife Conflict: Assessment of socio-psychological perspectives and actual threat from leopard in Motichur Range, Rajaji Tiger Reserve.* Technical Report. Wildlife Institute of India and Uttarakhand Forest Department.

Supplementary Information: Text S1. Methodology

Data used in the present study is a mix of primary and secondary data. Primary data was collected during the survey and by field visits between January–May 2022 in the study area. Whereas secondary data used in the present study were collected from the Uttarakhand Forest Department. We collected official year-wise summary records of total compensation or compassionate grants paid out to individual households from the Uttarakhand Forest Department, suffering livestock loss and human casualties by leopards in the Rajaji Tiger Reserve (RTR) for the past 11 years (2010–2021) to better understand the nature and extent of human-leopard negative interactions. Secondary data was verified via onsite verification of the incident occurrence place in the study area. We recorded information such as livestock predation and human casualties by leopards based on spatial location. Duplicate incidents were removed from the combined primary and secondary survey to obtain the maximum efficacy.

Result: From the year 2010–2021, data were a total number of (N = 84) conflict incidents with leopards. Most incidents involved livestock predation 59% (N = 50) and the remaining involved attacks on humans 41% (N = 34). We found that 48% (N = 24) of attacks by leopards on livestock were on calves, followed by 24% on adult cows (N = 12), and 22% on goats (N = 11). Only 2% of attacks were attributed to sheep and 1% to buffalo. Among attacks by leopards on humans, 62% (N = 21) resulted in a loss of life, with the remaining 38% (N = 13) suffering a major wound.

Table S1. Each predictor variable co-categories were assigned a numerical value and were recoded into categorical variables.

Predictor Variable	Category	Recorded Numeric Output
1. Gender	Male	2
	Female	1
2. Family Size	0–3	1
	4–6	2
	>6	3
3. Livestock head	0–5	1
	6–10	2
	11–15	3
	>15	4
4. Education	Illiterate	0
	Primary	1
	Secondary	2
	Graduate and above	3
5. Employment	Service	1
	Agriculture	2
	Daily wages	3
	Livestock farming	4
	Others	5
	No source of income	0
6. Past leopard experience	No	1
	Yes	2
7. Income	<50,000	1
	50,000–100,000	2
	100,000–500,000	3
	>500,000	4
8. Age	18–40	1
	41–60	2
	>60	3

Table S2. Generalized Variance Inflation Factor (GVIF) to check multicollinearity among the 8 predictor variables.

Variables	GVIF	Explanation for list of explanatory variables included for performing ordinal logistic regression
Gender	1.16	Gender plays a significant role in predicting local people's perception of wildlife (Teixeira et al. 2021). Carnivores were encountered sporadically by women than by men. This is supported by previous research that compared men and women (Mkonyi et al. 2017; Trajçe et al. 2019). This could be due to the fact that men are at the forefront of outdoor activities such as encountering predators to defend their cattle as well as their life. Women are in charge of indoor activities.
Family size	1.06	Families with multiple members require more natural resources such as fuelwood (for domestic energy needs), non-timber forest produce (NTFPs), and livestock grazing, requiring them to spend more time in protected areas and come into contact with carnivores Abukari & Mwalyosi (2018).
Livestock-head	1.08	Support for conservation models appears to be affected by livestock numbers. The number of livestock in a community is a crucial determinant of the interaction between local communities and carnivore conservation. Those with more livestock might suffer more livestock damage and have a negative attitude toward carnivore conservation than those with fewer livestock (Biru et al. 2017; Gebresenbet et al. 2018).
Education	1.06	Respondents with less education are more likely to work in agriculture and rely on native environments for a living. It is well known that a higher degree of education enables alternative livelihoods such as employment possibilities (Lozano et al. 2019; Young et al. 2020). Such alternative activities tend to prevent agricultural-related habitat loss and local people's encroachment on native wildlife habitat, encouraging human-carnivore cohabitation (Lozano et al. 2019).
Employment	1.1	Various occupations/employment can have different attitudes toward wildlife conservation (Dandy et al. 2012).
Past leopard experience	1.09	Those who have had a conflict with predators are less likely to base their views and future actions regarding wildlife conservation on objective facts or information, as these experiences might lead to emotional prejudice and subjectivity (Inskip & Zimmerman 2009; Slagle et al. 2012).
Income	1.1	Persons with higher incomes had a stronger affection for leopard and their conservation. This could be because high-income households are less affected by wildlife than poor families (Dhungana et al. 2016). Better access to conservation awareness, educational benefits, as well as compensation payments, increases the capacity to deal with the potential cost of leopard conservation. Another explanation could be having more livestock may indicate a wealthier family; losing a few livestock from a wealthy family may have little impact, whereas losing the same number of livestock from a poor family can be traumatic (Bhattarai & Fischer, 2014), and thus the potential predator may be perceived as a greater threat to a poor family. Second, an elite family may have more socio-political influence and better accessibility of compensation for predator losses, which may gradually neutralize their negative attitude toward leopards.
Age	1.11	Younger individuals have more positive attitudes toward carnivores (Casey et al. 2005; Suryawanshi et al. 2014) as they are less likely to encounter carnivores.

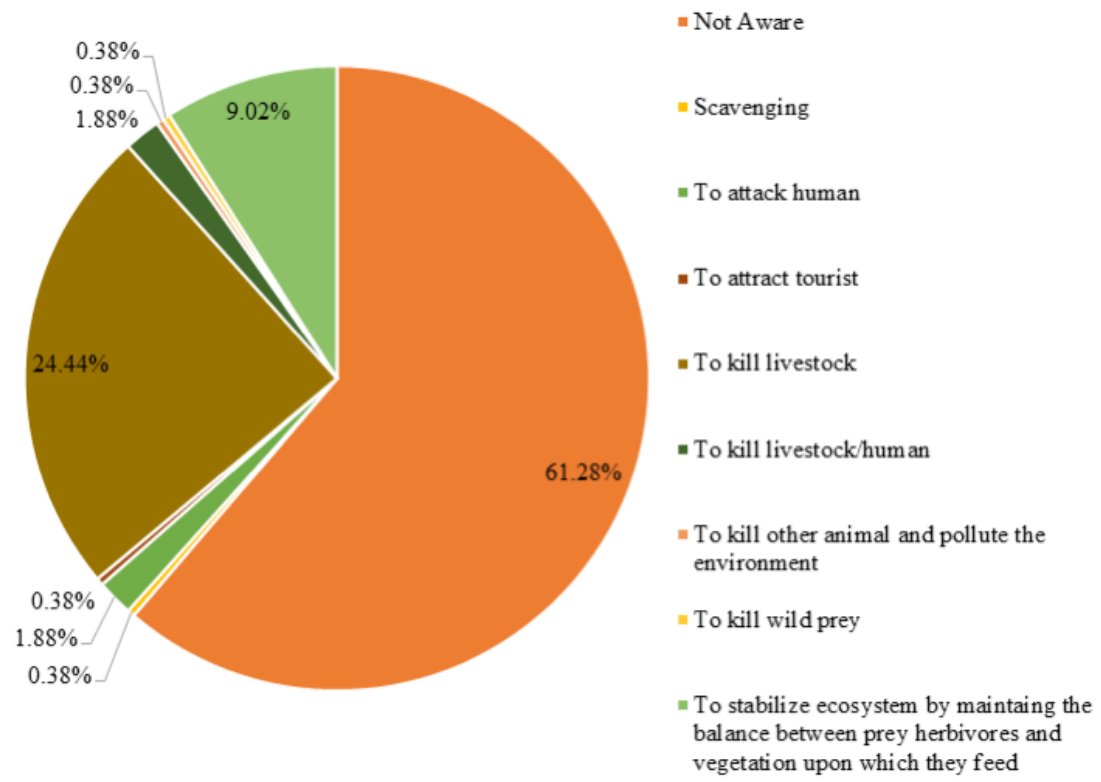

Figure S1. Respondents' perception towards the role of leopard in the RTR.

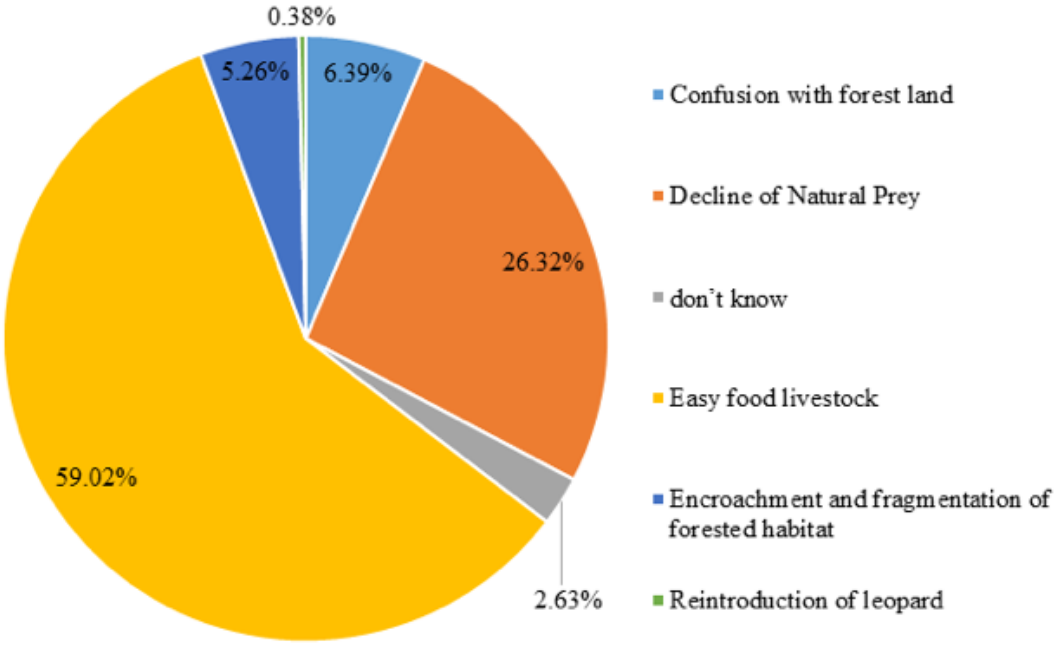

Figure S2. Respondents' perception about leopard predation in the RTR.

Table S3. A model comparison using the Akaike information criterion corrected for small sample sizes (AICc) of all 12 models to identify factors influencing the attitude of local people towards leopard conservation in Motichur and Shyampur range of RTR, Uttarakhand. We also report the number of parameters (k), the change in AICc scores (ΔAICc), the AIC weight (w), and the loglikelihood (LL).

Models	K	AICc	ΔAICc	*w*	LL
Gender + Age + Education	5	1001.00	0.00	0.28	-495.39
Gender + Family size + Livestock head + Education	6	1001.26	0.26	0.25	-494.47
Gender + Age + Employment + Education	6	1002.95	1.94	0.11	-495.31
Gender + Family size + Livestock head + Education + Employment	7	1003.37	2.37	0.09	-494.47
Gender + Family size + Livestock head + Education + Employment + Past leopard experience	8	1003.59	2.58	0.08	-493.51
Gender + Livestock head + Past leopard experience	5	1004.32	3.32	0.05	-497.04
Gender + Family size	4	1005.05	4.05	0.04	-498.45
Gender + Age	4	1005.49	4.49	0.03	-498.67
Gender + Family size + Livestock head + Education + Employment + Past leopard experience + Income	9	1005. 64	4.64	0.03	-493.47
Gender + Family size + Livestock head	5	1006.02	5.02	0.02	-497.89
Gender + Age + Employment	6	1007.49	6.49	0.01	-498.63
Gender + Family size + Livestock head+ Education + Employment + Past leopard experience + Income + Age	10	1007.65	6.65	0.01	-493.39

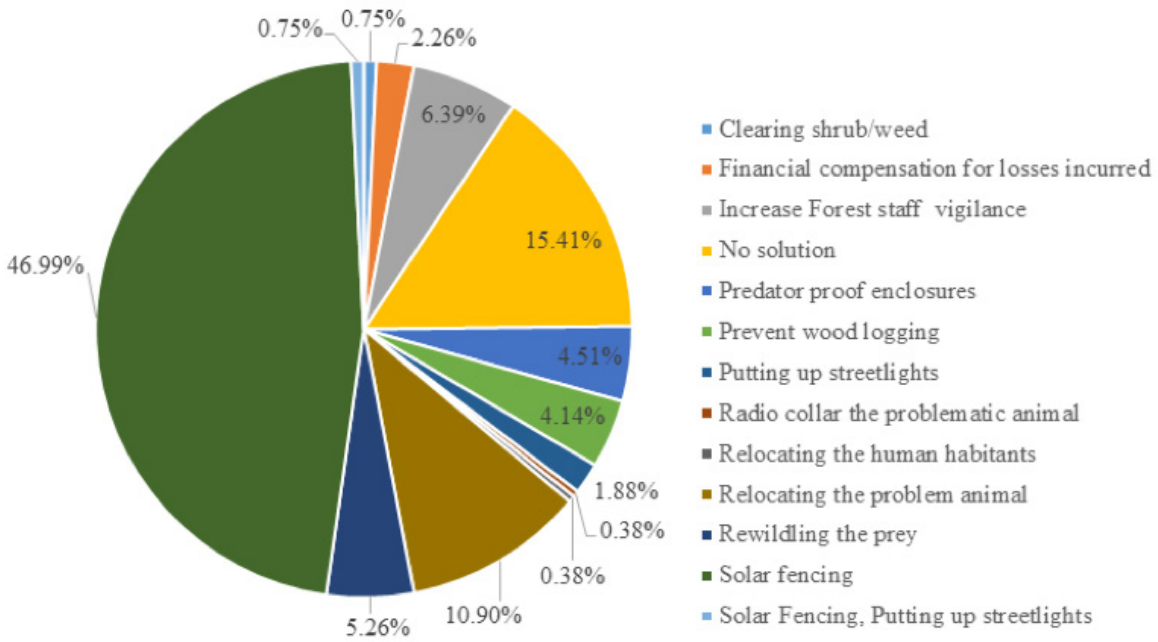

Figure S3. Mitigation measures suggested by residents of Motichur and Shyampur range, RTR.

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

Print copies of the Journal are available at cost. Write to:
The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

June 2024 | Vol. 16 | No. 6 | Pages: 25283–25494
Date of Publication: 26 June 2024 (Online & Print)
DOI: 10.11609/jott.2024.16.6.25283-25494

Publisher & Host

WILD zoo reach
Zoo Outreach Organisation

Threatened Taxa