

Perspectives of traditional Himalayan communities on fostering coexistence with Himalayan wolf and snow leopard

Naresh Kusi^{1,2}  | Claudio Sillero-Zubiri^{1,3} | David W. Macdonald¹ |
Paul J. Johnson¹ | Geraldine Werhahn^{1,3}

¹Wildlife Conservation Research Unit,
Department of Zoology, University of
Oxford, The Recanati-Kaplan Centre,
Tubney, UK

²Resources Himalaya Foundation,
Lalitpur, Nepal

³IUCN SSC Canid Specialist Group,
Oxford, UK

Correspondence

Naresh Kusi, Resources Himalaya
Foundation, GPO box 2448, Kathmandu,
Nepal, Dr. Pralad Yonzon Memorial
Conservation Chautari, Naya Bato,
Lalitpur, Nepal.
Email: naresh.kusi@gmail.com

Abstract

The Himalayan wolf *Canis* sp. and snow leopard *Panthera uncia* are found in the Nepalese Himalayas where conservation efforts target the latter but not the former. We conducted semistructured questionnaire surveys of 71 residents in upper Humla, upper Dolpa, and Kanchenjunga Conservation Area (KCA) during 2014–2016 to understand people's knowledge, perceptions, attitudes and interactions with these two carnivores. We fitted a cumulative link mixed model to predict Likert scale ordinal responses from a series of Generalized Linear Mixed Models. Overall, attitudes were more positive toward snow leopards than wolves. Livestock depredation was the main predictor of the general negative attitude toward wolves (Estimate = -1.30873 ; $p = .029866$) but there was no evidence for an effect for snow leopards (Estimate = -0.3640 ; $p = .631446$). Agropastoralists had more negative attitudes than respondents with other occupations toward both carnivores and men had more positive attitudes than women. Among our study areas, respondents in the community-owned KCA had the most positive attitudes. Our findings illustrate the need to reduce human–carnivore conflict through a combined approach of education, mitigation, and economic cost-sharing with respectful engagement of local communities. Specifically, to encourage more villagers to participate in livestock insurance schemes, they should be improved by including all large carnivores and adjusting compensation to the market value of a young replacement of the depredated livestock type. Carnivore conservation interventions should target the whole predator guild to achieve long-term success and to protect the Himalayan ecosystem at large.

KEYWORDS

compensation, conservation education, depredation, Himalaya, human–carnivore coexistence, Nepal

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2019 The Authors. Conservation Science and Practice published by Wiley Periodicals, Inc. on behalf of Society for Conservation Biology

1 | INTRODUCTION

The Himalayan wolf (currently recommended as *Canis lupus chanco* by Álvares et al., 2019; also see Werhahn et al., 2017, Werhahn et al., 2018) and snow leopard are top carnivores coexisting in the Himalayas and the Qinghai-Tibetan Plateau (QTP) of Asia. As top carnivores, they regulate ecosystem health and processes through trophic interactions with mesopredators, herbivores and the vegetation, facilitating biodiversity and ecosystem resilience (Ripple et al., 2014), and may contribute to nutrient cycling by supporting scavenger diversity (Wilmsers, Crabtree, Smith, Murphy, & Getz, 2003). Their beauty and charisma can provide economic benefits to local communities through tourism (Dickman, Macdonald, & Macdonald, 2011; Maheshwari & Sathyakumar, 2019; Vannelli et al., 2019) and as ambassadors for conservation marketing (Macdonald et al., 2017). Hence, their conservation is of wider interest (Nowell & Jackson, 1996; Treves & Karanth, 2003), but human–carnivore conflicts often hinder conservation efforts.

Human perceptions of carnivores as threats to their livelihoods, combined with the negative impacts humans have on their habitats, and subsequently their survival, are important drivers of human–carnivore conflict (Aryal, Brunton, Ji, Barraclough, & Raubenheimer, 2014; Dar, Minhas, Zaman, & Linkie, 2009; Kellert, Black, Rush, & Bath, 1996). As around the globe, pastoralists in central Asia are persecuting carnivores in response to livestock depredation (Lescureux & Linnell, 2013; Mishra & Fitzherbert, 2004). But pastoral communities in south Asia and QTP China, by virtue of adherence to the basic tenets of Buddhism that include love, respect, and compassion for all life forms (Karmapa & Dorje, 2011), are generally more tolerant of carnivores despite considerable loss of livestock to depredation (Suryawanshi, Bhatia, Bhatnagar, Redpath, & Mishra, 2014). This is explained by the fact that the sacred mountains around Buddhist monasteries constitute safe havens for wildlife including snow leopards and wolves (Li et al., 2014). This positive influence of Tibetan Buddhism provides great potential to, hand in hand with science, strengthen conservation of wildlife and humans alike.

Physical (body size, morphology, etc.) and behavioral traits (movement time and range, food habits, etc.) of carnivores, exposure to risks connected to the animals, together with social and cultural beliefs influence human perceptions and determine attitudes (Kellert et al., 1996). The mountain pastoralists in Asia usually have negative attitudes toward both snow leopards and wolves (Alexander et al., 2015; Bagchi & Mishra, 2006; Chen et al., 2016; Din et al., 2017; Mishra, 1997; Namgail, Fox, & Bhatnagar, 2007; Oli, Taylor, & Rogers, 1994;

Suryawanshi et al., 2014) because these carnivores frequently depredate on livestock, that form the backbone of household economy of pastoralists in the region (Rosen et al., 2012). In recent times, pastoralists in the region have shifted from subsistence to commercial agriculture and animal husbandry (Bauer, 2004; Mishra, 1997), increasing the economic value of livestock. Since the socioeconomic consequences of livestock depredation by carnivores in economically marginalized pastoral communities are usually severe (Aryal et al., 2014; Wang & Macdonald, 2006), livestock depredation is an important factor affecting hostility toward these carnivores. Also, livestock guarding practices in the region are aggravating the situation further, as yaks and horses are currently little tended and range freely in the pasturelands, facilitating the losses of livestock to carnivores (Mishra, 1997). Conservation interventions such as improved corrals and livestock vaccination (Nawaz & Mishra, 2016), financial incentives against carnivore-caused livestock mortalities (Mishra, Redpath, & Suryawanshi, 2016), and carnivore-based ecotourism (Vannelli et al., 2019) have proven effective in mitigating depredation losses in the region.

Conservation of large carnivores like wolves and snow leopards requires a better understanding of their conflict with humans (Namgail et al., 2007) because community perceptions and attitudes affect conservation effectiveness (Ferreira & Freire, 2009). In addition, a proper understanding of the human dimension and related social norms characterizing wildlife conflicts is essential to inform management and ensure local support (Gelcich, Edwards-Jones, Kaiser, & Castilla, 2006; Maden, 2004).

Many studies on human–carnivore conflicts in highland Asia have provided important conservation implications by understanding people's attitudes toward carnivores; either by characterizing the attitudes (Bagchi & Mishra, 2006; Ferreira & Freire, 2009; Liu et al., 2011; Oli et al., 1994; Wang, Lassoie, & Curtis, 2006) or by identifying the drivers for the attitudes (Li et al., 2015; Mishra, 1997; Suryawanshi et al., 2014). But these studies usually present surveyors' opinions as possible solutions rather than including those of local communities. In this study, we add to the efforts of identifying the drivers of attitudes and consider the opinions of the local communities while presenting the possible solutions; complementing that with recommendations from other studies and our own. Insights from the study have proven crucial in planning the conservation actions we look forward to implement by working closely with the local communities.

Throughout the Asian highlands, pastoralists' attitudes toward snow leopards and wolves differ: they show a comparatively better tolerance toward snow leopards

than toward wolves (Din et al., 2017; Jamtsho & Katel, 2019; Li et al., 2015; Maheshwari & Sathyakumar, 2019; Mishra, 1997; Suryawanshi et al., 2014; Suryawanshi, Bhatnagar, Redpath, & Mishra, 2013), even when snow leopards are responsible for higher economic loss than the wolves. Various factors like religion, income, education, species-specific characteristics, and cultural factors can explain the differences (Liu et al., 2011; Mishra, 1997). Tolerance toward wolves is further worsened in the Pamirs of central Asia because wolves are considered as the main problem carnivore in the region (Din et al., 2017; Khan, Ablimit, Nawaz, & Ali, 2014; Mishra & Fitzherbert, 2004).

Studies on attitudes toward carnivores in the Nepalese Himalayas, to date, have been limited to snow leopards (Gurung & Thapa, 2004; Hanson, Schutgens, Lama, Aryal, & Dhakal, 2018; Oli et al., 1994; Schutgens, Hanson, Baral, & Ale, 2018). This can be related to the fact that carnivore conservation in the Nepalese Himalayas has focused primarily on the snow leopard. Activities like carnivore population monitoring and raising conservation awareness, incentives for coexistence such as livestock insurance schemes, compensation schemes, predator-proof corrals, important policy and management documents like DNPWC (2017) and MOFSC (2017) target snow leopard only (notably excluding wolves). The recently amended wildlife damage relief guidelines (GON, 2015) grant compensation for livestock depredation by wolves also, but this provision is still awaiting implementation, and most Himalayan communities of Nepal are unaware of their entitlement to such compensations. This is possibly the first study from Nepal, revealing the differences in attitudes of local people toward wolves and snow leopards and seeking to understand the locally preferred solutions to mitigating human carnivore conflict to ensure that the solutions are sustainable and that they rightly address the local needs.

We conducted this study to provide insights into human–carnivore coexistence by (a) understanding the attitudes of local communities toward the Himalayan wolf and snow leopard in the Nepalese Himalayas, (b) identifying key drivers for these attitudes, and (c) identifying locally preferred conservation solutions to ensure local commitment to carnivore conservation. Based on the results, we discuss how conservation action can benefit from a more inclusive approach.

2 | METHODS

2.1 | Study area

The study comprised three areas in the Nepalese Himalayas: upper Humla (30.19°–30.42°N, 81.48°–81.42°E)

and upper Dolpa (28.97°–29.77°N, 82.49°–83.14°E) are located in the trans-Himalayan belt of north-western Nepal sharing an international border with the Tibetan Autonomous Region (TAR) of China, and Kanchenjunga Conservation Area (KCA, 27.48°–27.94°N, 87.65°–88.2°E) in north-eastern Nepal, bordering TAR and India, represents an alpine ecosystem. Upper Humla currently lies outside the protected area system, large parts of upper Dolpa fall into the government-managed Shey-Phoksundo National Park (SPNP) and KCA is owned and managed by the community (Figure 1).

Landscapes of the study areas vary from high altitude Himalayan valley floors, across steep mountain cliffs rising to the rolling grasslands of the Tibetan Plateau. Vegetation above 3,600 masl is dominated by dry alpine steppe rich in sedges and graminoids such as *Stipa* spp., *Carex* spp. and *Kobresia* spp. Grasses and shrubs such as *Caragana brevifolia* and *Lonicera spinosa* dominate drier sites and rugged slopes (Miehe, Pendry, & Chaudhary, 2016). Himalayan wolves and snow leopards coexist with other predators like Eurasian lynx *Lynx lynx*, Pallas's cat *Otocolobus manul*, Tibetan fox *Vulpes ferrilata*, red fox *Vulpes vulpes*, and brown bear *Ursus arctos* and prey on herbivores like Tibetan gazelle *Procapra picticaudata* and blue sheep *Pseudois nayaur* and small mammals like Himalayan marmot *Marmota himalayana* and woolly hare *Lepus oiostolus*. The study areas range in elevation between 3,600 and 5,600 masl. Precipitation is mainly in the form of snow.

Human communities in the study areas are mostly agropastoralists belonging to the Tibetan ethnic group whose dominant religion is Tibetan Buddhism (Bauer, 2004). Their livelihood is based on agriculture, livestock husbandry, and collection of non-timber forest products. Livestock herders graze yaks *Bos grunniens*, cattle *Bos Taurus*, yak-cattle hybrids (dzos/jhoppas, *Bos* spp.), horses *Equus ferus caballus*, goats *Capra aegagrus hircus*, and sheep *Ovis aries* in the alpine pastures above their villages during the late spring and summer seasons. Livestock is usually shifted among different pastures before bringing them down to the villages in the valley floors during winter.

2.2 | Sampling design

We conducted semistructured questionnaire surveys (Newing, Eagle, Puri, & Watson, 2011) during the spring and summer seasons of 2014–2016 to collect data on local people's knowledge, perceptions, attitudes, and interactions with Himalayan wolf and snow leopard. We used closed-format questions to minimize uncertainty (White et al., 2005) and to facilitate statistical analyses (Newing et al., 2011).

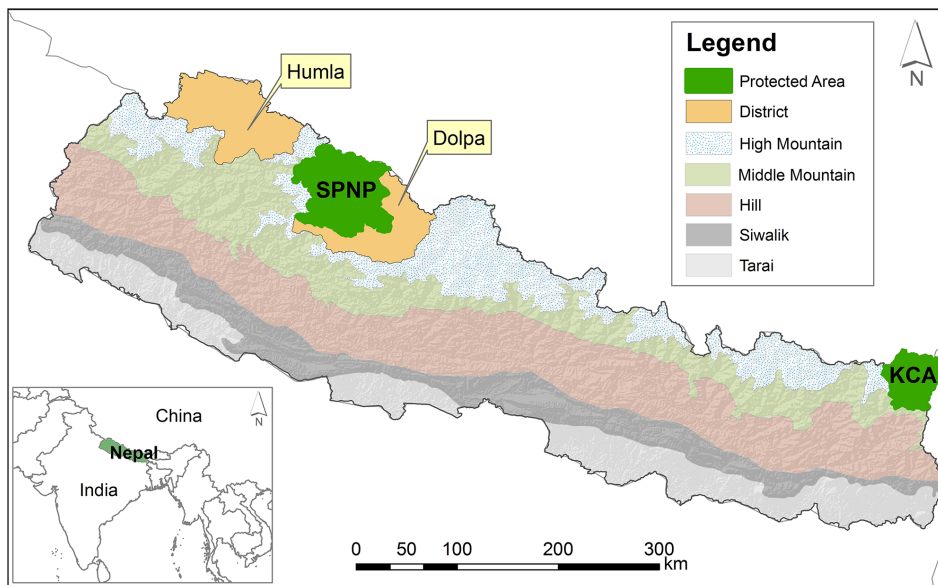


FIGURE 1 Study area location and physiographic division of Nepal. KCA and Dolpa are protected areas while Humla is not protected. KCA, Kanchenjunga Conservation Area

We applied convenience sampling (Etikan, Musa, & Alkassim, 2016) to conduct the surveys due to the low density of humans in the remote study areas and general absence of people from their homes during the survey periods (because they were busy sowing crops in the agricultural lands, herding livestock or had temporarily migrated for business and labor work in nearby towns). We conducted surveys in all villages (identified through discussions with forest officers and park authorities) within each study area (i.e., 5 villages in upper Humla, 13 in upper Dolpa, and 4 in KCA) to ensure our sampling was representative. Our survey dataset contained villagers of different age classes, occupations and gender in each study area (Table 1).

2.3 | Data collection

2.3.1 | Questionnaire surveys

We piloted the questionnaire in three villages of upper Humla in 2014 to test for its length, language, clarity, and potential sources of bias (White et al., 2005). We then adjusted some questions and finalized the questionnaire to run the surveys in 2015 (upper Humla) and 2016 (upper Dolpa and KCA). We conducted the interviews, each lasting 30–40 min, in the local languages using reliable local translators.

We prepared a closed checklist of wildlife (carnivores, herbivores, and small mammals) potentially found in the study areas following Jnawali et al. (2011). We used printed color-photographs of different mammal species to ask each respondent about the species' presence/absence and to ascertain individual's knowledge about the natural

environment in the study area. The use of photographs proved important, because the names given locally for some wildlife varied between study areas and between the villages within an area.

We divided the questionnaire into the following sections: (a) Wildlife understanding: Knowledge about wildlife found in the area and the population status (global and local) of Himalayan wolf and snow leopard; (b) Respondents background: age, gender, occupation, village, family size, religion, time in the area, origin, education level, and travelling (outside the district) experience; (c) Snow leopard and Himalayan wolf: Experiences with the carnivores, their population trends, main prey, and prey preference (wild versus domestic); (d) Depredation and economics: Livestock kept and mortality due to predation, current market value per head of livestock, problem predator ranking, reliance on livestock for income, social reaction norms to the appearance of a snow leopard or Himalayan wolf (near the villages and pastures); (e) Improving conflict: Existing practices to prevent livestock depredation, use of guard dogs, opinion on best methods to reduce depredation, livestock insurance and compensation schemes, knowledge/preference of other methods to improve the situation, assistance to commit to Himalayan wolf and snow leopard conservation; (f) Conservation and attitudes: Attitudes toward wildlife in general, snow leopard, and Himalayan wolf; (g) Religious and medicinal use: Religious significance and use of wildlife body parts in the local culture and traditional medicines and local stories involving Himalayan wolf or snow leopard. Please refer to the Supporting Information for the questionnaire form.

For the attitude section, we assigned a three-point Likert scale (−1 for disagree, 0 for maybe [neutral], and

TABLE 1 Respondent characteristics in upper Humla, upper Dolpa, and KCA

	Upper Humla	Upper Dolpa	KCA
<i>No. of respondents</i>	30 ^a	28	13
<i>Gender</i>			
Male	22	22	10
Female	8	6	3
<i>Age-class</i>			
21–30	5	1	2
31–40	11	7	5
41–50	7	6	3
51–60	3	7	2
61–70	0	6	1
71–80	4	1	0
<i>Occupation</i>			
Agropastoralist	21	20	9
Non-agropastoralist	9	8	4
<i>Average family size</i>	7.8	5.2	4.8
<i>Religion</i>			
Buddhism	30	27	13
Bon-po	0	1	0
<i>Time in the area</i>			
Since childhood	30	26	12
>20 years	0	2	0
10–20 years	0	0	0
5–10 years	0	0	1
<5 years	0	0	0
<i>Originally from the area?</i>			
Yes	30	27	12
No	0	1	1
<i>Schooling level</i>			
Illiterate	14	14	5
Adult literacy class	0	0	0
Monastery education	1	9	0
Primary school	11	2	5
High school	4	3	2
University	0	0	1
<i>Travelling outside the district</i>			
Never	4	3	0
Once or twice	2	6	4
A few times	16	11	2
Often	8	8	7

Note: Main characteristics are given in italics followed by their categories where present.

Abbreviation: KCA, Kanchenjunga Conservation Area.

^aWe included only 30 (of 32) surveys from upper Humla in the analysis. One respondent was interviewed twice and one could not provide any relevant information.

+1 for agree) to the responses. We calculated total attitude score by summing the attitude scores for the different questions. This generated a nine-point ordinal response ranging from −5 (most negative attitude recorded) to +3 (most positive attitude recorded).

For the statistical analysis, we pooled the occupation types into two categories: agropastoralist (including herder, laborer, and farmer) and non-agropastoralist (including teacher, school manager, business, and monk).

2.4 | Statistical analysis

Our survey dataset comprised a total of 71 questionnaires (upper Humla: 30, upper Dolpa: 28, and KCA: 13). We used numerical codes for answers where possible or used the narrative responses as qualitative data. We used attitude scores as response variables and treated “village” identity as a random factor to account for spatial clustering of respondents. We used variance inflation factor (VIF) to explore collinearity among predictors using the rms package of R (Harrell Jr, 2019). Where evidence for high collinearity was present ($VIF > 8$) we excluded variables that were substantially collinear (Dormann et al., 2013). “Schooling,” for example, was excluded as a potential predictor because it was significantly associated with both “gender” ($\chi^2 = 19.892$, $p = .0001$) and “occupation” ($\chi^2 = 58.75$, $p = 8.072e-11$). Similarly, there was a strong evidence that “travelling outside the district” was confounded with “occupation” (Fisher’s Exact test, $p = .003$); respondents whose principal occupation was “business”

TABLE 2 Description of predictors

Predictor	Description
Study area	Upper Humla: Lies outside the protected area (PA) system Upper Dolpa: Most parts fall into the government-managed Shey-Phoksundo National Park Kanchenjunga Conservation Area: A PA managed and owned by the community
Occupation	Agropastoralists (includes farmers, herders, and laborers) Non-agropastoralists (includes business, teacher, school manager, and monk)
Gender	Male or female
Livestock attacked by a wolf or a snow leopard	Reported (yes) or not reported (no)
Compensation scheme	Presence (yes) or absence (no)

were more likely to report travel. We therefore excluded “travelling outside the district” as a predictor. Also we excluded “originality” as a predictor because it was confounded with “study area” (Fisher’s Exact test, $p = .0001$). The “livestock insurance scheme” was present only in KCA, and was therefore completely confounded with study area. We treated it as a characteristic of “study area” and excluded it as a potential predictor. The number of respondents who claimed to have been threatened or attacked by a Himalayan wolf ($n = 1$, 0.8%) or a snow leopard ($n = 3$, 2.3%) was negligible; hence, we excluded “experiences with snow leopard or Himalayan wolf” as potential predictor. After excluding these and the collinear potential predictors, the final considered models included respondent characteristics (gender, occupation, whether they reported having experienced livestock attacks by snow leopard or Himalayan wolf, the study area and presence of compensation scheme) as predictor variables (Breslow & Clayton, 1993). See Table 2 for description of the predictors.

We performed all analyses in R Version 3.4.3 (R Development Core Team, 2017). We fitted a cumulative

link mixed random model with the `clmm` function in the “ordinal” package of R (Christensen, 2011) to construct models predicting Likert scale ordinal responses from a series of generalized linear mixed models (GLMMs) because mixed models provide a more flexible approach for analyzing non-normal data and accounts for random factors (Bolker et al., 2009). We used the R package “effects” (Fox et al., 2019) to visualize the effect sizes for predictors of attitude.

We used an Information Theoretic approach for model selection because it enabled us to examine several competing models using both explanatory value and parsimony (Grueber, Nakagawa, Laws, & Jamieson, 2011). We used the Akaike’s Information Criterion adjusted for small sample size (AICc) for ranking the models (Burnham & Anderson, 2002).

We calculated model weights by using the R package MuMIn (Barton, 2018) to evaluate relative model weights in the set of candidate models (Bolker et al., 2009). We also examined the parameter estimates of variables in the global models to assess the marginal significance of their effect on total attitude scores (the marginal effects

TABLE 3 Livestock economics showing average economic loss to Himalayan wolf and snow leopard in upper Humla, upper Dolpa and KCA during 2014–2016

Study area	Livestock type	Average # of livestock lost (and its monetary value in USD) per household toward		Average price (USD) per head
		Himalayan wolf	Snow leopard	
Upper Humla	Yak	0.1 (75)	0.3 (225)	750
	Horse	0.2 (175.6)	0	878
	Goat and sheep	0	0.5 (247.5)	495
	<i>Jhoppa</i>	0	0	720
	Cattle	0	0	360
	Total loss (USD)	250.6	472.5	
Upper Dolpa	Yak	0.7 (624.4)	0.5 (446)	892
	Horse	0.4 (679.6)	0.3 (509.7)	1,699
	Goat & sheep	1.6 (249.6)	3.1 (483.6)	156
	<i>Jhoppa</i>	0.1 (67.5)	0	675
	Cattle	0.1 (36.8)	0.04 (14.7)	368
	Total loss (USD)	1,657.9	1,454.0	
KCA	Yak	2.6 (2,399.8)	3.4 (3,138.2)	923
	Horse	0	0	
	Goat and sheep	0.4 (33.2)	0.6 (49.8)	83
	<i>Jhoppa</i>	0.2 (154.6)	0	773
	Cattle	0	0	390
	Total loss (USD)	2,588	3,188	

Abbreviation: KCA, Kanchenjunga Conservation Area.

TABLE 4 Problem carnivore ranking for wolves and snow leopards according to the study areas

Study area	Main problem carnivore
Upper Humla	Snow leopard (73.33%, $n = 22$)
Upper Dolpa	Snow leopard (60.71%, $n = 17$)
KCA	Wolf (76.92%, $n = 10$)

Note: Figures in parentheses represent the percentage of respondents complimented by their numbers who reported a specific carnivore as the main problem carnivore.

Abbreviation: KCA, Kanchenjunga Conservation Area.

indicating their effect on the response adjusting for all other effects in the model). As no single model was dominant we accounted for model uncertainty by using model averaging, based on model weights (Burnham & Anderson, 2002); potential problems with averaging arising from collinearity having been minimized by pruning collinear potential predictors (Cade, 2015). We averaged parameter estimates in all models up to a cumulative weight of 0.95. We explored model fit and diagnostics based on surrogate residuals using the R package “sure” (Greenwell, McCarthy, Boehmke, & Liu, 2017).

3 | RESULTS

3.1 | Respondent characteristics

Most respondents (32.39%, $n = 23$) were in the age class of 31–40 years old. Male respondents (76.06%, $n = 54$) predominated over females, and agropastoralist (70.42%, $n = 50$) was the dominant occupation. The average family size was 5.9 individuals (range 1–12, median 6). Buddhism was the main religion (98.6%, $n = 70$). Most respondents (97.18%, $n = 69$) were originally from the respective study area with 95.77% ($n = 68$) living there since childhood. The “illiterate” class dominated schooling level (46.48%, $n = 33$). Most respondents (97.18%, $n = 69$) had travelled outside the district at least once (Table 1).

3.2 | Knowledge and perceptions

Both Himalayan wolf (92.96%, $n = 66$) and snow leopard (94.37%, $n = 67$) were reported to be present in all three study areas. Wolves were considered at risk of local extirpation by respondents in KCA (69.2%, $n = 9$) and snow

TABLE 5 GLMM of ordinal attitude response toward (a) Himalayan wolf and (b) snow leopard, in upper Humla, upper Dolpa, and KCA

(a) Himalayan wolf				
Model-averaged coefficients: (conditional average)				
Predictor	Estimate	SE	z-Value	Pr ($> z $)
Livestock attacked by a Himalayan wolf	−1.30873	0.60258	2.172	0.029866 ^a
Occupation (non-agropastoralist)	1.18833	0.56456	2.105	0.035303 ^a
Gender (M)	1.08325	0.57486	1.884	0.059516 ^b
Study area (Humla)	0.07514	0.88891	0.085	0.932639
Study area (KCA)	1.82177	0.97961	1.860	0.062930 ^b
Compensation scheme	0.57465	1.86629	0.308	0.758151
(b) Snow leopard				
Model-averaged coefficients: (conditional average)				
Predictor	Estimate	SE	z-Value	Pr ($> z $)
Occupation (non-agropastoralist)	0.9536	0.5198	1.835	0.066564 ^b
Gender (M)	1.5891	0.5712	2.782	0.005403 ^c
Study area (Humla)	0.3789	0.6255	0.606	0.544685
Study area (KCA)	3.7957	0.8870	4.279	1.87e−05 ^d
Livestock attacked by a snow leopard	−0.3640	0.7588	0.480	0.631446
Compensation scheme	−0.3222	1.4810	0.218	0.827753

Abbreviations: GLMM, generalized linear mixed model; KCA, Kanchenjunga Conservation Area.

^a $p \leq .05$.

^b $p \leq .1$.

^c $p \leq .01$.

^d $p \leq .001$.

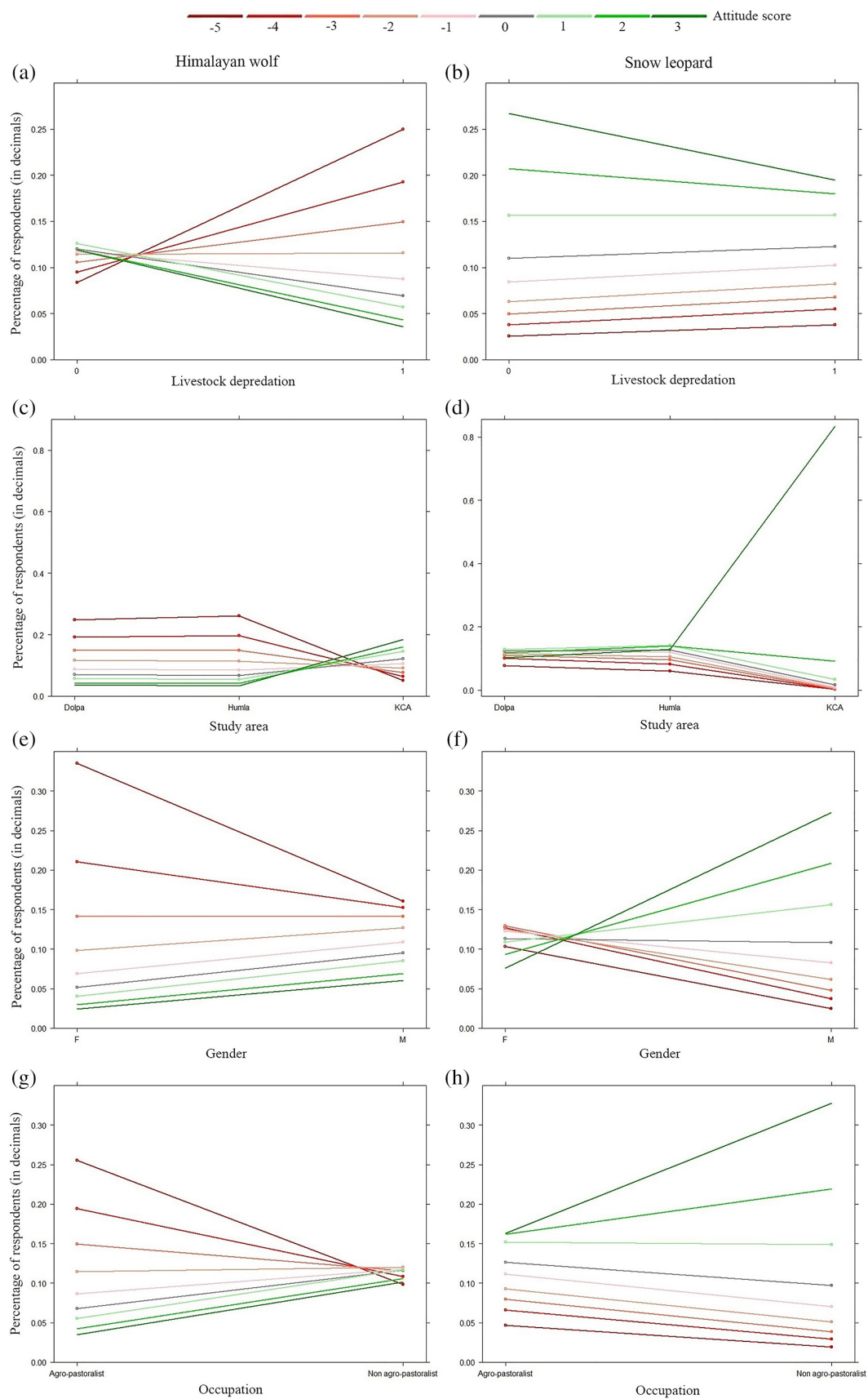


FIGURE 2 Legend on next page.

leopards by respondents in upper Humla (56.7%, $n = 17$). Average annual monetary loss per household reported due to livestock depredation was the highest in KCA (5,776 USD for 2015–2016), followed by Dolpa (3,112 USD for 2015–2016) and Humla (723 USD for 2014–2015; Table 3).

Both wolves (97.18%, $n = 69$) and snow leopards (88.73%, $n = 63$) were ranked “high” to “very high” as problematic carnivores across all study areas. However, most respondents ranked snow leopards as the main problem carnivore in upper Humla and upper Dolpa while most respondents in KCA ranked wolf as the main problem carnivore (Table 4). Wolves were reported to be killed in Humla by 35.5% of respondents (“sometimes” [$n = 9$], “rarely” [$n = 2$]) and by 21.4% respondents in Dolpa (“sometimes” [$n = 4$], “rarely” [$n = 2$]). The most prevalent motivation reported for this was to prevent future livestock loss (27.6%, $n = 21$), in response to past attacks on livestock (5.3%, $n = 4$) and to protect human safety (1.3%, $n = 1$). The methods reported to be used to kill wolves included snare traps (13.1%, $n = 10$), pit traps (9.2%, $n = 7$), carcass poisoning (5.3%, $n = 4$), smoking dens (3.9%, $n = 3$), and cornering and stoning individuals (1.3%, $n = 1$). Snow leopards were reported to be killed in

Humla by 53.3% of respondents (“sometimes” [$n = 12$], rarely [$n = 4$]), with the motivating causes reported being to prevent future livestock loss (21.0%, $n = 16$) and in response to past attacks on livestock (2.6%, $n = 2$). Reports of methods used to kill snow leopards included pit traps (13.1%, $n = 10$), carcass poisoning (3.9%, $n = 3$), surrounding and stoning the animal (3.9%, $n = 3$), snare traps (2.6%, $n = 2$), and firearms (1.3%, $n = 1$).

3.3 | Factors affecting attitudes

Model-averaged parameter estimates provided evidence for a link between both “study area” and “occupation” on attitudes toward both carnivores. Livestock depredation was associated with more negative attitudes toward wolves (Table 5 and Figure 2a,b). These were consistently included in the higher ranked models predicting attitudes, see Appendix S1.

People in KCA had more positive attitude toward the carnivores (Figure 2c,d): approximately 80% of respondents reported the highest attitude class concerning snow leopards compared to fewer than 20% in the other two study areas. A similar trend was observed for the

FIGURE 3 Measures applied for preventing livestock depredation in Humla, Dolpa, and KCA. The reported methods include livestock physical barriers (corrals for night, firewalls near corrals), deterrents (use of guarding dogs, self-guarding by herders, use of scarecrows, and shouting), killing the predator, worshipping and others (keeping all livestock together, avoiding depredation hotspots, using light system for night). KCA, Kanchenjunga Conservation Area

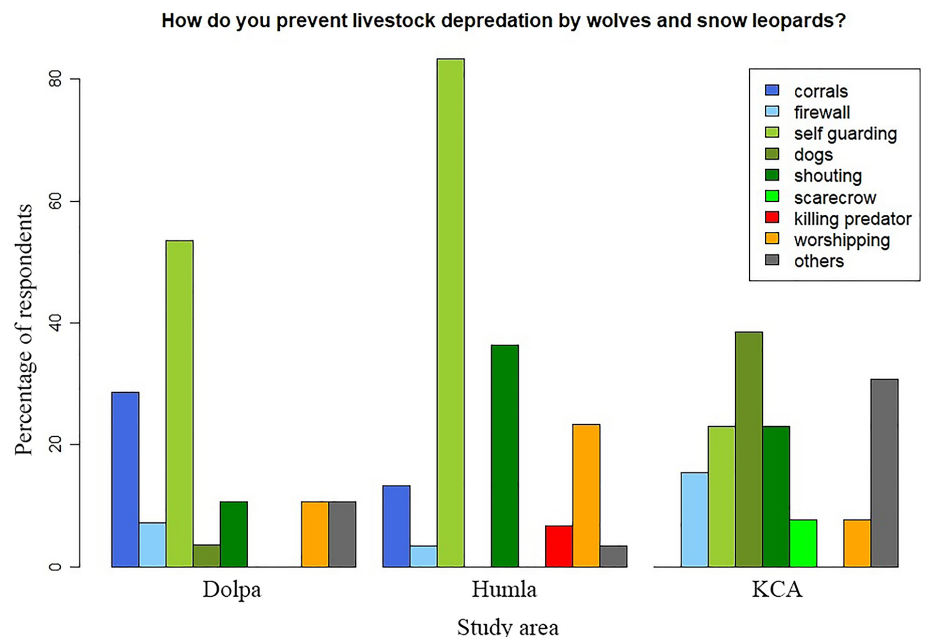


FIGURE 2 Effect plots illustrating the influence of predictors on attitudes toward wolves and snow leopards. (a) and (b) illustrate the effects of livestock depredation. Livestock depredation resulted into a clear negative attitude toward wolves but not for snow leopards. 0 = livestock depredation not reported and 1 = livestock depredation reported. (c) and (d) illustrate the effects of “study area.” People in KCA have a more positive attitude toward the carnivores than in Dolpa and Humla. (e) and (f) illustrate the effects of “gender.” Men have more positive attitude toward the carnivores than the women. M = Male and F = Female. (g) and (h) illustrate the effects of “occupation.” Agropastoralists have more negative attitudes toward both the carnivores. +3 represent the most positive attitude recorded while −3 represent the most negative attitude recorded. KCA, Kanchenjunga Conservation Area

Himalayan wolf: while hardly any respondent reported the highest attitude score in the other two study areas, close to 20% did in KCA. Also, men had more positive attitude toward the carnivores (Figure 2e,f). Agropastoralists had more negative attitudes toward both carnivores than respondents pursuing other occupations (Figure 2g,h). While for Himalayan wolves, responses were evenly distributed among the response classes, they were more skewed toward the positive attitude classes for snow leopards.

3.4 | Improving the conflict

Self-guarding of livestock was common in upper Humla (83.3%, $n = 25$) and upper Dolpa (53.6%, $n = 15$), while guard dogs were commonly used only in KCA (76.9%, $n = 10$). Livestock night corrals were also reported as important in all study areas. Respondents considered guarding by a herder and use of corrals as the two most important measures to prevent livestock depredation (see Figure 3 for other measures used to prevent livestock depredation in the respective study areas). Additional methods mentioned by the respondents to improve the situation were: enclosing livestock corrals with nets, improving livestock corrals by building higher walls, installing flashing lights as visual deterrent, a siren that notifies of an approaching carnivore, and using recorded human voices as acoustic deterrent. Respondents highlighted two items as being essential prerequisites if they were to commit to carnivore conservation: construction materials to build stronger corrals (18.4%, $n = 14$) and compensation equivalent to total loss (17.1%, $n = 13$).

4 | DISCUSSION

Villagers in the Himalayas of Nepal receive little support, either infrastructural or governmental, to help them face the material and financial consequences of coexisting with wolves and snow leopards. The combined circumstances of their dependence on livestock for livelihood, absence of support or adequate mitigation measures, and livestock losses all contribute to foster negative attitudes toward carnivores. The enthusiasm for conserving large carnivores among more affluent cross-sections of international society that rarely experience them in person (Macdonald, Burnham, Hinks, Dickman, & Malhi, 2015) is generally not shared by those with first-hand experiences of livestock losses to carnivores. In the Himalayas of Nepal this understandable hostility has, in the case of snow leopards, been reduced by respectful attention to

cultural and religious mores, but there has been no such attention to wolves. Comparison of local attitudes between our study areas revealed the greatest tolerance of carnivores in KCA, the only area that has adopted a community-owned conservation approach; this suggests to us that this approach should be trialled elsewhere.

Crucially, we found that while respondents in all study areas had more positive attitudes toward snow leopards than toward wolves, the impact on their attitudes of losing livestock was different between the two carnivores: it little affected attitudes to snow leopards, but radically worsened that toward wolves. This higher tolerance of snow leopards prevailed despite higher depredation by snow leopards than by wolves (Table 3). We see a combination of reasons responsible for this, including decades of conservation work to raise awareness for the snow leopard and financial support for reducing depredation conflict, and a high cultural and religious status of snow leopards; also reported by Suryawanshi et al. (2014) and Bhatia, Redpath, Suryawanshi, and Mishra (2017) in the Indian Himalayas and Alexander et al. (2015) in China. We interpret this as evidence that the iconic status of the snow leopard in local cultures may foster tolerance, and this hypothesis draws attention to the considerable relevance of religious influences on conservation (Gosler, Bhagwat, Harrop, Bonta, & Tidemann, 2013) remembering the respect in which snow leopards are held by Buddhism, the predominant religion in the region. For example, folklore in upper Dolpa holds that prominent Buddhist monks disguise themselves as snow leopards when visiting the Tibetan Plateau in search of rare medicinal herbs (Ale & Karky, 2002). Furthermore, considering their crepuscular nature, snow leopards are rarely seen, so another nonexclusive hypothesis for tolerance toward them might reflect the adage “out of sight, out of mind”. And wolves are widely disliked (Dressel, Sandström, & Ericsson, 2015). Folkloric portrayals of wolves often characterize them as evil (Dickman, 2010; Macdonald, 1987), and the European psyche is surely touched by the childhood influence of *Little Red Riding Hood*. The prevalent attitude among monks in our survey, that snow leopards (but not wolves) should be protected also reflects the dislike for wolves. Kellert et al. (1996) speculate that animosity toward wolves may generally be enhanced by behaviors such as howling, pack living, greater diurnal visibility, and easily detectable denning sites (which, it occurs to us, may be associated with incriminating prey remains). The lower conservation status, for example, on the IUCN Red List, of gray wolf *Canis lupus* as Least Concern (Mech & Boitani, 2010), compared to the snow leopard as Vulnerable (McCarthy, Mallon, Jackson, Zahler, & McCarthy, 2017), may affect capacity, or perceived need, to raise funds for

their conservation (Courchamp et al., 2006; Suryawanshi et al., 2014). We foresee the wolf's standing in the Himalayas deteriorating, and persecution intensifying as a consequence of socioeconomic changes in Asia, associated with increased global demand for cashmere, that is replacing large bodied livestock with smaller bodied cashmere-producing goats that are more vulnerable to wolf attacks (Namgail et al., 2007).

Agropastoralists, considering their dependence on livestock, were clearly, and unsurprisingly, more negative toward both wolves and snow leopards. They reported monetary loss due to livestock depredation equivalent to 15.8% of Nepalese per capita income in upper Humla, 125.2% in KCA and 67.5% in upper Dolpa. Per capita income of Nepal between 2014 and 2016 varied from 2,266 to 2,298 USD (World bank, 2018). While the losses in upper Humla are comparable to earlier studies in similar landscapes of Nepal (Oli et al., 1994) and Bhutan (Wang & Macdonald, 2006), they are much higher for upper Dolpa and KCA. The possibilities cannot be ruled out that some respondents could have misidentified a different carnivore species responsible for each predation event as either snow leopard or wolf and that some might have attributed deaths due to disease to carnivore depredation (Li et al., 2015) leading to overestimation of depredation losses. There are also chances that livestock that died due to reasons like falling off a cliff or during natural disasters like blizzards could have been scavenged by the predators which were wrongly considered as depredation by the respondents (Liu & Jiang, 2003). More importantly, the loss reported in KCA appears unrealistic; the monetary values were possibly exaggerated to take advantage of the funding provided by WWF Nepal. Unfortunately, we could not access any recorded data to validate the reports to account for the recall bias of the respondents. However these potential errors of self-reporting do not invalidate the importance of our findings that are reflective of the locals' perceptions (Li et al., 2015). One might expect a general hostility between stockmen and carnivores, and certainly the negative attitudes we report are mirrored in those of ranchers in the USA (Agarwala, Kumar, Treves, & Naughton-treves, 2010), Norway (Bjerke, Kaltenborn, & Thrane, 2001), and Brazil (Marchini & Macdonald, 2012).

Men were more positive than women in their attitudes toward the carnivores. A possible explanation is that men generally migrate from our study villages for seasonal work in nearby cities (in TAR) during the summer herding season. Consequently, they may (a) have less first-hand experience (plus responsibility and threat) than women of livestock depredation (Bickley et al., 2019) and (b) be more exposed to a wider spectrum of attitudes to nature. An additional factor may be that in

the Himalayas of Nepal women have less contact with conservation agencies compared to men (Gillingham & Lee, 1999). Insofar as this is detrimental to women's attitudes to conservation, Byers and Sainju (1994) make the proposal that women's education is a priority.

Of our three study areas, respondents from KCA had the most positive attitudes toward carnivores. Management and ownership of this conservation area belongs to the local communities which are adequately supported by both governmental and nongovernmental organizations. Features of the human–carnivore relationship conspicuously present in KCA are a community-based livestock insurance scheme, and promotion of conservation awareness. These interventions appeared to have fostered recovery of snow leopards and their wild prey, blue sheep (Gurung, Thapa, Kunkel, & Thapa, 2011), together with an increase in carnivore diversity. Wolves reappeared in the area in 2013 after an absence of 25 years (Subba et al., 2017), while in 2017, brown bear, never recorded previously in the area, were caught on camera-traps set by local citizen scientists (Tseten Sherpa, pers. comm. 2017).

Farhadinia, Johnson, Hunter, and Macdonald (2017) mention that dislike for wolves in Iran has the effect of eroding goodwill for the threatened Persian leopard *Panthera pardus saxicolor*. This suggestion arose because people losing livestock to wolves tended to have negative attitudes toward leopards, although wolves were responsible for greater economic loss in that study. Our findings offer a different perspective insofar as across the Himalayan landscape most carnivore conservation activities focus solely on snow leopards and thus it is only snow leopards that bring benefits to offset damage. Indeed, respondents in KCA stated that they would protect recolonizing wolves only if the KCA Management Council altered the livestock insurance scheme to provide compensation for livestock depredation by wolves comparable to that for snow leopards.

Carnivore conservation interventions focused on a single species are not beneficial for the protection of an entire ecosystem, particularly if they fail to educate people about the interrelatedness of different species and the importance of biodiversity for ecosystem resilience. A snow leopard focused conservation approach as practiced currently, has motivated local people to protect snow leopards and blue sheep only, while ignoring the rest of the wildlife community. Clearly, conservation of the entire carnivore guild is essential for the functionality of the natural community, and the ecosystem services it delivers (Wolf & Ripple, 2017). Building on our earlier studies (Kusi, Acharya, Ghimirey, Adhikary, & Werhahn, 2018; Werhahn, Kusi, Sillero-Zubiri, & Macdonald, 2017), we re-emphasize that damage relief payments

should urgently be extended to all carnivores depredating livestock. A legal framework (GON, 2015) for this is already in place in Nepal but awaits implementation.

Livestock depredation is worsened in our study areas because husbandry is often lax during herding seasons (Suryawanshi et al., 2013) which, exacerbating the threats, coincide with the breeding seasons of the Himalayan wolf (Feb–Jun) (Werhahn, Kusi, et al., 2017) and snow leopard (Jan–Jun) (McCarthy et al., 2017). Our respondents offered suggestions for improving herding practices, such as keeping livestock in larger herds attended by sufficient herders and avoiding known predation hotspots; that these obvious measures are in the villagers' minds, and yet not implemented is a symptom of the cognitive dissonance characteristic of human–wildlife conflict (see also Mijiddorj, Alexander, & Samelius, 2018). Herders' declared need for training can be met by demonstration of the construction of robust, durable, predator-proof, livestock corrals used to protect herds at night using locally available stones to build high walls in combination with wire netting especially for the open top (see Jackson & Wangchuk, 2001). Evidence based and, increasingly, experimentally validated, livestock corrals customized to local circumstances are now widely described and implemented worldwide (Loveridge et al., 2017) and there is a widespread and growing practical literature on the various interventions (flashing lights, sound deterrents, sirens, livestock guarding dogs) that may further mitigate risk. Insofar as no solution is infallible, it is often the case that a combination of methods is likely to be more effective than any one by itself (Espuno, Lequette, Poulle, Migot, & Lebreton, 2004; Zabel & Roe, 2009). Irrespective of the availability of financial incentives, lax livestock guarding needs to be appropriately handled because a better vigilance by livestock owners and herders is required to sustainably live with carnivores. An integrated system of incentives and disincentives, that involves co-responsibility between pastoralists and conservation practitioners, is likely to better address the root causes of depredation. Participatory engagement of villagers by strengthening their empowerment, skills, and sense of pride in living with the carnivores, can help bridge this gap (Jackson & Lama, 2016; Jackson, Mishra, McCarthy, & Ale, 2010; Mishra, Young, Redpath, Fiechter, & Rutherford, 2017).

Livestock insurance schemes can provide a strong incentive to improve husbandry (Mishra et al., 2003), but so far are uncommon in the Nepalese Himalaya (Chetri, Odden, Devineau, & Wegge, 2019). Where they have been trialled, the monetary compensation has often been insufficient, as indicated in KCA where many herders were unwilling to participate in the local livestock insurance scheme because the compensation offered for the

loss to a snow leopard of a yak worth USD 923 (in 2016) was as little as 7.6% (=USD 70) of the animal's market value. Unsurprisingly, herders expect compensation equivalent at least to the market cost of a replacement calf. Overall compensation payments (especially those that do not involve community investments), have proven ineffective in changing behavior or attitudes (Agarwala et al., 2010; Naughton-Treves, Grossberg, & Treves, 2003) which ask all conservation interventions to work toward improving community investments. Payments to encourage coexistence (PEC) are more promising (Dickman et al., 2011). Compelling examples come from Sweden where villages are paid for every certified carnivore reproduction in the reindeer grazing grounds (Zabel & Uller, 2008) and from Mexico where ranchers are paid for recording large carnivores in camera traps placed on their lands (Nelson, 2009). Combining PEC methods with incentives such as sales of handicrafts (Mishra et al., 2003) or home stays (Jackson & Wangchuk, 2004) and livestock vaccination should be considered for the Himalayas as they may be better suited to improve attitudes toward carnivores in the region.

There is no hope of eradicating livestock depredation unless wild carnivores have an adequate supply of wild prey (Werhahn et al., 2019). Furthermore, there is an interaction between the densities of wild and domestic prey, with the former facing competitive exclusion by the latter (Berger, Buuveibaatar, & Mishra, 2013; Karimov, Kachel, & Hackla, 2018). Conservation is an increasingly holistic matter, requiring transdisciplinary knowledge (Macdonald, 2019). So the coexistence of large carnivores, domestic stock, and wild prey requires understanding from biology, sociology, and agriculture, for example, at the interface of ensuring the continuation of the traditional practices of rotational grazing (Kusi et al., 2018). Indeed, wildlife conservation in the Himalayas, as elsewhere, should develop an integrated multispecies plan, engaging with and mindful of local human communities, and the fostering of coexistence.

ACKNOWLEDGMENTS

We thank the Department of National Parks and Wildlife Conservation and Department of Forests and Soil Conservation, Kathmandu, the Division Forest Office, Humla, Shey-Phoksundo National Park office, Dolpa and Kanchenjunga Conservation Area Management Council, Taplejung for permitting this research project. A special thanks to Tshiring L. Lama and Kaushal Yadav for conducting some of the questionnaire surveys. We appreciate the support from all field team members including Pema Rikzin Lama, Tashi Namgyal Lama, Pemba Dorje Tamang, Kunjok Rangdol Tamang, Pasang Dorje Tamang, Tashi Dondup Lama, and Bir Bahadur Sunar,

We thank Friends of Nature Nepal for supporting this research. Thanks to Alexandra Zimmerman for valuable discussions during the development of the questionnaire. The last author was supported an Oxford-Lady Margaret Hall NaturalMotion Graduate Scholarship.

CONFLICT OF INTEREST

The authors have no conflict of interest.

AUTHOR CONTRIBUTIONS

G.W. and N.K. conceptualized the study and conducted the field surveys to collect the data. N.K. and P.J.J. analyzed the data. N.K. led the writing with inputs from G.W., C.S., D.W.M., and P.J.J.

ETHICS STATEMENT

G.W. obtained an approval from the Central University Research Ethics Committee (CUREC) of the University of Oxford, UK to conduct the questionnaire surveys for the study.

DATA AVAILABILITY STATEMENT

The data associated with the manuscript are available upon formal request to N.K. and G.W.

ORCID

Naresh Kusi  <https://orcid.org/0000-0002-3485-8959>

REFERENCES

- Agarwala, M., Kumar, S., Treves, A., & Naughton-treves, L. (2010). Paying for wolves in Solapur, India and Wisconsin, USA: Comparing compensation rules and practice to understand the goals and politics of wolf conservation. *Biological Conservation*, 143, 2945–2955. <https://doi.org/10.1016/j.biocon.2010.05.003>
- Ale, S. B., & Karky, B.S. (2002). *Observations on conservation of snow leopards in Nepal*. Contributed papers to the snow leopard survival strategy summit.
- Alexander, J., Chen, P., Damerell, P., Youkui, W., Hughes, J., Shi, K., & Riordan, P. (2015). Human wildlife conflict involving large carnivores in Qilianshan, China and the minimal paw-print of snow leopards. *Biological Conservation*, 187, 1–9. <https://doi.org/10.1016/j.biocon.2015.04.002>
- Álvares, F., Bogdanowicz, W., Campbell, L.A.D., Godinho, R., Hatlauf, J., Jhala, Y.V., ..., Werhahn, G. (2019). Workshop on old world *Canis* spp. with taxonomic ambiguity—Conclusions and recommendations, Porto, Portugal.
- Aryal, A., Brunton, D., Ji, W., Barraclough, R. K., & Raubenheimer, D. (2014). Human-carnivore conflict: Ecological and economical sustainability of predation on livestock by snow leopard and other carnivores in the Himalaya. *Sustainability Science*, 9, 321–329. <https://doi.org/10.1007/s11625-014-0246-8>
- Bagchi, S., & Mishra, C. (2006). Living with large carnivores: Predation on livestock by the snow leopard (*Uncia uncia*). *Journal of Zoology*, 268, 217–224. <https://doi.org/10.1111/j.1469-7998.2005.00030.x>
- Barton, K. (2018). Package ‘MuMIn’ title multi-model inference. Cran-R 74.
- Bauer, K. M. (2004). *High Frontiers: Dolpo and the changing world of Himalayan pastoralists*. New York, NY: Columbia University Press.
- Berger, J., Buuveibaatar, B., & Mishra, C. (2013). Globalization of the cashmere market and the decline of large mammals in central asia. *Conservation Biology*, 27, 679–689. <https://doi.org/10.1111/cobi.12100>
- Bhatia, S., Redpath, S. M., Suryawanshi, K., & Mishra, C. (2017). The relationship between religion and attitudes toward large carnivores in Northern India. *Human Dimensions of Wildlife*, 22, 30–42. <https://doi.org/10.1080/10871209.2016.1220034>
- Bickley, S. M., Lemos, F. G., Gilmore, M. P., Azevedo, F. C., Freeman, E. W., & Songsasen, N. (2019). Human perceptions of and interactions with wild canids on cattle ranches in Central Brazil. *Oryx*, 1–8. <https://doi.org/10.1017/S0030605318000480>
- Bjerke, T., Kaltenborn, B. P., & Thrane, C. (2001). Sociodemographic correlates of fear-related attitudes toward the wolf (*Canis lupus lupus*). A survey in southeastern Norway. *Fauna Nor*, 21, 25–33.
- Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., & White, J. S. S. (2009). Generalized linear mixed models: A practical guide for ecology and evolution. *Trends in Ecology & Evolution*, 24, 127–135. <https://doi.org/10.1016/j.tree.2008.10.008>
- Breslow, N., & Clayton, D. (1993). Approximate inference in generalized linear mixed models. *Journal of the American Statistical Association*, 88, 9–25. <https://doi.org/10.2307/2290687>
- Burnham, K., & Anderson, D. (2002). *Model selection and multi-model inference* (2nd ed.). New York, NY: Springer.
- Byers, E., & Sainju, M. (1994). Mountain ecosystems and women: Opportunities for sustainable development and conservation. *Mountain Research and Development*, 14, 213–228.
- Cade, B. S. (2015). Model averaging and muddled multimodel inferences. *Ecology*, 96(9), 2370–2382.
- Chen, P., Gao, Y., Lee, A. T. L., Cering, L., Shi, K., & Clark, S. G. (2016). Human-carnivore coexistence in Qomolangma (Mt. Everest) Nature Reserve, China: Patterns and compensation. *Biological Conservation*, 197, 18–26. <https://doi.org/10.1016/j.biocon.2016.02.026>
- Chetri, M., Odden, M., Devineau, O., & Wegge, P. (2019). Patterns of livestock depredation by snow leopards and other large carnivores in the Central Himalayas, Nepal. *Global Ecology and Conservation*, 16, e00536. <https://doi.org/10.1016/J.GECCO.2019.E00536>
- Christensen, R. H. B. (2011). A tutorial on fitting cumulative link mixed models with clmm2 from the ordinal package. *Analysis*, 1, 1–18.
- Courchamp, F., Angulo, E., Rivalan, P., Hall, R. J., Signoret, L., Bull, L., & Meinard, Y. (2006). Rarity value and species extinction: The anthropogenic allee effect. *PLoS Biology*, 4, e415. <https://doi.org/10.1371/journal.pbio.0040415>
- Dar, N. I., Minhas, R. A., Zaman, Q., & Linkie, M. (2009). Predicting the patterns, perceptions and causes of human—carnivore conflict in and around Machiara National Park, Pakistan. *Biological Conservation*, 142, 2076–2082. <https://doi.org/10.1016/j.biocon.2009.04.003>
- Dickman, A. J. (2010). Complexities of conflict: The importance of considering social factors for effectively resolving human-wildlife

- conflict. *Animal Conservation*, 13, 458–466. <https://doi.org/10.1111/j.1469-1795.2010.00368.x>
- Dickman, A. J., Macdonald, E. A., & Macdonald, D. W. (2011). A review of financial instruments to pay for predator conservation and encourage human–carnivore coexistence. *PNAS*, 108, 126–134. <https://doi.org/10.1073/pnas.1118014108>
- Din, J. U., Ali, H., Ali, A., Younus, M., Mehmood, T., Normarashid, Y., & Ali, M. (2017). Pastoralist–predator interaction at the roof of the world: Conflict dynamics. *Ecology and Society*, 22(2), 32. <https://doi.org/10.5751/ES-09348-220232>
- DNPWC. (2017). *Snow leopard conservation action plan for Nepal (2017–2021)*. Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.
- Dormann, C. F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., ... Lautenbach, S. (2013). Collinearity: A review of methods to deal with it and a simulation study evaluating their performance. *Ecography*, 36, 027–046. <https://doi.org/10.1111/j.1600-0587.2012.07348.x>
- Dressel, S., Sandström, C., & Ericsson, G. (2015). A meta-analysis of studies on attitudes toward bears and wolves across Europe 1976–2012. *Conservation Biology*, 29, 565–574. <https://doi.org/10.1111/cobi.12420>
- Espuno, N., Lequette, B., Pouille, M.-L., Migot, P., & Lebreton, J. D. (2004). Heterogeneous response to preventive sheep husbandry during wolf recolonization of the French Alps. *Wildlife Society Bulletin*, 53, 1689–1699. <https://doi.org/10.1017/CBO9781107415324.004>
- Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5, 1–4. <https://doi.org/10.11648/j.ajtas.20160501.11>
- Farhadinia, M. S., Johnson, P. J., Hunter, L. T. B., & Macdonald, D. W. (2017). Wolves can suppress goodwill for leopards: Patterns of human–predator coexistence in northeastern Iran. *Biological Conservation*, 213, 210–217. <https://doi.org/10.1016/j.biocon.2017.07.011>
- Ferreira, M. N. E., & Freire, N. C. (2009). Community perceptions of four protected areas in the Northern portion of the Cerrado hotspot, Brazil. *Environmental Conservation*, 36(36), 129–138. <https://doi.org/10.1017/S0376892909990166>
- Fox, J., Weisberg, S., Price, B., Friendly, M., Hong, J., Andersen, R., ..., Team, R.C. (2019). Effects: Effect displays for linear, generalized linear, and other models. R Package Version 4.1-1.
- Gelcich, S., Edwards-Jones, G., Kaiser, M. J., & Castilla, J. C. (2006). Co-management policy can reduce resilience in traditionally managed marine ecosystems. *Ecosystems*, 9, 951–966. <https://doi.org/10.1007/s10021-005-0007-8>
- Gillingham, S., & Lee, P. (1999). The impact of wildlife-related benefits on the conservation attitudes of local people around the Selous Game Reserve, Tanzania. *Environmental Conservation*, 26, 218–228.
- GON. (2015). *Wildlife Damage Relief Guidelines 2012, First Amendment 2015*.
- Gosler, A., Bhagwat, S., Harrop, S., Bonta, M., & Tidemann, S. (2013). Leadership and listening: Inspiration for conservation mission and advocacy. In D. Macdonald & K. Willis (Eds.), *Key topics in conservation biology 2* (pp. 92–109). Chichester, UK: John Wiley & Sons.
- Greenwell, B., McCarthy, A., Boehmke, B., & Liu, D. (2017). *Sure: Surrogate Residuals for Ordinal and General Regression Models*. R package version 0.2.0.
- Grueber, C. E., Nakagawa, S., Laws, R. J., & Jamieson, I. G. (2011). Multimodel inference in ecology and evolution: Challenges and solutions. *Journal of Evolutionary Biology*, 24, 699–711. <https://doi.org/10.1111/j.1420-9101.2010.02210.x>
- Gurung, G., & Thapa, K. (2004). Snow Leopard (*Uncia uncia*) and human interaction in Phoo village in the Annapurna Conservation Area, Nepal.
- Gurung, G., Thapa, K., Kunkel, K., & Thapa, G. (2011). Enhancing herders' livelihood and conserving the snow leopard in Nepal. *CATnews*, 55, 17–21.
- Hanson, J. H., Schutgens, M. G., Lama, R. P., Aryal, A., & Dhakal, M. (2018). Local attitudes to the proposed translocation of blue sheep *Pseudois nayaur* to Sagarmatha National Park, Nepal. *Oryx*, 11, 1–7. <https://doi.org/10.1017/S0030605318000157>
- Harrell Jr, F.E. (2019). *RMS: Regression Modeling Strategies*. R Package Version 5.1-3.
- Jackson, R., & Wangchuk, R. (2001). Linking snow leopard conservation and people–wildlife conflict resolution: Grassroots measures to protect the endangered snow leopard from herder retribution. *Endangered Species UPDATE*, 18, 1.
- Jackson, R. M., & Lama, W. B. (2016). The role of mountain communities in snow leopard conservation. In T. McCarthy & D. Mallon (Eds.), *Snow leopards: Biodiversity of the World: Conservation from Genes to Landscapes* (pp. 139–149). San Diego, CA: Elsevier. <https://doi.org/10.1016/B978-0-12-802213-9/00011-0>
- Jackson, R. M., Mishra, C., McCarthy, T. M., & Ale, S. B. (2010). Snow leopards: Conflict and conservation. In D. W. Macdonald & A. J. Loveridge (Eds.), *Biology and conservation of wild felids* (pp. 417–430). Oxford, UK: Oxford University Press.
- Jackson, R. M., & Wangchuk, R. (2004). A community-based approach to mitigating livestock depredation by snow leopards. *Human Dimensions of Wildlife*, 9, 1–16. <https://doi.org/10.1080/10871200490505756>
- Jamtsho, Y., & Katel, O. (2019). Livestock depredation by snow leopard and Tibetan wolf: Implications for herders' livelihoods in Wangchuck Centennial National Park, Bhutan. *Pastoralism: Research, Policy and Practice*, 2, 1–10. <https://doi.org/https://doi.org/10.1186/s13570-018-0136-2>
- Jnawali, S.R., Baral, H.S., Lee, S., Acharya, K.P., Upadhyay, G.P., Pandey, M., ..., Amin, R. (2011). *The status of Nepal's mammals: The National Red List Series*. Kathmandu, Nepal: Department of National Parks and Wildlife Conservation.
- Karimov, K., Kachel, S. M., & Hackla, K. (2018). Responses of snow leopards, wolves and wild ungulates to livestock grazing in the Zorkul Strictly Protected Area, Tajikistan. *PLoS ONE*, 13, 1–14. <https://doi.org/10.1371/journal.pone.0208329>
- Karmapa, H. H., & Dorje, O. T. (2011). Walking the path of environmental Buddhism through compassion and emptiness. *Conservation Biology*, 25, 1094–1097. <https://doi.org/10.1111/j.1523-1739.2011.01765.x>
- Kellert, S. R., Black, M., Rush, C. R., & Bath, A. J. (1996). Human culture and large carnivore conservation in North America.

- Conservation Biology*, 10, 977–990. <https://doi.org/10.1046/j.1523-1739.1996.10040977.x>
- Khan, B., Ablimit, A., Nawaz, M. A., & Ali, R. (2014). Pastoralist experience and tolerance of snow leopard, wolf and lynx predation in Karakoram Pamir Mountains. *Journal of Biodiversity and Environmental Sciences*, 5(4), 214–229.
- Kusi, N., Acharya, R., Ghimirey, Y., Adhikary, B., & Werhahn, G. (2018). An update on the Tibetan argali *Ovis ammon hodgsoni* in Nepal. *Mammalia*, 83, 110–114. <https://doi.org/https://doi.org/10.1515/mammalia-2017-0167>
- Kusi, N., Manandhar, P., Subba, S. A., Thapa, K., Thapa, K., Shrestha, B., ... Werhahn, G. (2018). Shadowed by the ghost: The Eurasian lynx in Nepal. *CATnews*, 68, 16–19.
- Lescureux, N., & Linnell, J. D. C. (2013). The effect of rapid social changes during post-communist transition on perceptions of the human–wolf relationships in Macedonia and Kyrgyzstan. *Pastoralism: Research, Policy and Practice*, 3(1), 4. <https://doi.org/10.1186/2041-7136-3-4>
- Li, A. C., Jiang, Z., Li, C., Tang, S., Li, F., Li, C., ... Ping, X. (2015). Livestock depredations and attitudes of local pastoralists toward carnivores in the Qinghai Lake Region, China. *Wildlife Biology*, 21, 204–212. <https://doi.org/10.2981/wlb.00083>
- Li, J., Wang, D., Yin, H., Zhaxi, D., Jiagong, Z., Schaller, G. B., ... Lu, Z. (2014). Role of Tibetan buddhist monasteries in snow leopard conservation. *Conservation Biology*, 28, 87–94. <https://doi.org/10.1111/cobi.12135>
- Liu, B., & Jiang, Z. (2003). Diet composition of wolves *Canis lupus* in the northeastern Qinghai-Tibet Plateau, China. *Acta Theriologica*, 48(48), 255–263.
- Liu, F., McShea, W. J., Garshelis, D. L., Zhu, X., Wang, D., & Shao, L. (2011). Human-wildlife conflicts influence attitudes but not necessarily behaviors: Factors driving the poaching of bears in China. *Biological Conservation*, 144, 538–547. <https://doi.org/10.1016/j.biocon.2010.10.009>
- Loveridge, A. J., Kuiper, T., Parry, R. H., Sibanda, L., Hunt, J. H., Stapelkamp, B., ... Macdonald, D. W. (2017). Bells, bomas and beefsteak: Complex patterns of human-predator conflict at the wildlife-agropastoral interface in Zimbabwe. *Peer J*, 5, 1–24. <https://doi.org/10.7717/peerj.2898>
- Macdonald, D. W. (2019). Mammal conservation: Old problems, new perspectives, transdisciplinarity, and the coming of age of conservation geopolitics. *Annual Review of Environment and Resources*, 44, 61–88. <https://doi.org/https://doi.org/10.1146/annurev-environ-101718-033039>
- Macdonald, D. W. (1987). *Running with the fox*. London: Unwin-Hyman.
- Macdonald, E. A., Burnham, D., Hinks, A. E., Dickman, A. J., & Malhi, Y. (2015). Conservation inequality and the charismatic cat: *Felis felis*. *Global Ecology and Conservation*, 3, 851–866. <https://doi.org/10.1016/j.gecco.2015.04.006>
- Macdonald, E. A., Hinks, A., Weiss, D. J., Dickman, A., Burnham, D., Sandom, C. J., ... Macdonald, D. W. (2017). Identifying ambassador species for conservation marketing. *Global Ecology and Conservation*, 12, 204–214. <https://doi.org/10.1016/j.gecco.2017.11.006>
- Madden, F. (2004). Creating coexistence between humans and wildlife: Global perspectives on local efforts to address human–wildlife conflict. *Human Dimensions of Wildlife*, 9, 247–257. <https://doi.org/10.1080/10871200490505675>
- Maheshwari, A., & Sathyakumar, S. (2019). Snow leopard stewardship in mitigating human–wildlife conflict in Hemis National Park. *Human Dimensions of Wildlife*, 24, 1–5. <https://doi.org/10.1080/10871209.2019.1610815>
- Marchini, S., & Macdonald, D. W. (2012). Predicting ranchers' intention to kill jaguars: Case studies in Amazonia and Pantanal. *Biological Conservation*, 147, 213–221. <https://doi.org/10.1016/j.biocon.2012.01.002>
- McCarthy, T., Mallon, D., Jackson, R., Zahler, P., & McCarthy, K. (2017). *Panthera uncia*. IUCN Red List of Threatened Species. 8235, 27. <https://doi.org/10.2305/IUCN.UK.2017-2.RLTS.T22732A50664030.en>
- Mech, L.D., & Boitani, L. (2010). *Canis lupus*. IUCN Red List of Threatened Species. <https://doi.org/http://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T3746A10049204.en>
- Miehe, G., Pendry, C., & Chaudhary, R. (Eds.). (2016). *Nepal: An introduction to the natural history, ecology and human environment of the Himalayas*. Edinburgh, UK: Royal Botanic Garden Edinburgh.
- Mijidodj, T. N., Alexander, J. S., & Samelius, G. (2018). Livestock depredation by large carnivores in the South Gobi, Mongolia. *Wildlife Research*, 45(31), 237. <https://doi.org/10.1071/WR18009>
- Mishra, C. (1997). Livestock depredation by large carnivores in the Indian trans-Himalaya. *Environmental Conservation*, 24, 338–343.
- Mishra, C., Allen, P., McCarthy, T., Madhusudan, M. D., Bayarjargal, A., & Prins, H. H. T. (2003). The role of incentive programs in conserving the snow leopard. *Conservation Biology*, 17, 1512–1520. <https://doi.org/10.1111/j.1523-1739.2003.00092.x>
- Mishra, C., & Fitzherbert, A. (2004). War and wildlife: A post-conflict assessment of Afghanistan's Wakhan corridor. *Oryx*, 38, 102–105. <https://doi.org/10.1017/S0030605304000158>
- Mishra, C., Redpath, S. R., & Suryawanshi, K. R. (2016). Livestock predation by snow leopards: Conflicts and the search for solutions. In T. McCarthy & D. Mallon (Eds.), *Snow leopards: Biodiversity of the world: Conservation from genes to landscapes* (pp. 59–67). San Diego, CA: Elsevier Inc. <https://doi.org/10.1016/B978-0-12-802213-9/00005-5>
- Mishra, C., Young, J. C., Redpath, S. M., Fiechter, M., & Rutherford, B. (2017). Building partnerships with communities for biodiversity conservation: Lessons from Asian mountains. *Journal of Applied Ecology*, 54, 1583–1591. <https://doi.org/10.1111/1365-2664.12918>
- MOFSC. (2017). *Snow leopard and ecosystem management plan (2017–2026)*. Kathmandu, Nepal: Ministry of Forests and Soil Conservation.
- Namgail, T., Fox, J. L., & Bhatnagar, Y. V. (2007). Carnivore-caused livestock mortality in Trans-Himalaya. *Environmental Management*, 39, 490–496. <https://doi.org/10.1007/s00267-005-0178-2>
- Naughton-Treves, L., Grossberg, R., & Treves, A. (2003). Paying for tolerance: Rural citizens' attitudes toward wolf depredation and compensation. *Conservation Biology*, 17, 1500–1511. <https://doi.org/10.1111/j.1523-1739.2003.00060.x>
- Nawaz, M. A., & Mishra, C. (2016). Setting up community-based livestock vaccination initiatives for wildlife conservation: A case study of ecosystem health program. In C. Mishra (Ed.), *The partners principles for community-based conservation* (pp. 149–162). Seattle, MA: Snow Leopard Trust.

- Nelson, F. (2009). Developing payments for ecosystem services approaches to carnivore conservation. *Human Dimensions of Wildlife*, 1209, 381–392. <https://doi.org/10.1080/10871200903045228>
- Newing, H., Eagle, C. M., Puri, R. K., & Watson, C. W. (2011). *Conducting research in conservation: A social science perspective*. Abingdon: Routledge.
- Nowell, K., & Jackson, P. (Eds.). (1996). *Wild cats: Status survey and conservation action plan*. Gland, Switzerland: IUCN/SSC Cat Specialist Group.
- Oli, M. K., Taylor, I. R., & Rogers, M. E. (1994). Snow leopard *Panthera uncia* predation of livestock: An assessment of local perceptions in the Annapurna Conservation area, Nepal. *Biological Conservation*, 68, 63–68.
- R Development Core Team. (2017). R: A language and environment for statistical computing.
- Ripple, W. J., Estes, J. A., Beschta, R. L., Wilmers, C. C., Ritchie, E. G., Hebblewhite, M., ... Wirsing, A. J. (2014). Status and ecological effects of the world's largest carnivores. *Science*, 343(6167), 1241484. <https://doi.org/10.1126/science.1241484>
- Rosen, T., Hussain, S., Mohammad, G., Jackson, R., Janecka, J. E., & Michel, S. (2012). Reconciling sustainable development of mountain communities with large carnivore conservation. *Mountain Research and Development*, 32, 286–293. <https://doi.org/10.1659/MRD-JOURNAL-D-12-00008.1>
- Schutgens, M. G., Hanson, J. H., Baral, N., & Ale, S. B. (2018). Visitors' willingness to pay for snow leopard *Panthera uncia* conservation in the Annapurna Conservation area, Nepal. *Oryx*, 53, 1–10. <https://doi.org/10.1017/S0030605317001636>
- Subba, S. A., Shrestha, A. K., Thapa, K., Malla, S., Thapa, G. J., Shrestha, S., ... Ottvall, R. (2017). Distribution of grey wolves *Canis lupus lupus* in the Nepalese Himalaya: Implications for conservation management. *Oryx*, 51, 403–406. <https://doi.org/10.1017/S0030605316000296>
- Suryawanshi, K. R., Bhatia, S., Bhatnagar, Y. V., Redpath, S., & Mishra, C. (2014). Multiscale factors affecting human attitudes toward snow leopards and wolves. *Conservation Biology*, 28, 1657–1666. <https://doi.org/10.1111/cobi.12320>
- Suryawanshi, K. R., Bhatnagar, Y. V., Redpath, S., & Mishra, C. (2013). People, predators and perceptions: Patterns of livestock depredation by snow leopards and wolves. *Journal of Applied Ecology*, 50, 550–560. <https://doi.org/10.1111/1365-2664.12061>
- Treves, A., & Karanth, K. U. (2003). Human-carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology*, 17, 1491–1499.
- Vannelli, K., Hampton, M. P., Namgail, T., Black, S. A., Vannelli, K., Hampton, M. P., ... Black, S. A. (2019). Community participation in ecotourism and its effect on local perceptions of snow leopard (*Panthera uncia*) conservation. *Human Dimensions of Wildlife*, 24, 1–14. <https://doi.org/10.1080/10871209.2019.1563929>
- Wang, S. W., Lassoie, J. P., & Curtis, P. D. (2006). Farmer attitudes towards conservation in Jigme Singye Wangchuck National Park, Bhutan. *Environmental Conservation*, 33, 148–156. <https://doi.org/10.1017/S0376892906002931>
- Wang, S. W., & Macdonald, D. W. (2006). Livestock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. *Biological Conservation*, 129, 558–565.
- Werhahn, G., Kusi, N., Sillero-Zubiri, C., & Macdonald, D. W. (2017). Conservation implications for the Himalayan wolf *Canis (lupus) himalayensis* based on observations of packs and home sites in Nepal. *Oryx*, 53, 1–7. <https://doi.org/10.1017/S0030605317001077>
- Werhahn, G., Senn, H., Ghazali, M., Karmacharya, D., Sherchan, A. M., Joshi, J., ... Macdonald, D. W. (2018). The unique genetic adaptation of the Himalayan wolf to high-altitudes and consequences for conservation. *Global Ecology and Conservation*, 16, e00455. <https://doi.org/10.1016/j.gecco.2018.e00455>
- Werhahn, G., Senn, H., Kaden, J., Joshi, J., Bhattarai, S., Kusi, N., ... Macdonald, D. W. (2017). Phylogenetic evidence for the ancient himalayan wolf: Towards a clarification of its taxonomic status based on genetic sampling from Western Nepal. *Royal Society Open Science*, 4, 170186. <https://doi.org/10.1098/rsos.170186>
- Werhahn, G., Kusi, N., Li, X., Chen, C., Zhi, L., Martin, R. L., ... Macdonald, D. W. (2019). Himalayan wolf foraging ecology and the importance of wild prey. *Global Ecology and Conservation*, 20, e00780. <https://doi.org/10.1016/j.gecco.2019.e00780>
- White, P. C. L., Jennings, N. V., Renwick, A. R., Nola, H. L., Renwick, A. R., & Barker, N. H. L. (2005). Questionnaires in ecology: A review of past use and recommendations best practice. *Journal of Applied Ecology*, 42, 421–430.
- Wilmers, C. C., Crabtree, R. L., Smith, D. W., Murphy, K. M., & Getz, W. M. (2003). Trophic facilitation by introduced top predators: Grey wolf subsidies to scavengers in Yellowstone National Park. *The Journal of Animal Ecology*, 72, 909–916. <https://doi.org/10.1046/j.1365-2656.2003.00766.x>
- Wolf, C., & Ripple, W. J. (2017). Range contractions of the world's large carnivores. *Royal Society Open Science*, 4, 170052. <https://doi.org/10.1098/rsos.170052>
- World Bank. (2018). Nepal GDP per capita PPP 1990–2018. [WWW Document]. Retrieved from <https://tradingeconomics.com/nepal/gdp-per-capita-ppp>
- Zabel, A., & Roe, B. (2009). Optimal design of pro-conservation incentives. *Ecological Economics*, 69, 126–134. <https://doi.org/10.1016/j.ecolecon.2009.08.001>
- Zabel, A., & Uller, K. H. (2008). Conservation performance payments for carnivore conservation in Sweden. *Conservation Biology*, 22, 247–251. <https://doi.org/10.1111/j.1523-1739.2008.00898.x>

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Kusi N, Sillero-Zubiri C, Macdonald DW, Johnson PJ, Werhahn G. Perspectives of traditional Himalayan communities on fostering coexistence with Himalayan wolf and snow leopard. *Conservation Science and Practice*. 2020;2:e165. <https://doi.org/10.1111/csp2.165>