Determinants of herder attitudes towards the Vulnerable snow leopard *Panthera uncia* in Yushu Prefecture, China

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Abstract Yushu Prefecture in Qinghai Province provides some of the largest known stretches of habitat for the Vulnerable snow leopard *Panthera uncia* in China. People living in these areas are dependent on agropastoralism. Support from local communities is necessary for effective long-term conservation action for snow leopards, but loss of livestock to snow leopards can create financial burdens that induce negative attitudes and encourage retaliatory killing. We assessed factors driving herders' attitudes towards snow leopards and their conservation. We found that herders had higher agreement with positive than with negative statements about snow leopards despite nearly half reporting livestock loss to snow leopards within the last 5 years. No retaliatory killing was reported. Herders with more years of formal education and fewer livestock losses were more likely to have positive attitudes whereas those with lower importance of snow leopards to their religion, fewer livestock losses, and fewer years of education were more likely to have negative attitudes. Understanding the multifaceted mechanisms responsible for positive views towards species is imperative for reaching conservation goals. Our findings ascribe to the importance of increased education and adherence to Tibetan beliefs in promoting conservation tolerance towards snow leopards in Qinghai Province, but also indicate a need for further research into the impact of livestock loss.

Keywords Carnivore, China, human–wildlife conflict, livestock, *Panthera uncia*, snow leopard, survey, Tibetan Plateau

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Introduction

Humans, livestock, predators and prey share common resources (Aryal et al., 2014). This overlap leads to interactions between humans and animals that have negative outcomes, such as economic loss (Pettigrew et al., 2012), retaliatory killings as a response to livestock predation (Oli et al., 1994), human mortality (Treves & Karanth, 2003) and disease (Thirgood et al., 2005). Such outcomes threaten large mammals and are anticipated to increase in severity (Kansky & Knight, 2014). Felids are often affected despite their low densities because they occupy large home ranges and attack domestic animals and humans (Treves & Karanth, 2003). Because many felids are threatened, killings can be detrimental to their populations (Woodroffe & Ginsberg, 1998). Such loss can have macroecological impacts as large felids influence trophic cascades downwards, and increase biodiversity (Miller et al., 2001).

Carnivores place financial burden on herders via livestock depredation, leading to negative attitudes, retaliatory killing, and disagreements between community members and agencies seeking to protect wildlife (Treves & Karanth, 2003). Livestock loss is, however, preventable by non-lethal means (Ogada et al., 2003). Predator proof corrals have been successful in India (Jackson & Wangchuk, 2004), Africa (Lichtenfeld et al., 2015) and North America (Cluff & Murray, 1995). Increased human activity has been effective in Kenya (Ogada et al., 2003), and shifting campsites decreased loss in Mongolia (Mijiddorj et al., 2018). Guard dogs *Canis familiaris* have been used to alert herders and ward off predators (Ogada et al., 2003). In addition, post-predation interventions, such as livestock insurance, can reduce financial loss and negative perceptions, although these are often insufficient (Jackson & Wangchuk, 2004; Hemson et al., 2009).

The success of mitigation strategies largely depends on community participation (Jackson & Wangchuk, 2004). Effective implementation requires research on the attitudes of local stakeholders (Dickman, 2010; Kansky & Knight, 2014). Although values direct attitudes, attitudes precede and direct behaviour (Vaske & Manfredo, 2012) and thus knowledge of the attitudes of herders is necessary for inferring actions towards carnivores. Attitudes are influenced by many factors, including knowledge, social norms, economic constraints and religious affiliation (Dickman, 2010).

Few studies have examined the attitudes of pastoralists in Central Asia despite overlap of people with carnivores, including the threatened snow leopard *Panthera uncia* (Green & Zhimbiev, 1997; Suryawanshi et al., 2014).

The snow leopard is categorized as Vulnerable on the IUCN Red List (McCarthy et al., 2017). The species influences surrounding ecosystems through predation on wild ungulates and competition with sympatric carnivores (Li et al., 2014). Reduced wild prey populations combined with higher abundance of domestic animals leads to livestock predation by snow leopards (Schaller et al., 1988). Depredation events are costly to herders, and foster negative attitudes towards snow leopards and motivate calls for their elimination. Although there have been previous studies of attitudes towards snow leopards in China (Xu et al., 2008; Li et al., 2014, 2015; Alexander et al., 2015), findings cannot be generalized across regions (Alexander et al., 2015). Additionally, repeated assessments are needed to examine temporal changes, particularly on the Tibetan Plateau where rapid societal and environmental changes are occurring (Bauer, 2015).

We sought to identify variables influencing the attitudes of herders towards snow leopards and their conservation. Associations between herding practices, animal loss and demographics were explored to understand the most important factors influencing attitudes. We hypothesized that negative attitudes would be associated with greater livestock loss and fewer years of formal education, whereas positive attitudes would be associated with fewer losses, more years of formal education, livestock insurance and Tibetan beliefs. We further predicted that herders would consider depredation the most threatening risk to livestock and that herders using predator proof corrals would report fewer losses.

Study area

Interviews were conducted in Suojia Village, Zhiduo County, Yushu Prefecture, Qinghai Province, China (Fig. 1). Of the 38,793 km² of Zhiduo County (excluding Hoh Xil National Nature Reserve) 22,395 km² overlaps with Sanjiangyuan National Park (Dai et al., 2019). The 152,000 km² Sanjiangyuan National Park is the largest stretch of continuous snow leopard habitat in China (Li et al., 2013; Liu et al., 2016). The area has alpine meadow vegetation with limestone massifs and mountain ranges of < 5,500 m altitude (Schaller et al., 1988). The climate is windy and dry with temperatures from −20 °C in January to 8 °C in July (Mallon, 2004). Interview sites were at a mean altitude of 4,429 m (range 4,109–4,670 m).

Methods

Questionnaire development Preliminary interviews were conducted with five herders, to identify any problems with clarity (Hemson et al., 2009). The revised questionnaire contained statements regarding attitudes towards snow leopards, importance of snow leopards to religion, and perceived wildlife abundance, ranked on a Likert type scale (Likert, 1932), followed by questions regarding animal ownership and management, livestock loss to snow leopards, knowledge of retaliatory killing, threats to livestock, and demographics (Supplementary Material 1). A 5-year recollection period was used to avoid recall bias (Bernard, 2013). Questions regarding retaliatory killing were worded to reduce social desirability bias (Fisher, 1993). The questionnaire was limited to one page to avoid interviewee fatigue and disinterest (de Vaus, 2002).

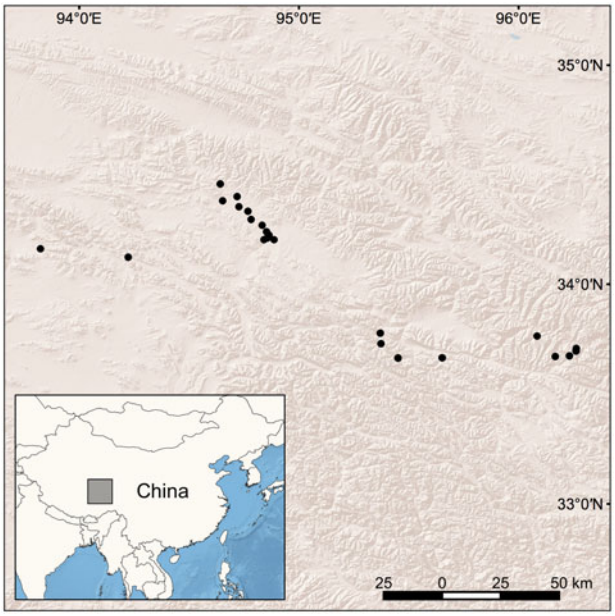

FIG. 1 Interview locations in Suojia Village, Yushu Prefecture, Qinghai Province, China.

Data collection Herders were interviewed in July 2018. Interviews were verbal, to avoid any potential misunderstandings stemming from illiteracy, and lasted c. 15 minutes. Local guides served as translators. The content, objectives and anonymity were explained to the potential interview subjects, and interviewees were told they could halt the interview at any time. The snowball sampling strategy was used to maximize sample size and engender participant trust (Goodman, 1961; Sadler et al., 2010).

Data analysis Likert scale scores for negatively worded attitude statements were reversed to match the Likert scale scoring of positively worded attitude statements. For example, a 1 became a 7, a 2 became a 6, and so on. Reported scores from each herder were summed and divided by the total number of interviews to calculate the percentage of herders who had positive, neutral, or negative attitudes towards a specific statement. The Likert type

TABLE 1 The eight predictors used in model construction to assess variables contributing to positive and negative attitudes towards the snow leopard *Panthera uncia*.

Predictor	Explanation	Variable Level
Covariate		
Number of animals lost	Number of livestock lost to snow leopards in previous 5 years	Numeric
Years of formal education	Number of years of formal education completed by herder	Numeric
Factor		
Snow leopard abundance	Perception of snow leopard abundance in study area	Ordinal. Coded as 0 if reported 1–4 (low abundance) & 1 if reported 5–7 (high abundance) on Likert scale
Dog ownership	Herder owns one or more dogs	Ordinal. Coded as 0 for no dogs, 1 if ≥ 1 dogs owned
Guarding	Herders actively guard their livestock to deter predators	Ordinal. Coded as 0 if herders do not guard livestock, 1 if herders do guard livestock
Insurance	Herders possess livestock insurance to offset financial burden of livestock depredation	Ordinal. Coded as 0 if herders do not possess livestock insurance, 1 if herders do possess livestock insurance
Important to religion	Herders consider snow leopards important to their religion	Ordinal. Coded as 0 if reported 1–4 (not important to religion) & 1 if reported 5–7 (important to religion) on Likert scale
Loss to snow leopards	Herder experienced a livestock depredation event they believe was by a snow leopard	Ordinal. Coded as 0 for no reported loss, 1 for loss of ≥ 1 animals

scale values of 1, 2 and 3 were collapsed into a Disagree category, 4 assigned to a Neutral category, and 5, 6 and 7 were collapsed into an Agree category. Cronbach's alpha was used to ensure internal consistency within all five attitude statements (Cronbach, 1951). A principal component analysis (PCA) with varimax rotation and pairwise exclusion of cases was used to identify variables contributing most to variation in attitudes (Kaiser, 1958; Jolliffe, 2002). Components with eigenvalues > 1 were selected for interpretation (Kaiser, 1960) and internal consistency of statements in separate components assessed. Likert type scores for statements in each component were averaged to give an overall agreement score. A Wilcoxon signed-rank test was completed to assess statistical differences between PCA components (Wilcoxon, 1945). Relationships among variables were examined using Spearman's rho (Spearman, 1904). Those exhibiting multi-collinearity with high significance ($P < 0.01$) had one variable removed based on author expertise and number of other highly significant correlations (Dormann et al., 2013). Generalized estimating equations were used to determine influential predictors of positive and negative attitudes. These equations are appropriate for datasets with non-normal distributions, without having to make data corrections (Kowalski & Tu, 2008; Tang et al., 2012). A series of general models were constructed based on eight predictor variables (Table 1). The first model was built using all variables. The least impactful variable was then removed in a stepwise fashion for each sequential model. The quasi-likelihood under the independence model criterion was used to rank models, with the lowest quasi-likelihood value deemed most appropriate (Cui, 2007; Hardin & Hilbe, 2003). *SPSS 25.0* (SPSS, Chicago, USA) was used for all analyses, with significance set at $P < 0.05$.

Results

Interview responses We completed interviews with 73 herders (67 men, six women), over an area of c. 476 km², of whom 94.5% reported pastoralism and 5.5% reported civil service employment as being their primary income source. The greatest Euclidian distance between sites where interviews were conducted was 231 km. No retaliatory killings of snow leopards were reported. The results of the other interview questions are presented in Table 2.

Principal component analysis and correlation coefficients Reliability statistics showed internal consistency ($\hat{a} = 0.72$). There were two components with eigenvalues > 1, accounting together for 67.3% of variance observed (Table 3). The highest scores for component 1 were associated with positive attitudes towards snow leopards, which we refer to as Snow Leopard Positive ($\hat{a} = 0.70$). The highest scores for component 2 were associated with negative attitudes, which we refer to as Snow Leopard Negative ($\hat{a} = 0.53$). Agreement was significantly higher for positive than for negative statements ($P < 0.001$). The mean scores for each attitude statement and per cent of agreement, neutrality and disagreement were evaluated and correlation coefficients for predictor variable relationships resulted in the removal of four variables (Table 4).

Attitude correlates The model with the lowest quasi-likelihood score for Snow Leopard Positive included number of animals lost (−0.125, 95% CI −0.221–−0.028, $P = 0.012$) and years of education (0.077, 95% CI 0.18–0.135, $P = 0.011$). The model with the lowest quasi-likelihood score for Snow Leopard Negative included number of animals lost (−0.154,

TABLE 2 Results of interviews with 73 herders (67 men, six women), with demographics, perceptions of wild animal abundance, animal holdings, management practices, livestock loss and perceptions of threats to livestock.

Questions	Answers			
Demographics	Mean (range)			
Age (years)	37.4 ± SD 10.7 (21–73)			
No. of years of formal education	2.0 ± SD 3.3 (0–12)			
No. of children	1.4 ± SD 1.9 (0–8)			
Perception of abundance (1[none]–7[many])	Mean (range)			
Blue sheep *Pseudois nayaur*	6.2 (1–7)			
Argali *Ovis ammon*	5.6 (1–7)			
Snow leopard	5.0 (2–7)			
Animal holdings	Yak	Sheep	Dog	
% of herders who own species	98.8	3.0	71.2	
Mean (range) no. owned	72.7 (0–250)	0.6 (0–20)	1.2 (0–5)	
Total no. of animals	4,723	40	81	
Management practices	Insurance	Guarding	Predator proof corrals	
% of herders who use practice	56.2	33.8	4.2	
Livestock loss in previous 5 years	Yak	Horse[1]	*Total*	
No. of animals lost	75	4	79	
Mean (range) no. of animals lost per household	2.5 ± SD 2.2 (0–12)			
% of herders who lost livestock to snow leopards	45.8			
Perception of threats	Disease	Predation	Grassland degradation	Drought
% of herders who consider threat as greatest to livestock	36.7	43.3	20.0	0.0

[1]All horses previously owned by interviewees had been predated, therefore horses are not listed under animal holdings.

TABLE 3 Principal Component Analysis factor loadings for Snow Leopard Positive and Snow Leopard Negative factors, mean Likert score for each question on a seven point scale (1, strongly disagree with statement, to 7, strongly agree with statement), and per cent agreement of herders to each statement.

	Snow Leopard Positive loading score	Snow Leopard Negative loading score	Mean Likert score	% of herders who		
				agree with statement	are neutral on statement	disagree with statement
We need snow leopards in the wild	0.811		5.8	95.8	4.2	0.0
I enjoy seeing snow leopards	0.756		5.7	91.4	4.3	4.3
We need to keep snow leopards safe	0.767		5.8	95.8	1.4	2.8
I am concerned snow leopards will kill my animals (reversed)		0.755	3.0	18.3	9.9	71.8
I am afraid of snow leopards (reversed)		0.886	2.6	15.3	4.2	80.6

95% CI −0.244–−0.063, P = 0.001), years of education (−0.099, 95% CI −0.174–−0.024, P = 0.010) and importance of snow leopards to religion (−1.119, 95% CI −2.175–−0.63, P = 0.038; Supplementary Table 1).

Discussion

Similar to previous studies in China, herders had positive attitudes towards snow leopards (Li et al., 2014, 2015; Alexander et al., 2015). The factors most strongly associated with positive attitudes were more years of formal education and fewer livestock lost. Education has previously been linked to positive attitudes towards snow leopards (Suryawanshi et al., 2014). In our study, age and education were negatively correlated, suggesting that younger herders are receiving more schooling. Reduced nomadism among Tibetans has decreased the income generated from traditional sources such a pastoralism, lessening the assistance families need from children and allowing time for schooling (Bauer, 2015). Students now have more opportunities for conservation education in school and through organizations that inspire environmental protection (Shen & Tan, 2012). In addition, students learn to read, promoting lifetime

TABLE 4 The Spearman rank-order correlation coefficients (with two-tailed significance in parentheses) of relationships between predictor variables.

	Important to religion	Snow leopard abundance	No. of livestock owned[1]	Dog owned	Guarding	Predator proof corral[1]	Insurance	No. of livestock lost	Age[1]	Years of formal education	No. of children[1]
Important to religion											
Snow leopard abundance	−0.156 (0.203)										
No. of livestock owned[1]	0.094 (0.439)	0.301 (0.011)*									
Dog owned	0.233 (0.066)	0.085 (0.505)	0.317 (0.009)**								
Guarding	0.201 (0.100)	0.103 (0.401)	0.061 (0.615)	0.144 (0.248)							
Predator proof corral[1]	−0.284 (0.019)*	0.119 (0.333)	−0.103 (0.392)	−0.356 (0.003)**	0.146 (0.225)						
Insurance	−0.015 (0.903)	−0.167 (0.174)	−0.042 (0.728)	0.006 (0.960)	−0.233 (0.051)	0.180 (0.134)					
No. of livestock lost	−0.052 (0.669)	0.083 (0.496)	0.264 (0.024)*	0.075 (0.550)	−0.158 (0.188)	−0.015 (0.902)	0.053 (0.659)				
Age[1]	−0.054 (0.661)	0.164 (0.182)	−0.068 (0.571)	−0.260 (0.038)*	0.032 (0.793)*	0.334 (0.005)**	−0.225 (0.063)	0.147 (0.221)			
Years of formal education	−0.158 (0.223)	−0.209 (0.103)	0.049 (0.706)	−0.026 (0.848)	−0.191 (0.140)	0.106 (0.418)	0.285 (0.026)*	0.274 (0.030)*	−0.499 (0.000)**		
No. of children[1]	−0.027 (0.837)	0.020 (0.879)	−0.037 (0.771)	−0.262 (0.047)*	0.003 (0.982)	0.188 (0.143)	0.047 (0.719)	0.200 (0.113)	0.619 (0.000)**	−0.301 (0.018)*	

*P < 0.05 (2-tailed); **P < 0.01 (2-tailed).
[1]Variable removed from consideration in general model construction.

awareness of posted wildlife laws and knowledge of the benefits of carnivores (Suryawanshi et al., 2014).

Previous research, in Spiti Valley, India, found that livestock depredation by snow leopards did not substantially influence attitudes (Suryawanshi et al., 2014). In contrast, we found that the number of animals lost contributed to both greater positive and negative attitudes towards snow leopards. Intuitively for positive attitudes, those who lost less livestock would be more likely to agree with positive statements. For negative attitudes, it is possible they may have been instilled prior to loss, or that the herder experienced greater predation more than 5 years previously, and therefore agreed with negative statements. Another possibility is that herders with more negative attitudes exercise greater caution and use protective measures not outlined in our survey (e.g. fenced pastures, housing newborn livestock), thus reducing loss. Livestock loss was positively correlated with number of livestock owned, indicating that all herders experienced comparable rates of predation. However, the cultivation of negative attitudes and likelihood of retaliation against snow leopards for livestock predation may be dependent on the predated animal's size, age and condition.

Tibetan religious beliefs, which mandate respect for wildlife, may contribute to lower likelihood of holding negative attitudes towards snow leopards. Tibetan Buddhism influences c. 80% of the geographical regions that overlap with snow leopard habitat (Li et al., 2014). Snow leopards were considered religiously important by 93% of the herders we interviewed. Such beliefs probably contribute to the absence of retaliatory killing, although previous interviews in the same area during 2009–2011 reported their occurrence (Li et al., 2013, 2014). Although it appears heartening that no killings were reported to us, it is nevertheless possible that a greater number of interviews would have uncovered such reports, or that herders adopted a 'universal silence' in our presence (Oli et al., 1994).

Other sympatric carnivores, such as the wolf *Canis lupus*, probably face a greater risk of retaliatory killing despite Buddhist teachings (Mishra, 1997). Although we did not enquire about attitudes towards wolves, six herders expressed concern about predation of livestock by wolves. Wolves are viewed negatively because herders presume they play a larger role in livestock predation than snow leopards (Suryawanshi et al., 2013). Herders are considered knowledgeable in discerning the species responsible for kills, via resulting wounds (Aryal et al., 2014). However, some kills reported in this study as being by snow leopards could nevertheless have been misidentified and caused by wolves or domestic dogs.

Over 70% of herders interviewed owned at least one dog. Predator proof corrals were positively correlated with herder age, whereas dog ownership was negatively correlated, demonstrating that dogs are more popular with younger herders. Neither predator proof corrals, guarding, nor dog

ownership were correlated with number of livestock lost, suggesting these practices alone may not be sufficient to prevent loss, are not deployed effectively or are implemented post-predation. However, the model including the predictor variable livestock guarding was numerically closely competitive in the final model shaping positive attitudes, and therefore may be playing the largest role among the deterrent methods assessed in this study.

Dogs can spread disease (Mamaev et al., 1995), stress, harass and kill wildlife (Lenth et al., 2008; Young et al., 2011), and compete with native species for resources (Vanak et al., 2009). The number of dogs reported in our study is probably a small portion of the total population because ownership is informal, with limited spaying/neutering, leading to free ranging and feral individuals (Home et al., 2017). In trans-Himalayan India, dogs were responsible for 40% more livestock mortalities than snow leopards (Suryawanshi et al., 2013). Research examining how dogs may be affecting wildlife and livestock is needed.

Nearly half of the herders who reported livestock losses possessed insurance. In China, compensation is targeted towards losses caused by protected animals (Pettigrew et al., 2012). Herders did not comment on insurance, but it is widely accepted that the programmes are insufficient (Madhusudan, 2003). Conservation performance payments that compensate herders for achieving goals that benefit carnivores may be an alternative in areas with inadequate financial coverage of livestock losses (Zabel & Holm-Müller, 2008; Kunkel et al., 2016).

Herders indicated comparatively high numbers of snow leopards, blue sheep *Pseudois nayaur*, and argali *Ovis ammon* on the Likert scale provided to them. Although reports of wildlife abundance may have limited consistency across herders, they provide useful information (Davis & Wagner, 2003). We had planned to conduct counts of prey, to substantiate the responses of the interviewed herders, but most of the wild ungulate populations had at the time moved to higher elevations as a result of higher temperatures and increased human activity (X. Ran, pers. comm., 2018), making this infeasible. For snow leopard abundance, scat surveys as part of a separate, contemporaneous study examining snow leopard population genetics indicated the presence of six females in the area (Zhang et al., 2019). Pastoralists depend on their environment and can serve as strong conservation allies (Foggin & Torrance-Foggin, 2011), and local perceptions and scientific studies can be in agreement regarding the status of wildlife populations (van der Hoeven et al., 2004; Danielsen et al., 2014), although more research on this is needed in our study area.

Predation was considered the primary threat to livestock by 43% of herders, followed by disease at 37%. Predation has been reported to be of the greatest concern in other studies, even when disease caused more mortality (Dar et al., 2009). Grassland degradation was the third ranked threat, at 20%, with herders implicating the pika *Ochotona curzoniae* as a pest that kills grass roots and competes with livestock for vegetation (Zhou et al., 2004). Drought and other weather conditions were not reported as being threats, probably because major climatic events are relatively infrequent in this area.

Our study contributes to previous studies of herder attitudes towards snow leopards in China, and provides data 7 years after a previous survey in the same area (Li et al., 2013). Similar to findings by Li et al. (2013), herders had positive views towards snow leopards, with formal education playing a significant role in greater positive attitudes and fewer negative attitudes. It is unlikely that older adults harbouring negative views will change their views through conservation education alone and compensation for actions that protect apex predators may be required (Conforti & de Azevedo, 2003). How livestock loss shapes attitudes towards snow leopards is unclear; more research is needed to determine livestock factors impacting tolerance, including species (i.e. sheep, goat or yak), and age and quality of animal lost. Predator proof corrals, guarding and dogs do not appear to reduce losses significantly, but this finding could be influenced by inconsistent implementation and temporal shifts in management practices. Herders may be effective sources of information on relative wildlife abundances, but this should be corroborated with population surveys. Our results support the notion that Tibetan beliefs play an important role in protecting snow leopards (Li et al., 2013), exemplifying the role of societal and cultural norms in perceptions of wildlife (Dickman, 2010).

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Conflicts of interest None.

Ethical standards An Institutional Review Board exemption was granted by Duquesne University as no identifiable information was gathered. The research otherwise abided by the *Oryx* guidelines on ethical standards.

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