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RESEARCH ARTICLE

Claws, consequences and coexistence: Local community attitudes toward large carnivores in mountain landscapes

Kat Douglas, Zahra Ebrahimi Monfared, Seyedhamed Mirkarimi, Adrian Paterson, Mahmood Soofi

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Abstract Human attitudes toward large carnivores are shaped by multiple interrelated socio-psychological factors, yet conservation interventions often focus on reducing material impacts while paying less attention to underlying attitude drivers. We investigated attitudes towards three large carnivore species: Persian leopard (*Panthera pardus*), grey wolf (*Canis lupus*), and brown bear (*Ursus arctos*) among communities around Golestan National Park, Iran. Using interview data from 292 participants across 30 villages, we applied Bayesian structural equation modelling to examine how cognitive beliefs, social beliefs, perceived management responsibility, and livestock loss relate to attitudes towards each species. Cognitive beliefs emerged as the strongest predictor across all three species, whereas social beliefs, management responsibility, and livestock loss varied in influence. The limited role of livestock loss suggests that reducing carnivore impacts alone is insufficient to promote coexistence. Instead, conservation efforts should combine practical conflict-mitigation measures with strategies engaging local beliefs, social norms, and expectations of wildlife management.

Keywords Bayesian structural equation modelling (SEM) · Conservation psychology · Golestan National Park · Human-carnivore conflict · Human-carnivore interactions · Human-wildlife coexistence

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s13280-026-02486-9.

INTRODUCTION

Mitigating negative interactions between local communities and wildlife and promoting coexistence, particularly in areas where communities border protected areas, is a central challenge in conservation (Dickman 2010; Kolipaka et al. 2015; Perry et al. 2022; Soofi et al. 2022b; Ebrahimi-Monfared et al. 2025a). Large carnivores pose a real threat to property and occasionally to human lives (Soofi et al. 2022a; Asdollahi et al. 2023). While nature conservation is important, the brunt of the negative impacts of large carnivores is borne by the communities that live alongside them in their natural spaces and that rely on these areas for their livelihoods, particularly small-scale households (Khorozyan et al. 2015; Ghoddousi et al. 2018). Conservation action must therefore keep well-being and livelihoods at the forefront of its conservation decision-making.

These conservation-livelihood tensions are particularly evident in villages bordering Golestan National Park in northeastern Iran, where Persian leopard (*Panthera pardus tulliana; synonym = P. p. saxicolor)*), grey wolf (*Canis lupus*), and brown bear (*Ursus arctos*), coexist with pastoralists and crop farmers in shared landscapes (Khorozyan et al. 2015, 2017; Meinecke et al. 2018; Soofi et al. 2022b; Ebrahimi-Monfared et al. 2025b). Previous research in this landscape has improved understanding of livestock depredation, conflict mitigation, community perceptions, and emotions toward large carnivores (Babrigir et al. 2017). However, conservation practitioners have limited evidence on how multiple social-psychological factors interact to influence attitudes toward different carnivore species. Understanding these relationships is important because coexistence challenges are formed by the direct costs of living with wildlife as well as by people's beliefs, social

influences, and perceptions of management. Effective conservation interventions require approaches that address both material impacts and the underlying social and psychological drivers of human–carnivore relationships (Babrgir et al. 2017; Zimmermann and McQuinn 2025).

Growing human populations and agricultural expansion have intensified negative interactions between people and wildlife in the Hyrcanian forests (Meinecke et al. 2018). Attacks on livestock (by wolves, leopards, and occasionally bears) and damage to crops, including rice, fruit trees, vegetables, and beehives (by bears), impose substantial economic losses on already vulnerable households (Meineke et al. 2018; Asadollahi et al. 2023).

Carnivore species are capable of adapting to human-modified environments, such as the grey wolf (*Canis lupus*), which has adapted to livestock as a food source when wild prey sources have been depleted and selects breeding sites based on human disturbance risk (Sazatornil et al. 2016; Behmanesh et al. 2018). While adaptive, this behaviour increases negative interactions. Retaliatory and precautionary killing of carnivores by farmers is a common response to livestock loss (Badola et al. 2021; Soofi et al. 2022b). Although attitudes are not always negative, some communities show more tolerance, or even positive attitudes, toward carnivores after repeated non-lethal encounters (Dickman 2010). The intensity of a human-carnivore interaction can be a strong influence on the formation of attitudes (Hemson et al. 2009; Snyman 2012). For example, some communities have experienced high rates of predation and report strong negative attitudes towards wolves (Bisi et al. 2007; Eriksson et al. 2015), whereas others are more tolerant, despite experiences with depredation (Majić and Bath 2010; Gosling et al. 2019).

While quantifying actual predation events is important, understanding community perceptions and attitudes toward carnivores is equally critical (Asadollahi et al. 2023; Carroll et al. 2024). Attitudes shape a person's disposition toward a species and their willingness to support conservation actions (Castillo-Huitrón et al. 2024). Attitudes are enduring psychological constructs composed of beliefs, affect (emotions), and evaluative tendencies towards large carnivores (Heberlein 2012; Perry et al. 2022). Understanding these attitudes enables the design of conservation strategies that are both ecologically effective and socially supported (Perry et al. 2022).

Attitude formation is multidimensional. Cognitive beliefs, including evaluations, knowledge, and perceptions, form the conceptual foundation, though they do not always reflect objective reality (Trafimow and Sheeran 1998; Glikman et al. 2012; Perry et al. 2022). Perceived risk strongly predicted tolerance of recovering black bear populations in Ohio, USA (Zajac et al. 2012), and negative attitudes toward recovering wolf populations in Germany and Sweden exceeded those in Spain and Portugal, despite fewer wolves, highlighting a more complex relationship than purely tangible threats (Stöhr and Coimbra 2013). Social norms and cultural values further shape attitudes independently of actual depredation. Communities with continuous wolf presence differ from those experiencing a recovered population (Gosling et al. 2019), and some groups tolerate predation based on cultural or spiritual beliefs (Lozano et al. 2019). Affective responses (emotions) can outweigh cognitive assessments (Glikman et al. 2012), and perceptions of institutional responsibility and trust in government also play a significant role: greater governmental support is associated with more positive carnivore attitudes (Arbieu et al. 2019; Ghasemi et al. 2021). This is particularly relevant in the Iranian context, where post-attack support is often limited by funding and bureaucracy, which contributes to illegal retaliation (Behmanesh et al. 2019).

Despite growing research on human-carnivore coexistence from a conservation psychology perspective (Castillo-Huitrón et al. 2020, 2024; Ghasemi et al. 2021; Newsom et al. 2025), limited attention has been given to simultaneously examining multiple, dynamic drivers of attitudes, including attitudinal constructs and lived experience, within a unified framework (Ebrahimi Monfared et al. 2025a). Studies that have applied multivariate attitudinal frameworks typically focus on a single species, limiting insights into whether drivers differ across species (Bruskotter et al. 2026; Ghasemi et al. 2026b). To address this gap, we used interview data (2022) from residents of 30 villages surrounding Golestan National Park. Employing Bayesian structural equation modelling (SEM), we ask: (1) what socio-psychological factors, including cognitive beliefs, social norms, emotions, perceived management responsibility, and direct wildlife interactions, shape community attitudes toward large carnivores? (2) Do lived experiences (e.g., livestock loss, ranger contact, insurance coverage) influence attitudes directly or indirectly, through their effects on beliefs and emotions (e.g., fear, pride, and beliefs of danger)? Specifically, we hypothesised that negative wildlife interactions, regulations, social and cognitive beliefs, perceived management responsibility, and emotions would directly influence attitudes toward large carnivores. We further hypothesised that demographic factors, communication with rangers, livestock loss, insurance coverage, and livestock management practices would function as exogenous predictors, with cognitive beliefs, emotions, and demographic characteristics expected to exert the strongest influence on attitudes.

MATERIALS AND METHODS

Study area

Our study was conducted in villages surrounding Golestan National Park, located in northeastern Iran, which is both biologically and culturally significant. Established in 1957 as Iran's first biosphere reserve (Zehzad et al. 2002), the park spans approximately 91895 ha with an elevational range from 450 to 2411 m (Soofi et al. 2022a). This park includes multiple biomes, including Hyrcanian temperate and relict forest, steppe vegetation, and semi-arid habitat (Fig. 1; Akhani 2023), making it a vital refuge for the biodiversity of the region. This biologically rich landscape supports several large mammalian carnivores, many of which are listed as threatened or endangered, including the Persian leopard, grey wolf, and brown bear. The park also hosts a range of important mammalian herbivores, such as the urial (*Ovis vignei*), bezoar goat (*Capra aegagrus*), red deer (*Cervus elaphus maral*), and roe deer (*Capreolus capreolus*) (Firouz 2005). The area surrounding the park is inhabited by several human ethnic groups: Turks, Kurds, Fars, Baluch, and Sistani. The predominant means of income are from agriculture, animal husbandry, horticulture, and ecotourism (Ebrahimi Monfared et al. 2025a).

Survey design

Two local Iranian field researchers (one male and one female) conducted face-to-face interview surveys between April and November 2022 in villages surrounding Golestan National Park. Villages (n = 30) were selected if they lay within a 5 km buffer zone surrounding the park, due to the greater likelihood of them being impacted by the three focal large carnivore species, Persian leopard, grey wolf, and brown bear (Soofi et al. 2018; Ghoddousi et al. 2020; Soofi et al. 2022a). Professions of the villagers interviewed (n = 292) included livestock and crop farmers, beekeepers, teachers, freelancers, and others (not indicated). 71% of the interviews (n = 210) were given in the Turkmen language, with the remaining 29% (n = 82) conducted in Farsi. A pilot study (n = 15) was conducted to assess question clarity, appropriateness, and interview length before the main survey (Young et al. 2018).

The questionnaire captured a broad range of variables relevant to human-carnivore coexistence. Attitudes toward carnivores were assessed through support for lethal control

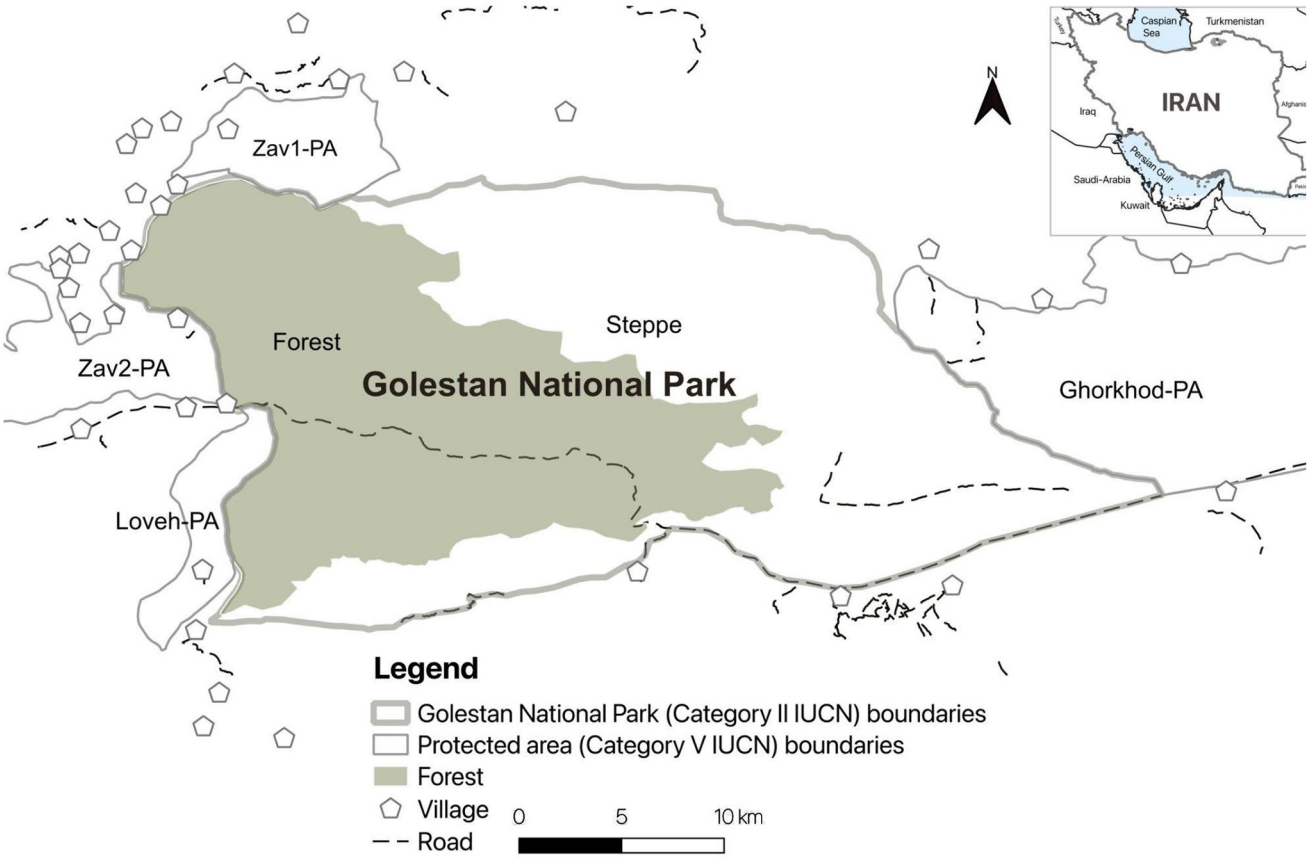


Fig. 1 Map of the study area, showing Golestan National Park, the locations of the villages where interview surveys were conducted, and the dominant vegetation types (forest and steppe) within the park. Figure from Ebrahimi Monfared et al. (2025a)

following livestock attacks and government-led population recovery and relocation. 'Cognitive beliefs' assessed perceived tourism benefits and the importance of conservation. 'Social norms' examined family and community expectations around retaliatory killings of carnivores. 'Emotions' collected responses concerning respondents' feelings of fear and pride towards large carnivores (Ebrahimi Monfared et al. 2025a). 'Regulatory ideas' collected views on legal frameworks and community involvement. We also collected information on livestock loss and management practices (including vaccination and the use of guardian dogs), insurance coverage, negative human–wildlife interactions, and communication with wildlife rangers during emergencies, as well as demographic information (e.g., age, literacy and income). Full survey items are included in the Supplementary Material. We recorded responses on a 5-point Likert scale (1-5), binary (0/1), or ordinal (such as age). Categorical data (e.g., village, gender, ethnicity, and ecological knowledge) were excluded as only numerical data could be used within the chosen analytical format.

Participants were given a full explanation of the study objectives and informed that their "participation in this interview survey was entirely voluntary, anonymised, and solely used for scientific purposes" (Soofi et al. 2024). The respondents were also notified that they had the right to end the interview for any reason without fear of consequences.

Statistical analysis

We used Bayesian Structural Equation Modelling (SEM) to test our hypothesised relationships between our predictor variable and community attitudes towards large carnivores, which is particularly suitable for socio-psychological research as it enables the simultaneous estimation of multiple interrelated relationships, including both direct and indirect effects (causal), within a single analytical framework (Anderson and Gerbing 1988; Kline 2016). Unlike conventional regression approaches, SEM allows the evaluation of complex causal pathways among latent constructs that cannot be measured directly, such as beliefs, attitudes, norms, and behavioural intentions (Anderson and Gerbing 1988; Lee 2007; Muthen and Asparouhov 2012; Kline 2016; Byrne 2016). SEM is especially important in studies of human–wildlife coexistence, where attitudes and behavioural responses are influenced by multiple interacting psychological and social factors rather than by single predictors acting independently. We applied a Bayesian SEM because it is a flexible and powerful statistical approach for estimating complex models and explicitly quantifying uncertainty in parameter estimates (Lee 2007; Muthén and Asparouhov 2012). Given our interest in understanding the relationships among multiple social-psychological constructs, Bayesian SEM was well suited to evaluating the overall structure of these pathways within a single model.

SEM comprises two important steps: the measurement model and the structural model (see Fig. 2). In the measurement model, we tested whether the survey items reliably measured their intended latent variable using a confirmatory factor analysis (CFA), which evaluates how well a set of observed survey items (manifest variables) represent a single latent (or construct) variable. For example, several questions about perceived tourism value and conservation importance together form the latent construct 'cognitive beliefs'. Thus, the confirmatory factor analysis tests whether these items load onto their intended construct sufficiently and consistently (Brown 2015).

The reliability of each latent construct was assessed using Cronbach's alpha (α) and McDonald's omega (ω), both calculated from the posterior factor loadings and residual variances (Hair et al. 2013; Hayes and Coutts 2020). Values ≥ 0.70 were considered acceptable, indicating that the survey items within each construct measure reliability consistently. Standardised factor loadings were examined relative to both latent and observed variance to confirm that each item contributed meaningfully to its construct.

All three measurement models produced very similar results. For all carnivore species, social beliefs about killing carnivores and cognitive belief systems negatively influenced attitudes toward large carnivores. The factors contributing to attitudes (the response variable) were positive: "*If I get compensation for loss of livestock, I have no problem with leopards/wolves/bears in the area*" and "*If*

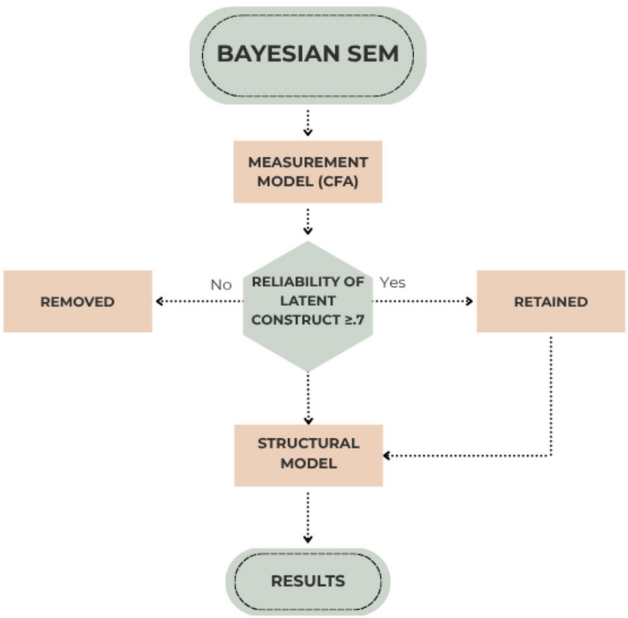


Fig. 2 Flowchart to represent the two-step workflow of Bayesian SEM modelling. CFA is an abbreviation for Confirmatory Factor Analysis

leopards/wolves/bears do not cause damage, I support their conservation". The latent variable cognitive belief was represented by two indicators: a negative attitude statement ("*A leopard/wolf/bear that is responsible for attacking livestock should be killed*") and a positive attitude ("*leopard/wolf/bear conservation is important*"). The positive item was reverse-coded so that higher scores on both items reflected more negative beliefs toward a carnivore. Social beliefs were measured using two variables: "*My family believes that any carnivore that harms livestock should be killed*" and "*My fellow villagers kill the carnivores that prey on the livestock*". The observed variable representing responsibility for carnivore management following an attack was measured using the statement "*In case of a leopard/wolf/bear attack, the government should try to capture and relocate the leopard/wolf/bear in the region*".

We included an observed variable capturing perceived governmental responsibility for carnivore management (e.g., '*In case of a leopard/wolf/bear attack, the government should try to capture and relocate the leopard/wolf/bear in the region*') in all three models. For the leopard and wolf models, we also included observed variables for experiences of livestock loss; however, this variable made the bear model unreliable, so we removed it. We removed items with low factor loadings to strengthen construct validity.

Attitude was specified as the primary endogenous response variable, whereas Cognitive Belief is an endogenous latent variable that represents an intermediate construct in the structural model and also predicts Attitude. Exogenous variables are variables that are not predicted by other variables within the specified model, whereas endogenous variables are predicted by other variables within the model (Wang and Wang 2020). Beta (β) is used for paths between endogenous variables, whereas gamma (γ) is used for paths from exogenous to endogenous variables.

Following the two-step approach outlined by Anderson and Gerbing (1988), after ensuring the measurement model step, we then constructed the structural model based on our hypotheses. The two-step approach ensures that any misfit in the structural model is reflective of the relationships themselves, not due to how the constructs were measured. We estimated the measurement model using 5000 iterations. We modelled each species (leopard, wolf, and bear) separately. Highly correlated constructs were examined for discriminant validity prior to inclusion in the final structural model.

We implemented Bayesian estimation using a Gibbs sampler algorithm within a Markov chain Monte Carlo (MCMC) framework. Bayesian methods combine prior information with observed data and explicitly account for uncertainty in parameter estimates, providing a probabilistic representation of the posterior distribution (Merkle et al., n.d.). Bayesian MCMC estimation is well-suited to smaller sample sizes and non-normal data (Lüdtke et al., 2021). Through iterative sampling, posterior distributions of model parameters were generated, enabling probabilistic inference regarding parameter estimates and structural relationships. This approach expresses uncertainty rather than single-point estimates, allowing for a more nuanced interpretation.

To assess the credibility of our model estimates, we calculated the Bayesian credible interval (CrI 2.5–97.5%) for all parameters (Merkle et al., n.d.). A credible interval represents the range within which 95% of the posterior probability mass lies for a given parameter (Brown 2015). We considered parameters to show evidence of an effect when the 95% CrI excluded zero and the direction of the estimate was consistent with theoretical expectations (e.g., social beliefs endorsing leopard killing were expected to negatively influence attitudes toward leopards).

Overall model fit was assessed using the posterior predictive p-value (PPP), which evaluates the extent to which replicated data generated from the model resemble the observed data while accounting for parameter uncertainty. Posterior predictor p- values close to 0.50 indicate good model fit (Gelman and Hill 2007; Merkle et al. n.d.). We also examined BRMSEA (Bayesian Root Square Error of Approximation), BGammaHat, adjBGammaHat, and BMc, which are noncentrality-based fit indices used to evaluate approximate model fit and the extent of model misspecification beyond that captured by posterior predictive checks (Garnier-Villarreal and Jorgensen 2020). All models were fitted using the 'blavaan' package (Merkle et al., n.d.) in R version 4.4.1 (R Core Team 2024), interfaced with Stan (Stan Development Team 2024).

RESULTS

Post-hoc analysis

Participant characteristics (age, gender, ethnicity, literacy status, and income sources/livelihoods) are summarised in Table 1. 923 NA responses were collected across the entire dataset (3.11%).

Measurement model

All retained items had factor loadings above 0.40 and were statistically credible (Kline 2016) (see Tables 2, 3, 4 below). Fit indices indicated relatively acceptable model fits for all species, with PPPs of 0.23 for leopards, 0.17 for wolves, and 0.22 for bears. A PPP between 0.05 and 0.950.05-0.95 is considered an acceptable model, and 0.5 is

Table 1 Participant characteristics (gender, age, ethnicity, literacy, and income sources/livelihoods) of the 292 respondents surveyed across 30 villages bordering Golestan National Park, northeastern Iran (Ebrahimi Monfared et al. 2025a)

Characteristic	Participant details
Gender	244 men, 48 women
Age	Mean 44.42 years (SD = 13.01)
Ethnicity	210 Turkmen, 57 Fars, 13 Kurds, 6 Turk, 5 Baluch
Literacy	Mean score 1.34 (SD = 0.90) on a 0–3 scale (0 = illiterate, 1 = elementary education, 2 = secondary education, 3 = academic)
Income sources/ livlihoods	Farming & livestock breeding (99), Self-employed (91), Homemaker (41), Livestock breeder (13), Employee (13), Farmer (11), Retired (9), Farming, livestock breeding & beekeeping (3), Farming & beekeeping (2), Ecotourism (1), Farming & ecotourism (1)

Table 2 Construct, question wording, factor loadings, and reliability coefficients for leopard. Posterior mean (M), standard deviation (SD), standardised factor loading (λ), Cronbach's alpha (α), and McDonald's omega (ω) are reported for each construct. †Item was reverse-coded prior to analysis

Construct, question, response	Posterior Mean	SD	Factor loading (λ)	Cronbach's α	McDonald's ω
Attitudes				0.67	0.71
If I get compensation for loss of livestock, I have no problem with leopards in the area	3.73	0.73	0.61		
If leopards do not cause damage, I support their conservation	3.82	0.61	0.86		
Cognitive belief				0.52	0.64
A leopard that is responsible for attacking livestock should be killed	1.89	1.02	0.86		
Leopard conservation is important†	1.24	0.57	0.48		
Social belief				0.61	0.67
My family believes that any carnivore that harms livestock should be killed	2.64	1.26	0.87		
My fellow villagers kill the carnivores that prey on the livestock	3.11	1.04	0.53		
Responsibility of management				NA	NA
In case of a leopard attack, the government should try to capture and relocate the leopard in the region	3.49	0.95	NA		
Livestock loss				NA	NA
Do you have the experience of loss of livestock or agricultural damage due to a leopard attack	0.00	1.00	NA		

the best fit (Suhr 2006) (see Supporting Information for full reporting on fit indices).

Structural model

The hypothesised leopard model fit the data well, with a PPP of 0.11. The McDonald's omega was $\omega = 0.83$. The leopard model showed a negative relationship between all latent and observed variables and attitudes towards leopards, except for responsibility for management. Cognitive beliefs had a negative and substantial interaction ($\beta = -0.48$, CrI -0.68 to -0.28) with attitudes towards large carnivores. Responsibility for management had a positive and substantial effect ($\beta = 0.19$, CrI = 0.07 to 0.31) on attitude, but its magnitude was low (see Fig. 3 and Table 2). Tendencies of participants had a negative but less substantial effect ($\beta = -0.13$, CrI -0.30 to 0.08) on attitudes towards regarding the killing of leopards, providing evidence that when people in one's village hold beliefs that leopards should be killed, it is likely to produce a negative attitude towards leopards, but the posterior distribution of the parameter included zero, indicating weak evidence for an effect. Livestock loss had a negative but uncertain effect ($\beta = -0.06$, CrI -0.18 to 0.06).

For the wolf structural model, the PPP indicated an adequate model fit (PPP = 0.39). The McDonald's omega suggested acceptable internal consistency ($\omega = 0.78$). Attitudes towards wolves were negatively associated with

Table 3 Construct, question wording, factor loadings, and reliability coefficients for wolves. Posterior mean (M), standard deviation (SD), standardised factor loading (λ), Cronbach's alpha (α), and McDonald's omega (ω) are reported for each construct. †Item was reverse-coded prior to analysis

Construct, question, response	Posterior Mean	SD	Factor loading (λ)	Cronbach's (α)	McDonald's (ω)
Attitudes				0.64	0.72
If I get compensation for loss of livestock, I have no problem with wolves in the area	3.59	0.84	0.51		
If wolves do not cause damage, I support their conservation	3.55	0.89	0.96		
Cognitive belief				0.61	0.63
A wolf that is responsible for attacking livestock should be killed	2.80	1.19	0.65		
Wolf conservation is important†	1.57	0.86	0.71		
Social belief				0.61	0.64
My family believes that any carnivore that harms livestock should be killed	2.64	1.26	0.75		
My fellow villagers kill the carnivores that prey on the livestock	3.11	1.04	0.62		
Responsibility of management				NA	NA
In case of a wolf attack, the government should try to capture and relocate the wolf in the region	3.56	0.89	NA		
Livestock loss				NA	NA
Do you have experience of loss of livestock or agricultural damage due to wolf attack	0.00	1.00	NA		

Table 4 Construct, question wording, factor loadings, and reliability coefficients for the bear structural equation model. Posterior mean (M), standard deviation (SD), standardised factor loading (λ), Cronbach's alpha (α), and McDonald's omega (ω) are reported for each construct. †Item was reverse-coded prior to analysis

Construct, question, response	Posterior Mean	SD	Factor loading (λ)	Cronbach's (α)	McDonald's (ω)
Attitudes				0.68	0.73
If I get compensation for loss of livestock, I have no problem with bears in the area	3.68	0.80	0.65		
If bears do not cause damage, I support their conservation	3.82	0.58	0.86		
Cognitive belief				0.58	0.60
A bear that is responsible for attacking livestock should be killed	1.90	0.93	0.58		
Bear conservation is important†	1.32	0.69	0.73		
Social belief				0.61	0.68
My family believes that any carnivore that harms livestock should be killed	2.64	1.26	0.69		
My fellow villagers kill the carnivores that prey on the livestock	3.11	1.04	0.75		
Responsibility of management				NA	NA
In case of a bear attack, the government should try to capture and relocate the bear in the region	3.47	0.96	NA		

cognitive beliefs ($\beta = -0.63$, CrI -0.83 to -0.44), whereas the relationships with social beliefs ($\beta = 0.00$, CrI -0.18 to 0.21), responsibility for management ($\beta = 0.17$, CrI 0.05 to 0.31), and livestock loss ($\beta = 0.01$, CrI -0.10 to 0.12) were weak or close to zero. Social beliefs and livestock loss had CrIs that overlapped zero, indicating limited evidence for these relationships (Fig. 3; Table 3). Cognitive beliefs were positively associated with responsibility for management ($\beta = 0.30$, CrI 0.17 to 0.43) and social beliefs ($\beta = 0.45$, CrI 0.27 to 0.60).

For the bear structural model, the PPP indicated acceptable model fit (PPP = 0.20), and McDonald's omega was $\omega = 0.83$. This model was more simplistic than the leopard and wolf models because livestock loss was not

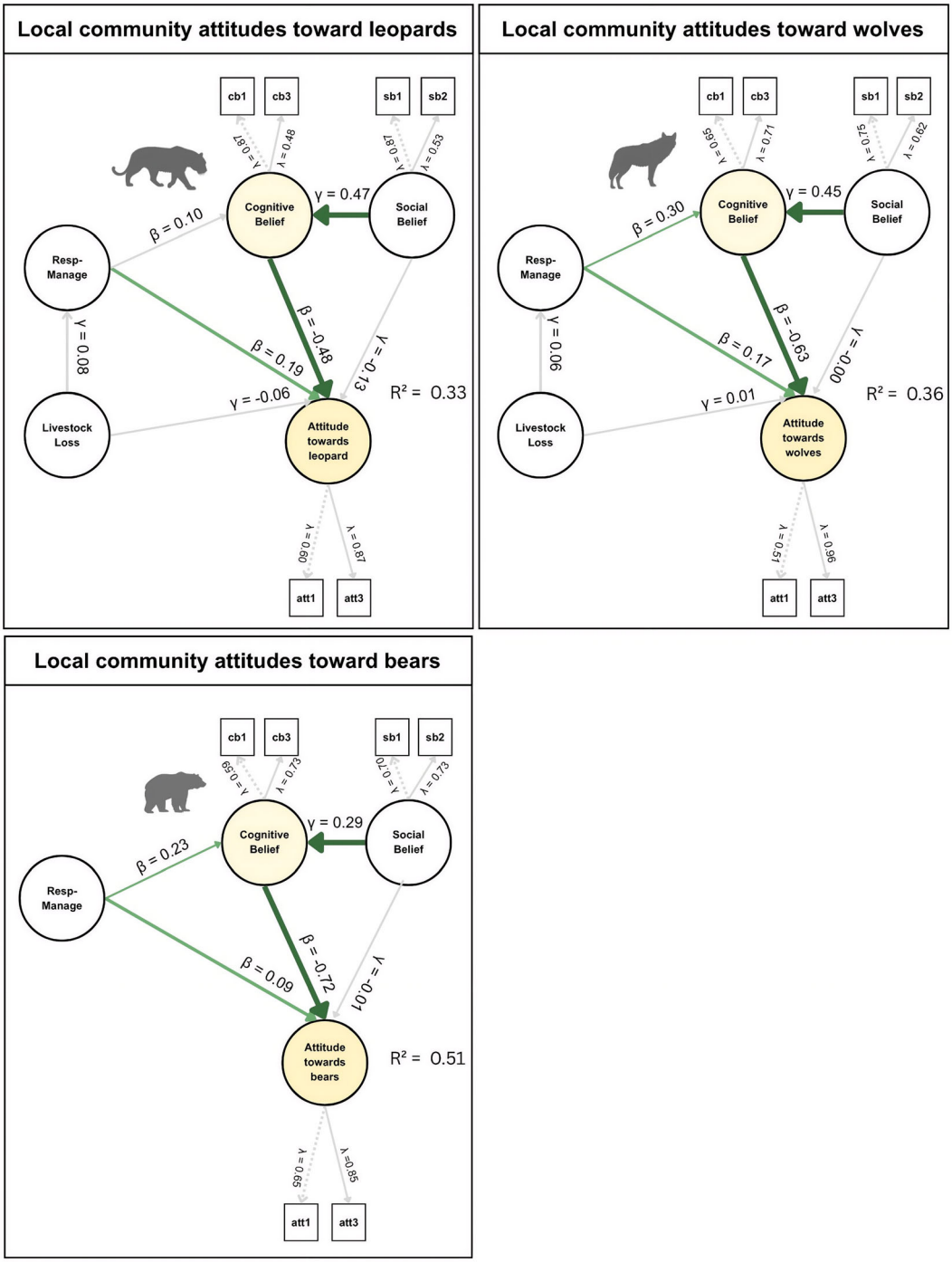


Fig. 3 Bayesian structural equation modelling results of local community attitudes toward leopards, wolves, and bears around Golestan National Park, northeastern Iran. Circles represent latent variables; squares represent observed indicator items. Lambda (λ) values show standardised factor loadings, indicating the strength of the relationship between each latent variable and its indicators; dotted lines denote the marker indicator fixed to identify each latent variable in the model. Beta (β) values show standardised path coefficients for regressions between two exogenous items (e.g., Responsibility for Management to Cognitive Beliefs); gamma (γ) values show standardised path coefficients between one endogenous and one exogenous (Social Belief to Cognitive Belief). Green lines and coefficients indicate a substantial relationship; grey lines and coefficients indicate a non-substantial relationship. Line thickness is scaled to the magnitude of the standardised coefficient. The double-headed grey arrow between Responsibility for Management and Livestock Loss represents the estimated covariance between these two exogenous variables, not a directional or causal relationship. R^2 values indicate the proportion of variance in attitude explained by the model for each species

retained. Cognitive beliefs showed a substantial negative association with attitudes towards bears ($\beta = -0.72$, CrI -0.91 to -0.54). In contrast, relationships between attitudes and social beliefs ($\beta = -0.01$, CrI -0.17 to 0.19) and responsibility for management were weak, with a credible interval overlapping with zero ($\beta = 0.09$, CrI -0.04 to 0.23). Social beliefs were positively related to cognitive beliefs ($\beta = 0.29$, CrI 0.08 to 0.46), as was responsibility for management ($\beta = 0.23$, CrI 0.09 to 0.37) (see Figure 3). The credible intervals for both relationships excluded zero, indicating positive associations (Figure 3; Table 4).

DISCUSSION

Across all three carnivore species, cognitive beliefs were the strongest and most consistent predictor of attitudes, supporting our hypothesis. Respondents who indicated that carnivore conservation is not important, or that carnivores should be killed for causing damage, held more negative attitudes overall. This pattern is consistent with evidence from central Iran, where education was found to have the greatest influence on attitudes towards large carnivores, particularly wolves, with recommendations to provide public education to increase awareness of ecological benefits as well as training to protect themselves and their livestock against carnivore attacks fundamental to finding coexistence (Behmanesh et al. 2018). Therefore, increasing education programmes to explain the ecological importance of carnivores, shift perceptions of danger to a more realistic risk, and to provide tools and training for protection, such as electric fencing, fox lights, and other non-lethal deterrents, can help change cognitive beliefs to be more positive and ultimately improve attitudes towards large carnivores (Gawronski and Bodenhausen 2006; Perry et al. 2022; Ghasemi et al. 2026a).

Social beliefs had a negative interaction with attitudes in all three models, indicating that when a person's peers believe carnivores should be killed, they are also likely to hold negative attitudes towards large carnivores, supporting our hypothesis. Additionally, these social beliefs had a positive interaction with cognitive beliefs across models, indicating that when peers believe large carnivores should be killed, it amplifies a person's beliefs that large carnivores are dangerous. This 'peer pressure' shows the importance of social viewpoints in shaping an individual's belief systems; however, considering the weak relationship in our model, this could be through their influence on cognitive beliefs, rather than directly. There could also be a degree of social desirability bias, where respondents give answers that they believe are the 'right' ones to be accepted and respected by their community, rather than actually expressing their own opinions, a common bias to encounter when using attitudinal survey methods (Gao et al. 2023; Zélie and Hunziker 2025). Although the direct pathway from social beliefs to attitudes was weak and non-significant, it was retained for model stability. Indirectly or otherwise, our models highlight the importance of focusing on community belief systems and needs when considering conservation interventions. Conservation outcomes can improve when societal values shift (Ghasemi et al. 2026a), so a focus on these community belief systems is a crucial component in creating positive conservation beliefs.

Livestock loss was included as an independent observed variable in the leopard and wolf models but showed a weak, non-substantial interaction with attitudes. The weak interaction could indicate that reducing the material costs of coexistence, while still important for the welfare of the household, is not sufficient on its own to change attitudes. While less directly important than hypothesised, a stronger experiential predictor comes vicariously, for example, when a neighbour experiences livestock loss (Birdsong et al. 2024). Vicarious experience was not an area that we could explore further with our data, and it would be a good area for future research. Livestock loss was not incorporated into the bear model, a logical conclusion considering bears are more likely to raid crops and beehives (Madadi et al. 2023). Madadi et al. (2023) found that the negative interactions with bears in northern Iran mainly consisted of raiding orchards (44%) and beehives (32%), with minimal events of livestock attacks (13%) or human attacks (11%). This is reflected further when looking at human-caused mortalities of large carnivores in Iran from 1980 to 2021, which found that bears were more likely to be killed by humans than wolves and leopards, but the reason was mainly due to the potential threat to human life and crops, contrasting with wolves and leopards, who were killed for livestock depredations (Parchizadeh and Belant 2021). A question more specifically aimed at crop damage or negative interactions in general could have been beneficial for this model to supplement the interaction with negative personal experiences.

Responsibility for carnivore management acted as an observed variable rather than a latent variable, differing from our hypothesis, but supported the expectation that responsibility for management had a direct effect on attitude formation. Belief that the government should be responsible for managing carnivores after an attack was linked with more positive attitudes, but also with more negative cognitive beliefs in the wolf and bear models. This suggests that the two belief systems may operate more independently, rather than reinforcing each other and should be taken in conjunction with other coexistence methodologies. A review of governance on wolves in Germany, Sweden, Spain and Portugal found that, despite

community participation, adapting perceptions towards wolves was a crucial step to improving attitudes (Stöhr and Coimbra 2013).

Several hypothesised variables were excluded as they destabilised the models. Age, despite being shown to influence attitudes towards carnivores in other studies (Van Der Meer and Dullemont 2020; Jacobsen et al. 2021), as well as gender, ethnicity, literacy status, and occupation, were all removed. Law and community participation, initially considered as a latent variable, were also removed. While compensation schemes are common tools utilised to mitigate negative interactions inflicted, they are often viewed as ineffective, unfair, and without community engagement or transparency (Fernández-Gil et al. 2016; Ravenelle and Nyhus 2017). In Iran, systematic compensation schemes are lacking, and compensation has been cited as bureaucratic and rare (Behmanesh et al. 2018; Esmaeili et al. 2019). Our data confirm this, with only 1.7% (n = 5) of respondents reporting that they received compensation, potentially unsurprising considering this reported lack of compensatory support. Community engagement is a crucial component in the success of conservation programmes (Dawson et al. 2021; Ghayoumi et al. 2023). However, there is a disconnect between government and local communities when it comes to environmental control and management, exacerbated by a lack of trust between external experts and locals (Ghayoumi et al. 2023). Despite a high willingness to participate, limited involvement and low trust in enforcement inhibit effectiveness (Kolahi et al. 2014). Ultimately, the inclusion of law as a latent variable made the model unstable, leading to its removal, perhaps reflecting the fragmentation of the legal and participatory framework in Iran. This would be an interesting area to explore further. While we did hypothesise the significance of these variables, and while these are cited as some of the most-researched components when it comes to perceptions of large carnivores (Newsom et al. 2025), we can reflect on the weight that thought processes, both individual and communal, have on attitude formation. Conservation is very context-specific, with different communities and their unique environment reflecting different thought patterns, which are incredibly important to understand in how attitudes are formed. More research exploring these processes would be interesting for a greater understanding of how we can use this knowledge to find more effective coexistence techniques.

Emotion (fear, happiness and pride) was also removed from the model. While Ghasemi et al. (2021) highlight that emotional 'mental shortcuts' often outweigh risk perception in carnivore conservation, large predators are often associated with emotions of anger, fear, and disgust (Castillo-Huitrón et al. 2020). Fear is a key driver of negative attitudes and retaliatory killings more than actual livestock loss (Dickman 2010; Jacobsen et al. 2021; Ebrahimi Monfared et al. 2025b). Charismatic species, such as leopards, and ecotourism benefits can induce positive emotions like pride and happiness (Jacobs 2012; Landová et al. 2018; Ebrahimi Monfared et al. 2025a). The removal of emotions from our model could indicate insufficient survey items or social desirability bias, where respondents underreport fear to avoid appearing "weak" (King and Bruner 2000; Kleiven et al. 2004; Kreuter et al. 2008; Teessar 2024). Our data could reflect this bias, with many respondents reporting minimal fear of leopards (53.24%), wolves (52%), and bears (49%). The reported lack of fear could indicate that our respondents are not fearful of large carnivores, but it could also indicate a resistance of participants to report emotions of fear. Exploratory analysis including emotion as a latent variable was included, but the model did not converge, giving unreliable estimates, so we cannot draw firm conclusions from it (see Supporting Information, Table S13). However, when we considered only the estimated results for emotions, and not the model as a whole, emotions did appear to have a positive impact on attitudes, with more positive emotions influencing more positive attitudes towards large carnivores. Future research should incorporate more specialised and diverse questions to better understand and isolate these emotional drivers.

Ecological knowledge, while collected, was recorded categorically so it could not be included within our analysis. Descriptively, however, the data suggest multiple knowledge gaps amongst participants, such as population trends (leopards: 37%, wolf: 39%, bear: 41%), litter sizes (leopard: 40%, wolf: 43%, bear: 44%), or sociality of behaviour (leopard: 29%, wolf: 25%, bear: 31%). Additionally, some respondents answered these questions but gave incorrect responses. We can conclude that the ecological knowledge of local community members pertaining to large carnivores near Golestan National Park has scope to be increased. Ecological knowledge is important in increasing positive attitudes, with increased knowledge leading to attitude change, but also high levels of knowledge creating resistance to attitude changes (Glikman et al. 2012; Behmanesh et al. 2018). A future study would benefit from including this as a factor influencing attitude formation.

Our study has several limitations that may inform how these findings are interpreted. First, our final models were quite simplistic, containing only two latent variables, with each latent and response variable containing only two items. While SEM best practices suggest having at least three manifest variables per latent variable, it is acceptable to settle for two when loadings are low on individual items, thereby increasing the structural integrity of the model (Hayduk and Littvay 2012). Second, some survey items may have been misinterpreted by respondents

(Olteanu et al. 2019). Conceptually related questions (e.g., experiencing livestock loss, perceiving carnivores as dangerous, and perceiving carnivores as damaging) were inconsistent in responses from the same respondent, suggesting there could be confusion in the wording or intent of some questions. Third, two interviewers of different genders and language backgrounds (Turkmen and Farsi) conducted the fieldwork, which may have impacted the disclosure of certain responses. Finally, the underrepresentation of women in our sample (16%) reflects the cultural barriers to participation rather than a sampling choice. This, therefore, limits the generalisability of these findings across the wider community.

CONCLUSION

Despite some limitations, this study provides clear evidence that belief systems, including individual (cognitive), collective (social), and the responsibility for management (government versus individual), play a central role in shaping human attitudes towards large carnivores, in this instance, the Persian leopard, grey wolf, and brown bear. Although some hypothesised variables, such as law and emotions, could not be retained in the final models, the findings clearly highlight the importance of underlying belief systems. Our research was conducted at a local scale; however, we anticipate that its findings may have relevance beyond the study area. Since attitudes towards large carnivores are often formed by underlying belief systems, social norms, and perceptions of institutional responsibility, these factors have been identified in diverse human–carnivore contexts. As such, the mechanisms identified here may help inform research and conservation practice in other settings, while acknowledging that relative importance is likely to vary across cultural, social, and ecological contexts. By targeting these beliefs through education, community engagement, and culturally sensitive conservation strategies, there is strong potential to foster coexistence and build more positive, resilient relationships between people and wildlife.

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Data availability Data with full survey answers can be found as a link in the supporting information accompanied by this submission.

Declarations

Ethics approval Ethical clearance letter no. 355135-81947/202.

Statement of inclusion This study is a collaboration between researchers from multiple countries, utilising shared data to explore various themes relating to the area. Authors from the country of interest were leaders in the data collection and have also published separate research based on this data.

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