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Research Article

Fear and belief predict perceived carnivore abundance in Golestan National Park, Iran

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Understanding local communities' perceptions of large carnivore abundance is essential for effective conservation. These perceptions are formed not only by external factors, such as the risks and costs associated with livestock loss, but also by socio-psychological dimensions, including beliefs (e.g. support for killing problematic carnivores), emotions (e.g. fear, happiness-and-pride), and demographic characteristics. Such factors highlight the importance of incorporating human dimensions in conservation strategies. In 2022, we conducted interviews followed by semi-structured questionnaires with local communities (n = 292) living in 30 villages around Iran's first biosphere reserve. We examined how beliefs, emotions, experiences of livestock loss, and demographic characteristics influence communities' perceptions of three carnivore species (i.e. leopard, grey wolf, and brown bear). Estimated carnivore abundance varied widely, with average perceived abundances of 69 leopards (95% credible interval (CrI) = 25–181), 333 wolves (CrI = 180–597), and 95 brown bears (CrI = 10–819). Emotions such as happiness-and-pride regarding the presence of carnivores were associated with lower perceived abundance, suggesting that individuals who hold favourable views tend to report smaller population sizes. In contrast, family beliefs supporting the killing of carnivores were consistently linked to higher perceived abundance across all species. Expressed fear was positively associated with higher perceived numbers of bears and wolves. Despite some positive attitudes, local community members tended to overcount carnivore populations. For instance, leopards were perceived to be nearly three times more numerous than scientific estimates, emphasising a discrepancy that may potentially misguide conservation efforts. We suggest engaging local communities in conservation activities, such as wildlife monitoring, to help address misconceptions, reduce fear, and promote more positive attitudes toward large carnivores. Such approaches are essential for developing socially informed, effective, and inclusive conservation strategies.

Keywords: density, emotions, large predators, misconceptions, socio-psychology

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Introduction

Overexploitation, persecution, and habitat loss have reduced large carnivores' distribution range by approximately 50% worldwide (Ripple et al. 2014, Bragina et al. 2015, Rija et al. 2020, Prugh et al. 2023). As humans and large carnivore interactions increase due to expanding shared landscapes, understanding these interactions becomes crucial for effective conservation planning (Aryal et al. 2014, Franchini et al. 2021). Economic loss caused by large carnivore predation on livestock has been recognised as the primary driver of conflict (hereafter referred to as interaction; Redpath et al. 2014), but these negative interactions are not solely driven by economic factors. Large carnivores are often viewed as indicators of biodiversity conservation and ecosystem health (Lozano et al. 2019, Leflore et al. 2020, Morehouse et al. 2020), although they are often perceived negatively by local communities. Their presence can evoke a complex range of attitudes among local communities, potentially hindering conservation efforts (Lin et al. 2021, Nesbitt et al. 2023). Although humans are not purely financially rational beings, internal factors such as emotions (e.g. fear of large carnivores) play a vital role in shaping attitudes and behaviours (Ajzen and Fishbein 2000, St. John et al. 2010). In some cultural groups, large carnivores provide recreational, emotional, and cultural benefits (e.g. happiness-and-pride) due to the value they hold for people (Castillo-Huitrón et al. 2020). Recent research in Ethiopia, for instance, revealed that local communities perceived lions and leopards' populations to be declining, whereas mesopredators were perceived to be increasing (Gebo et al. 2022a). Additionally, over half of the participants expressed negative attitudes toward damage-causing species, particularly the spotted hyena, black-backed jackal, common genet, and several mongoose species (Gebo et al. 2022a).

Therefore, understanding how local communities perceive large carnivore abundances and how their attitudes and emotions form these perceptions is crucial for effective conservation strategies, especially given the threats these species pose to livestock and human safety (Treves and Karanth 2003, Feldmeier et al. 2024). Earlier studies on perceptions and attitudes studies initially focused on understanding human cognitive biases and environmental hazards (Slovic 1987), but have since broadened to include human perceptions of wildlife and associated risks, such as fear of large carnivores (Heberlein 2012). These perceived environmental risks can directly or indirectly influence local communities, shaping their attitudes and perceptions toward the species. Perception involves the psychological processes through which individuals observe, interpret, and evaluate environmental stimuli (e.g. wildlife) thereby influencing their understanding and response to the surrounding world (Bennett 2016, Johansson et al. 2016).

According to Heider's naïve psychology (Heider 1958), people tend to build mental models of the environment including wildlife abundance, based on personal experiences (e.g. livestock loss), cultural narratives, emotions (fear, happiness-and-pride), and social learning (e.g. hearing stories from neighbours and relatives).

Insights into local communities' thoughts, emotions, and beliefs and their influence on attitudes toward coexistence with carnivores can provide practical guidance for conservation planning and decision-making (Treves and Santiago-Ávila 2020, Arbieu et al. 2024, Castillo-Huitrón et al. 2024). Values shape attitudes, which in turn influence behaviour. For example, research on local communities' opinion about wolves' restoration in Michigan's Upper Peninsula revealed notable discrepancies between perceived and actual wolf populations. Respondents from the Upper and Lower Peninsula guesstimated wolf pack sizes to range between 80 and 500 wolves, while the best population estimate at the time was no more than 20 wolves (Heberlein 2012). Following the release of four wolves in Michigan in 1974, human–wolf interaction quickly emerged: two wolves were shot, one was trapped, and one was killed by a vehicle. These events highlight the importance of understanding people's attitudes toward large carnivores to develop effective conservation strategies (Heberlein 2012). Thus, if local communities' perceptions do not align with actual population densities, conservation efforts may be misdirected (Treves and Karanth 2003, Bennett 2016). Furthermore, research in Chitwan National Park, Nepal, identified that, despite economic losses, local communities were likely to support wildlife conservation, implying a complex relationship between perceived abundance and conservation attitudes (Lamichhane 2019). Another study has shown that improving understanding of both population abudnace and local communities' perceptions is essential for effective communication about the status of ungulate populations. This, in turn, can help foster community support for their management and reduce species-specific biases (Carpio et al. 2024).

Fear is another factor that may lead to an overestimation of risk, causing people to perceive threats as greater than they actually are (Johansson et al. 2016, St. John et al. 2018, Gebo et al. 2022a). These misperceptions can influence how communities interpret the risks posed by these animals and influence their conservation behaviours and natural resource management strategies (Nesbitt et al. 2023). Although greater consensus on wildlife abundance among local communities can indicate a strong connection to their environment and enhance their role in conservation efforts (Braga-Pereira et al. 2022), limited research has investigated how community members perceive the population abundance of different large carnivore species in shared landscapes. Little is known about how perceptions are influenced by factors such as attitudes, fear, demographics, and carnivore-related damages (Gebo et al. 2022a). In this study, we aimed to quantify how local communities perceive the population abundance of three large carnivore species, Persian leopard *Panthera pardus saxicolor* (synonym *P. p. tulliana*), grey wolf *Canis lupus*, and brown bear *Ursus arctos*, and to examine how socio-psychological factors (e.g. attitude, fear, happiness-and-pride, and experience of livestock loss) and environmental factors affect the perceived population abundance of large carnivores. Using Bayesian generalized linear mixed models (GLMMs), we tested the following hypotheses:

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1) A higher intensity of fear toward large carnivores (i.e. Persian leopard, grey wolf, and brown bear) in Golestan National Park (GNP) is expected to increase local communities' perceived abundance of these species, regardless of cultural groups (Prugh et al. 2023).
2) Stronger family beliefs supporting the killing of problematic carnivores are expected to be positively associated with perceptions of higher abundance of these species (Braga-Pereira et al. 2024).
3) Greater feelings of happiness-and-pride in sharing the landscape with large carnivores around GNP may be coupled with a stable or lower perceived population abundance of these species (Dheer et al. 2021).

Material and methods

Study area

Our study area is positioned in the villages around GNP, which is the first designated (1957) biosphere reserve in northeastern Iran, where the Hyrcanian temperate and relict forests meet with steppe vegetation and semi-arid ecosystems. GNP covers an area of 91 895 km^2 and features an elevation gradient ranging from 450 to 2411 m a.s.l. (Akhani 2023; Fig. 1). Due to its unique geographical position, the park marks the easternmost boundary of these forests in Alborz Mountains and lies at the transition zone where Irano–Turanian vegetation types dominate (Majnoonian et al. 1998). GNP is known for its rich biodiversity and hosts approximately 20% of the country's flora. Additionally, as a UNESCO Biosphere Reserve, GNP and its buffer zone are home to variety of large mammalian species such as Persian leopard (Kiabi et al. 2002, Hamidi et al. 2014), grey wolf, brown bear, urial sheep *Ovis vignei*, bezoar goat *Capra aegagrus*, and Caspian red deer *Cervus elaphus maral* (Soofi et al. 2017, Ghoddousi et al. 2019).

GNP is also surrounded by diverse local communities, each representing distinct cultural groups. The northern and northwestern areas are predominantly inhabited by Turkmen populations, while the southern and southeastern villages are inhabited by Turks, Kurds, Fars, Baluch, and Sistani communities. The economic activity in the region includes agriculture, livestock husbandry, horticulture, and ecotourism (Ghoddousi et al. 2017).

Study design

Prior to interview surveys, we obtained an ethical clearance letter from the Iranian Department of Environment

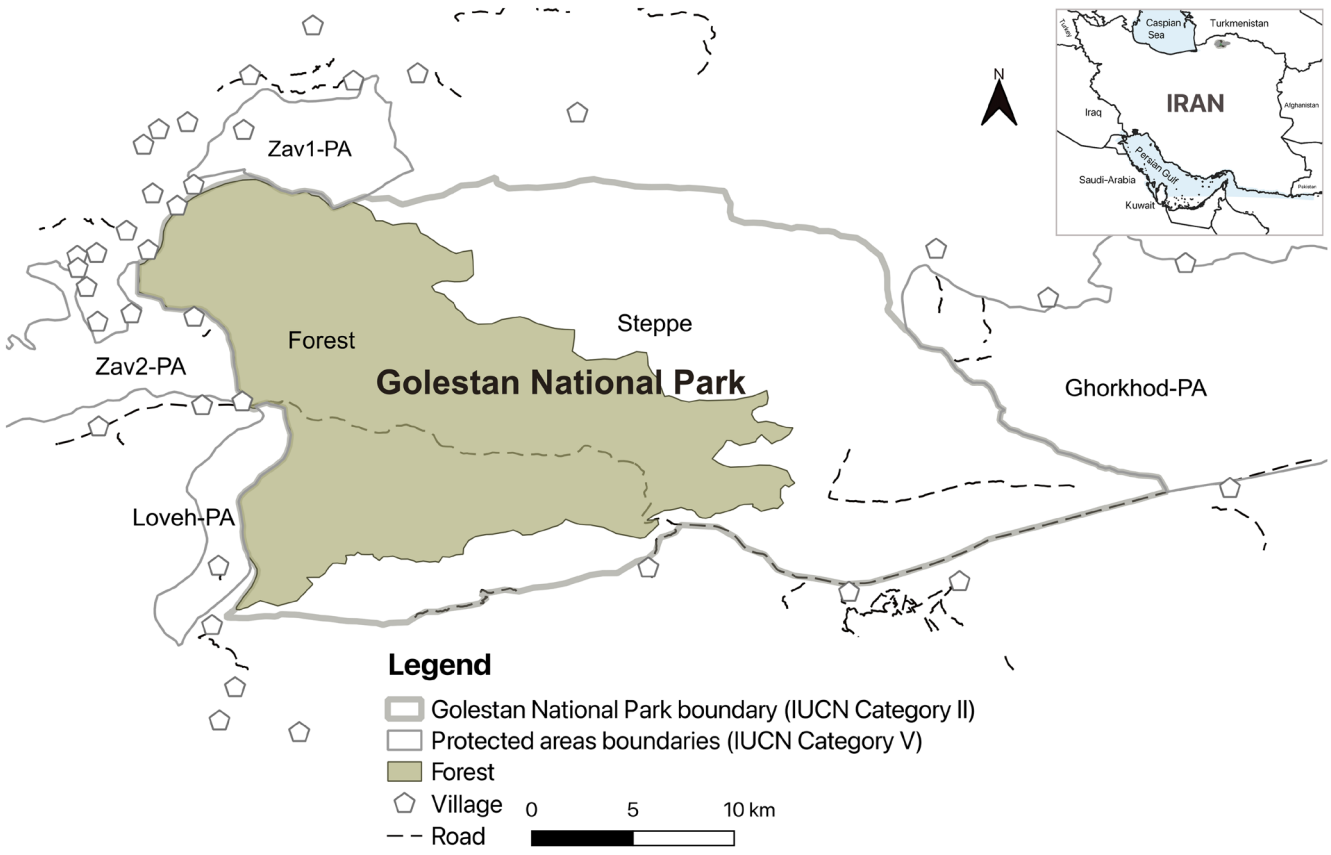


Figure 1. Map showing Golestan National Park (GNP) in northeastern Iran and the locations of villages surrounding the park where interview surveys were conducted. Boundaries of GNP (IUCN Category II) and other protected areas (IUCN Category V) are indicated. IUCN, International Union for Conservation of Nature.

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(reference: 355135–81947/2022). We selected villages within a 5-km buffer of the park boundary, as these areas are more likely to be affected by large carnivores (Khorozyan et al. 2017, Ghoddousi et al. 2020).

Data collection

The questionnaire was structured into three sections: the first section assessed participants' perceptions of large carnivore population abundance, focusing on Persian leopard, grey wolf, and brown bear. The second section was to ask for demographic information such as age, sex, ethnicity, education, and occupation. The third section contained respondents' attitudes toward large carnivores along with emotional dimensions of respondents, including their fear and family belief in killing problematic carnivores (Supporting information). To check the suitability of our questionnaires (followed by interviews) and the survey duration, we carried out a pilot study with 15 interviewees before the primary interview survey (Young et al. 2018). Initially, we arranged meetings with the head of Golestan National Park and 2–3 rangers and discussed our research purposes with them. We informed participants by phone about the general purpose of our research, place, and approximate duration of interview. We emphasised that participation was entirely voluntary and that personal information would remain fully anonymous, and would be exclusively used for scientific research. To minimise the risk of selection bias, we avoided disclosing the specific objectives.

We conducted in-person interviews between April and November 2022, with two local qualified researchers administering them. The interviews were administrated in the Farsi language, the official language of Iran, and is familiar to people. However, since the Turkmen community is the dominant community in our study area, the survey team also communicated in Turkmen when necessary to ensure clearer understanding and participation in the interview. Participants were from diverse social groups such as farmers, herders, beekeepers, homemakers, ecotourism, and employed individuals, who were asked to report their perceived abundance of the three large carnivore species that occur in their living spaces. Also, we examined respondents' attitudes (e.g. 'carnivores should be protected'), beliefs ('my family believes that any carnivore that attacks livestock should be killed'), and fear of carnivores based on five-point Likert scales (Gebo et al. 2022a, Castillo-Huitrón et al. 2024).

Data analyses

We used the Bayesian GLMM with a negative binomial (NB) distribution (i.e. multi-level regression models) using the 'brms' (Bürkner 2017) R package in Stan (Stan Development Team 2017) via the R ver. 4.2.2 interface (www.r-project.org). First, we evaluated the suitability of our response variable (perceived abundance of carnivores reported by respondents) within both Poisson and negative binomial distributions. Our model favoured the NB distribution (Zuur et al. 2009, McCullagh 2019). We tested the effect of the hypothesised variables (Table 1) on perceived abundance of each carnivore species. All predictor variables were standardised (Dormann et al. 2007). We checked for multicollinearity among covariates by calculating Spearman's correlation coefficient test. We avoided including predictor variables in the same model if their relationships were equal to and larger than the cut-off point of $|rho| \geq 0.7$ (Supporting information). We allowed the intercept to vary with normal prior (mean $\mu = 0$, standard deviation $\sigma^2 = 10$) and coefficients with weakly and vectorised prior *student_t* (degree of freedom $v = 3$, mean $\mu = 5.1$, $\sigma^2 = 2.5$), which allows for specifying priors for multiple parameters simultaneously (Gelman et al. 2008). Our modelling process comprised two steps: first, we fitted separate models with linear effect of every individual covariate including education, fear, and belief strength on perceived abundance of each carnivore species. Since our interview data included diverse occupations (e.g. farmers, herders, self-employed, retired, homemakers, bee keepers, ecotourism), to generalise the outcomes of our models across all social groups we therefore considered the cultural groups (i.e. Turkmens, Fars, Kurds, Balouch) and jobs as the group level random effect parameters in our models (Bürkner and Vuorre 2019). Next, we continued our modelling by expanding the hypothesised covariates and finally we ranked all the models based on the leave-one-out cross-validation (LOO-CV) method (Vehtari et al. 2017). The model ranking enabled us to identify the best-fitting model, and the covariates with a substantial effect on abundance, defined as those whose 95% credible intervals (CrI) did not overlap with 0. Predictor variables were considered less substantial if their CrIs marginally overlapped with 0, and non-substantial otherwise (Benjamin et al. 2018). We based inferences on the outcomes of the best-fitting model (see full model ranking in the Supporting information). We used the *conditional_effects* function in the 'brms' R package to estimate the mean abundance and credible intervals for each predictor variable separately.

Results

Post hoc

Overall, we conducted in-person interviews with 292 community members from 30 villages (n = 121 households) including 48 women and 244 men. Respondents were divided into five age groups (range = 18–60 years), which represented various education levels (illiterate, n = 55; primary school, n = 112; elementary school, n = 94; academic, n = 31). Participants also came from diverse social groups, including Turkmens (n = 210, 71.92%), Fars (n = 58, 19.86%), Kurds (n = 13, 4.45%), Turks (n = 6, 2.05%), and Baluchi (n = 5, 1.71%).

Participants' perceived population abundance

Regarding the perceived abundance of large carnivores reported by participants, abundance for the Persian leopard ranged from zero to 800, with 138 respondents indicating they were uncertain about the population abundance of the species. For wolves, perceived abundances were largely variable, ranging from zero to 2000 individuals, with 123 respondents

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Table 1. Predictor variables, questions, units, and their effects on perceived abundance of Persian leopard, grey wolf, and brown bear in Golestan National Park (GNP).

Variables	Questions	Units	Hypothesis	Source
Fear	I feel fear of leopard, wolf, brown bear	Likert scale (1–5)	Increased fear would be associated with a higher perceived abundance (counts reported by respondents) of large carnivores	Prugh et al. 2023
Family belief	My family believes that any carnivore that attacks livestock should be killed	Likert scale (1–5)	Family beliefs supporting the killing of problematic carnivores would positively influence perceived abundance of them	Braga-Pereira et al. 2024
Happiness-and-pride	I feel proud and happy about the presence of Persian leopard/grey wolf/brown bear in our region	Likert scale (1–5)	Higher happiness-and-pride regarding the presence of large carnivores in and around GNP would decrease perceived abundance of these carnivores	Dheer et al. 2021
Livestock loss	How many livestock did you lose to carnivores?	Count	Livestock loss may increase human perceptions of large carnivore abundance due to incurred damage	Treves and Karanth 2003
Age		Count	Respondents in higher age groups would perceive large carnivore population abundance as more abundant	Gebo et al. 2022a
Cultural group		Categorical	Perceived abundance of large carnivores varies among ethnic groups. Variable included as a random effect parameter	Mbise 2022
Job		Categorical	Perceived abundance of large carnivores varies substantially based on respondents' occupations. Variable included as a random effect parameter	Carpio et al. 2024
Education			Higher education levels may be coupled with more realistic guestimates of carnivores' abundance	Gao et al. 2023
Habitat type		Steppe/forest	Different habitat types are associated with variation in both actual and perceived abundance of large carnivores	Gebo et al. 2022b
Elevation		m a.s.l.	Elevation may influence perceived carnivore abundance by shaping actual species presence and affecting human observation and experiences	Carpio et al. 2024

reporting uncertainty about the number of wolves. Perceived brown bear population abundance was also strongly varied from two to 1000 individuals, with 138 participants reporting uncertainty. The highest perceived population abundance was reported for wolves, with an average of 350 individuals in and around Golestan National Park. This was followed by brown bears (mean = 117) and Persian leopard (mean = 87). These findings were independent of respondents' ethnicity and occupation (Fig. 2).

Persian leopard

The results of our best-fitting model indicated that emotions related to happiness-and-pride toward leopards had a substantial negative effect on perceived abundance ($\beta = -0.40$, CrI = −0.61 to −0.20) (Fig. 3A, Table 2). This may imply that respondents who felt less happy or proud about leopards tended to perceive higher abundance of leopard. We also found that the family beliefs substantially and positively influenced perceived leopard abundance ($\beta = 0.35$, CrI = 0.15 to 0.55; Fig. 3B, Table 2). This suggests that respondents with stronger negative family beliefs about the leopard were more likely to perceive higher numbers of leopards in their living spaces. Additionally, livestock loss had less substantial effect on perceived abundance of leopards ($\beta = -0.16$, CrI = −0.34 to 0.03; Fig. 3C, Table 2). Findings also revealed that habitat type had no substantial influence on perceived abundance of leopards ($\beta = 0.08$, CrI = −0.30 to 0.47).

Grey wolf

In the grey wolf model, our results indicated that family belief had a positive effect on perceived wolf abundance ($\beta = 0.17$, CrI = −0.05 to 0.39; Fig. 4A, Table 2). An increase in negative beliefs was associated with a higher perceived abundance of wolves. The emotional states of happiness-and-pride concerning wolves had a negative but non-substantial impact on perceived abundance ($\beta = -0.17$, CrI = −0.40 to 0.05; Fig. 4B, Table 2). Additionally, the feeling of fear toward wolves showed a positive effect and less-substantial effect on perceived abundance ($\beta = 0.16$, CrI = −0.07 to 0.39; Fig. 4C, Table 2).

Brown bear

For the brown bear, our results indicated that emotions such as happiness-and-pride concerning the presence of bears in local communities had a significant negative effect on perceived population abundance ($\beta = -0.37$, CrI = −0.57 to −0.17; Fig. 5A, Table 2). Family belief showed a positive

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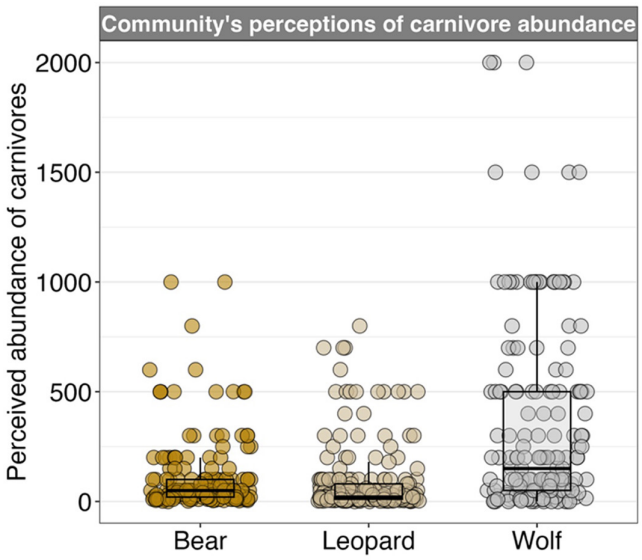


Figure 2. Boxplot shows local community perceptions of the population abundance of the three large carnivore species around Golestan National Park. The circles on each box illustrate the distribution of perceived abundance values. The black horizontal line within each box indicates the median. The boxes represent interquartile range, and the whiskers denote the minimum and maximum values. [Correction added on November 24, 2025 after first online publication: The figure part relating to People's perceptions has been deleted in this version.]

and substantial effect on perceived bear abundance (β = 0.29, CrI = 0.10 to 0.48; Fig. 5B, Table 2). This suggests that respondents with a negative family belief about bears perceived higher bear abundance. Residents with a higher feeling of fear of bears were more likely to perceive higher bear abundance (β = 0.27, CrI = 0.06 to 0.47; Fig. 5C, Table 2). The effect of gender (male) was positive but non-significant (β = 0.22, CrI = −0.92 to 1.53). Lastly, education had a positive but less substantial effect on perceived abundance (β = 0.15, CrI = −0.05 to 0.33; Fig. 5D, Table 2).

Discussion

Large carnivores are frequently perceived negatively by local communities, with their presence often triggering a complex range of attitudes that can hinder conservation efforts (Lin et al. 2021). While human responses to wildlife are not solely based on economic reasoning, internal factors, particularly emotions such as fear, beliefs, and emotions play important roles in shaping perceptions and behaviours toward these species (St. John et al. 2010). Providing reliable and accessible information may help reduce cognitive biases, such as over- or underestimation of abundance by local communities. Cognitive fix is one of the three environmental fixes that has been proposed for fixing environmental

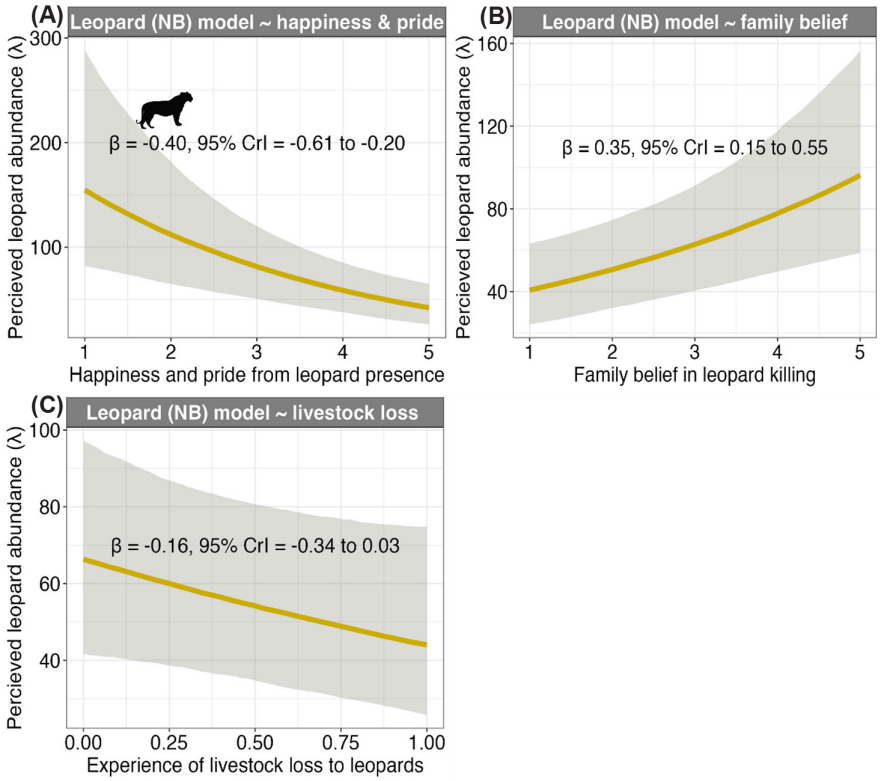


Figure 3. Response curves estimated from the best-fitting model of perceived population abundance of Persian leopards in Golestan National Park: (A) shows happiness-and-pride towards leopards; (B) illustrates the family belief (support for the killing of carnivores that prey on livestock); (C) displays the livestock loss influence on the perceived abundance of the Persian leopard. The grey shaded colour illustrates the 95% credible interval, and the solid lines (yellow) are the posterior means. Only covariates with substantial and less substantial effects are displayed.

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Table 2. Summary of the best-fitting Bayesian multi-level regression model with negative binomial distribution used to quantify the perceived abundance of the Persian leopard, brown bear, and grey wolf as reported by local communities around Golestan National Park, Iran. CrI indicates the 95% credible interval; SD denotes the standard deviation; Rhat represents Gelman–Rubin convergence diagnostic.

Models	Estimate	SD	2.5% CrI	97.5% CrI	Rhat	Bulk_ESS	Tail_ESS
Persian leopard							
Intercept	4.10	0.21	3.67	4.48	1.00	3596	3964
Family belief	0.35	0.10	0.15	0.55	1.00	4190	3928
Feeling fear of leopard	0.11	0.11	−0.10	0.32	1.00	4100	3867
Happiness-and-pride	−0.40	0.11	−0.61	−0.20	1.00	4125	3852
Habitat type	0.08	0.20	−0.30	0.47	1.00	3768	3931
Livestock loss	−0.16	0.09	−0.34	0.03	1.00	3851	3957
Grey wolf							
Intercept	5.82	0.11	5.62	6.04	1.00	5375	5447
Family belief	0.17	0.11	−0.05	0.39	1.00	5716	5700
Feeling fear of wolf	0.16	0.12	−0.07	0.39	1.00	5634	5355
Happiness-and-pride	−0.17	0.12	−0.40	0.05	1.00	5580	5169
Brown bear							
Intercept	4.45	0.90	2.64	6.21	1.00	3164	3280
Family belief	0.29	0.10	0.10	0.48	1.00	3480	3225
Happiness-and-pride	−0.37	0.10	−0.57	−0.17	1.00	3748	3560
Feeling fear of bear	0.27	0.10	0.06	0.47	1.00	3655	3527
Education	0.15	0.10	−0.05	0.33	1.00	3715	3472
Gender (male)	0.22	0.61	−0.92	1.53	1.00	3423	3289

problems (Heberlein 2012). This is a key factor in achieving sustainable coexistence between humans and wildlife (Bruskotter et al. 2014). Importantly, sustainable management practices for large carnivores must consider local communities' emotions and beliefs regardless of whether their fears are considered rational (Johansson et al. 2012). Here we reveal how social-psychological factors influence how local communities perceive large carnivore abundance in Iran's first biosphere reserve. Among the three carnivore species studied, participants perceived leopards to have the

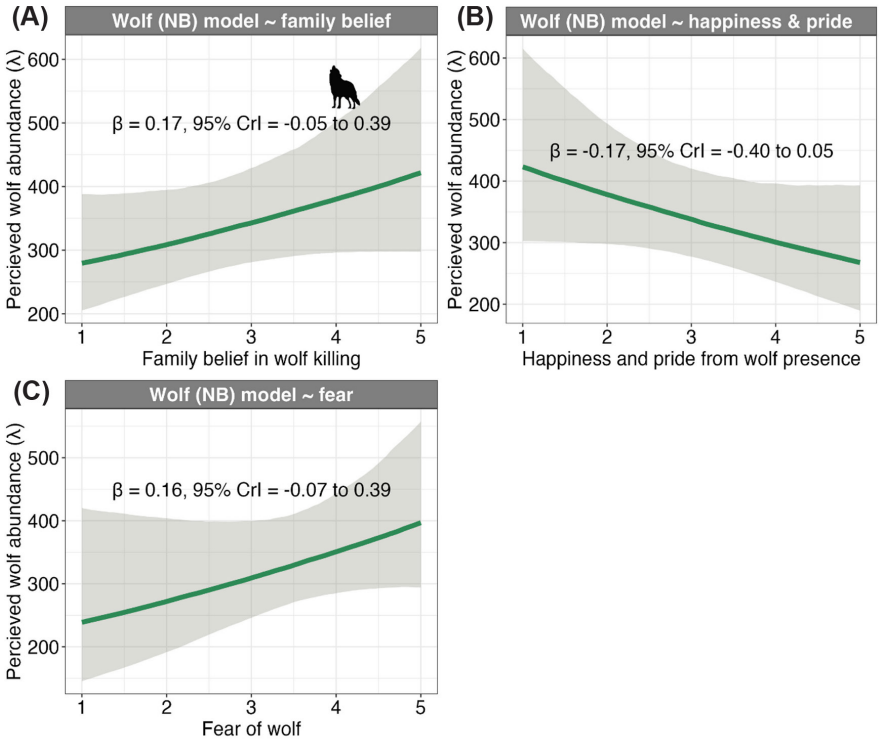


Figure 4. Response curves estimated from the best-fitting model of perceived population abundance of grey wolves in Golestan National Park: (A) illustrates the family belief (support for the killing of carnivores that prey on livestock); (B) displays the influence of happiness-and-pride towards wolves' presence; and (C) effect of fear on the perceived abundance of wolves. The grey shaded colour illustrates the 95% credible interval, and the solid lines (green) are the posterior means. Only covariates with substantial and less substantial effects are displayed.

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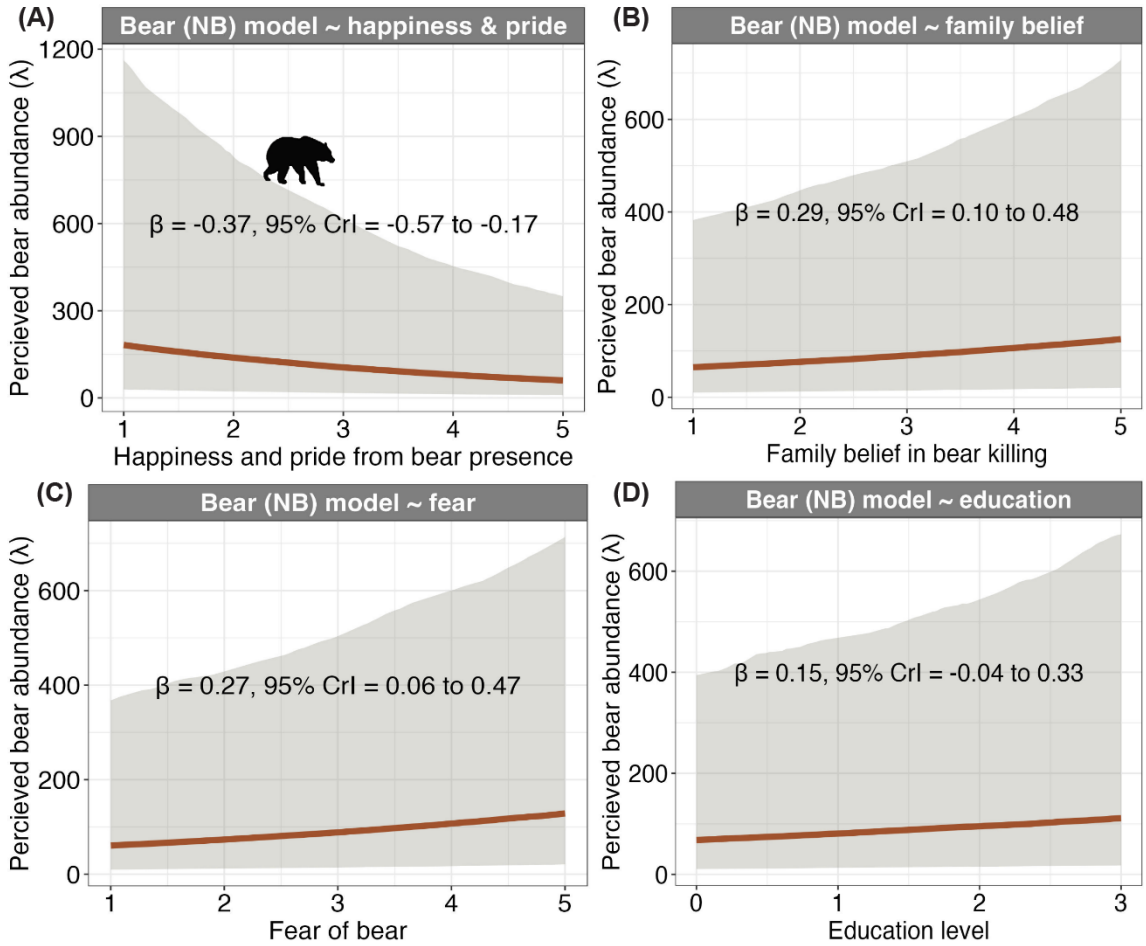


Figure 5. Response curves estimated from the best-fitting model of perceived population abundance of brown bears in Golestan National Park. (A) Illustrates the influence of happiness-and-pride from bear presence; (B) shows the family belief in bear killing (support for the killing of carnivores that prey on livestock); (C) fear intensity on perceived abundance of bears; and (D) shows the effects of education level on perceived abundance of bears. The grey shaded colour illustrates the 95% credible intervals, and the solid lines (brown) are the posterior means. Only covariates with substantial and less substantial effects are displayed.

lowest abundance (estimated mean = 69; CrI = 25–181), which is nearly three times higher than the mean population estimate of 27 individuals reported by Hamidi et al. (2014) using camera traps, in Golestan National Park (CrI = 23–42). However, there are no recent scientific estimates for the populations of Persian leopard, brown bears, and grey wolves in the park. We surmise that the leopard population may have remained relatively stable since the 2014 estimates.

We found that family beliefs supporting the killing of problematic carnivores were a key factor influencing local communities' perceptions of large carnivores' abundance. Individuals with stronger negative family beliefs tended to perceive these species as more abundant in their living environment. These perceptions varied largely, as some respondents have reported notably high estimates, suggesting that fear-related experiences may increase perceived abundance.

We further found that respondents who felt greater happiness-and-pride about the presence of leopards were less likely to focus on the threats they pose. This positive emotional state may contribute to an underestimation of risks or a perception of environment stability, thereby reflecting positive experiences and a sense of co-existence that can reduce fear and perceived risk associated with these carnivores (Dheer et al. 2021). In contrast, increased family beliefs supporting the killing of leopards were linked to higher perceived abundance of the species. Individuals who have experienced livestock loss to leopards are likely to perceive their numbers to be lower; possibly they tend to attribute frequent depredation to a few problem individuals rather than to a large population. This aligns with the belief that leopards are rare (Farhadinia et al. 2019), yet especially dangerous. However, experience of livestock loss emerged as a marginally significant predictor of perceived carnivore abundance.

Such overreporting may be especially linked to large carnivores that evoke strong psychological responses, influencing attitudes toward human–wildlife interactions (Treves and Karanth 2003). Furthermore, heightened family support

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for killing wolves was linked to higher perceptions of their abundance. Conversely, community members who expressed greater happiness-and-pride tended to perceive wolves as less abundant. A pattern that mirrored perceptions of leopard and bears emerged. Our findings reveal that the more fearful local communities feel toward wolves and bears, the more likely they are to overreport their abundance, highlighting how fear can distort perceptions of wildlife abundance. This pattern may be explained by the availability heuristic (i.e. a mental shortcut used to make quick decisions or judgments, especially under uncertainty; Dickman et al. 2010, König et al. 2020), where individuals assess the frequency of events based on how easily they can recall them. In the case of wolves, their pack-living behaviour may contribute to enhanced visibility and salience, leading to perceptions of higher population abundance. Additionally, Soofi et al. (2022) found that both leopards and wolves contribute to livestock predation in the Hyrcanian forests of northern Iran, with wolf predation being three times greater than that of leopards. Similar to the results for leopards, increased happiness-and-pride are likely to decrease the perceived abundance of bears. In contrast, family beliefs supporting the killing of bears and fear appear to have a positive effect on local community perceptions, potentially leading to an increased perceived abundance of bears. Fear may reduce local communities' willingness to support coexistence with large carnivores. Previous research has shown that individuals who fear grizzly bears are less likely to express a desire for coexistence (Wechselberger et al. 2005, Canepa 2008). Furthermore, local communities living near carnivores often experience fears due to the presence of these animals in their surroundings, which leads them to overcount carnivore populations (Ashish et al. 2022). To mitigate negative attitudes and foster more supportive behaviour toward conservation, addressing fear through education, community engagement, and positive experiences with wildlife is essential (Johansson and Karlsson 2011). A better understanding of human emotions toward wildlife has important practical implications for wildlife management and conservation. It can facilitate dialogue between managers and stakeholder groups while supporting communication strategies aimed at reducing local community's fears (Johansson et al. 2016, Eklund et al. 2023).

To effectively reduce fear of brown bears and wolves, it may be more beneficial to understand the emotional reactions of local communities rather than focusing solely on the behaviours of these animals (Johansson and Karlsson 2011). Results suggest that providing reliable information about carnivore population ecology can help alleviate fears and promote coexistence strategies, ultimately fostering collaboration between wildlife managers and local communities.

In our second hypothesis, the results revealed that family beliefs supporting the killing of carnivores preying on livestock are likely to influence the perceived abundance of large carnivores. These findings corroborate with previous findings showing that cultural beliefs and values can influence the perception of the carnivore population abundance by indigenous communities (Moller et al. 2004). Recent research by Nesbitt et al. (2023) in rural areas of Montana in the USA showed that local communities with positive attitudes and emotional connections toward grizzlies are more likely to perceive the grizzly population as insufficiently low (Nesbitt et al. 2023). Elsewhere, beliefs about tiger population status were found to directly influence tolerance levels, underlining the importance of addressing socio-psychological dimensions in conservation strategies (Inskip et al. 2016). Although family beliefs can foster negative perceptions of large carnivores, they can also be leveraged to promote positive attitudes through targeted community engagement, ultimately enhancing conservation efforts.

In our third hypothesis, we found that expressed happiness-and-pride emerged as a consistent covariate, likely decreasing the perceived abundance of these carnivore species. In the wolf model, happiness-and-pride showed a negative effect, although its effect was less substantial. This suggests that community members who feel positive emotions toward large carnivores may underestimate their population abundance, potentially reflecting a disconnect between emotional appreciation and realistic perceptions of ecological realities. These findings are consistent with similar research indicating that positive sentiments toward wildlife can lead to misperceptions about their true numbers (Clark et al. 2017, Lamichhane 2019). Therefore, it is essential to address these discrepancies in understanding local perceptions and promote conservation awareness initiatives that foster a reliable understanding of large carnivore population abundance, as well as the potential risks associated with their attacks on livestock and local communities. This could improve coexistence strategies and enhance community support for conservation efforts, underlining the importance of comprehensively understanding emotional factors in wildlife management (Treves and Santiago-Ávila 2020, Nesbitt et al. 2023).

Research has shown that greater knowledge of carnivores couples with more positive attitudes toward them, emphasising the critical role of awareness-raising in promoting human–carnivore coexistence (Gebo et al. 2022b). Gebo et al. (2022a) reported that perceptions of carnivore population abundance are influenced by factors such as livestock ownership and educational attainment, with many respondents opposing conservation efforts due to concerns about livestock predation. To address these issues, it is essential to provide accurate information and improve the local community's knowledge regarding the true abundance of carnivores.

We conclude that facilitating coexistence between local communities and large carnivores requires attention to the socio-psychological factors influencing perceived abundance. Our findings indicate that strong family beliefs supporting the killing of problematic carnivores are associated with higher perceived abundances of leopards and, to a lesser extent, wolves. In contrast, feelings of happiness-and-pride appear to reduce perceived abundance, particularly for leopards and brown bears, with a weaker effect observed for wolves. Notably, fear had minimal influence on perceptions

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of bear and wolf abundance. These insights suggest that awareness-raising programs could help foster more accurate perceptions of carnivore populations. Such initiatives may also enhance community-wide involvement in conservation efforts. Furthermore, results suggest involving local community members directly in wildlife monitoring, as a strategy to promote coexistence, correct misconceptions, and building long-term support for carnivore conservation.

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Author contributions

Zahra Ebrahimi Monfared: Conceptualization (equal); Data curation (lead); Formal analysis (supporting); Funding acquisition (lead); Investigation (lead); Methodology (equal); Project administration (lead); Resources (supporting); Writing – original draft (equal); Writing – review and editing (equal). **Seyedhamed Mirkarimi**: Conceptualization (equal); Funding acquisition (supporting); Investigation (supporting); Methodology (supporting); Resources (supporting); Supervision (equal); Writing – review and editing (supporting). **Hannaneh Mohammadi Kangarani**: Conceptualization (supporting); Data curation (supporting); Funding acquisition (supporting); Supervision (equal); Writing – review and editing (supporting). **Mahmood Soofi**: Conceptualization (lead); Formal statistical analysis (lead); Methodology (lead); Supervision (equal); Validation (lead); Visualization (lead); Writing – review and editing (lead).

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Data availability statement
Data are available from the Zenodo Repository: https://zenodo.org/records/17469318 (Monfared et al. 2025).

Supporting information
The Supporting information associated with this article is available with the online version.

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