

# Evaluation of human attitudes and factors conducive to promoting human–lion coexistence in the Greater Gir landscape, India

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**Abstract** Coexistence of people and large carnivores depends on a complex combination of factors that vary geographically. Both the number and range of the Asiatic lion *Panthera leo leo* in the Greater Gir landscape, India, has increased since the 1990s. The challenge has been managing the success of conservation, with a particular focus on the spillover population ranging extensively in human-dominated landscapes. To understand the factors conducive to lion survival in this landscape, we undertook an interview-based survey. Overall, people expressed positive, tolerant attitudes towards lions. There was a distinct contrast between people's liking for lions (76.9% of respondents) compared to leopards (27.7%) in spite of greater depredation of livestock by lions (82.6%) than by leopards (17.4%). Younger people and respondents having greater awareness regarding lions expressed positive attitudes. Although community discussions on lions had a positive effect, there was no evidence that land-holding, management interventions, personal encounters with lions, or association of lions with religion affected attitudes. Respondents who had experienced livestock depredation tended to express negative attitudes. Respondents with positive attitudes towards lions favoured non-interventionist strategies for managing lions in the village areas. We advocate consideration of varied factors influencing tolerance of wildlife in conservation planning. We emphasize that site-specific human–wildlife conflict issues such as crop-foraging by wild ungulates and variation in attitudes towards different species should also be considered. Specifically, improved livestock management, motivation of local youth and their participation in awareness campaigns could all further strengthen the prevalent positive attitudes towards lions.

**Keywords** Asiatic lion, carnivore, cultural coexistence, Greater Gir landscape, human–wildlife conflict, local attitudes, *Panthera leo leo*, tolerance

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Received 18 December 2018. Revision requested 18 February 2019.

Accepted 12 June 2019. First published online 24 February 2020.

Supplementary material for this article is available at [doi.org/10.1017/S0030605319000760](https://doi.org/10.1017/S0030605319000760)

## Introduction

Conservation of threatened species is less daunting within protected areas, where wildlife laws are easier to enforce compared to efforts required to safeguard dispersing wild animals ranging outside protected areas in human-dominated landscapes (Woodroffe & Ginsberg, 1998). Resolving conflict involving carnivores that range beyond the boundaries of protected areas is a particular challenge (Treves, 2009). A variety of strategies have been implemented to conserve carnivores by improving local livelihoods (van Eeden et al., 2017).

Highlighting benefits associated with the presence of a species, rather than perceived negative effects, can improve people's tolerance of carnivores (Bruskotter & Wilson, 2014). Research on human–wildlife conflict has typically focused on quantifying the severity of conflict in terms of its economic impact (Redpath et al., 2013). However, negative impacts of human–wildlife conflict may account only for tangible socio-economic costs and overlook other less visible costs relating to the health and well-being of local communities (Barua et al., 2013). Similarly, benefits are often ill-defined or based on superficial measures that overlook ecosystem services, and ecological and economic benefits associated with the focal species and habitat (Meena et al., 2014).

The coexistence of people and wildlife, particularly species of the order Carnivora, requires tolerance even in the absence of material loss, as perceived risk of losses can threaten carnivore survival (Vucetich & Macdonald, 2017). The perception of human–wildlife conflict often involves more than material effects and can originate from attitudes and values that are embedded in culture and history (Redpath et al., 2013). Religious and cultural aspects may be as important as economic and ecological attributes (Kellert, 1985).

Tolerance towards wild animals exhibits considerable geographical variation as a result, at least in part, of human cultural differences (Dickman et al., 2013). Conservation strategies vetted and validated in one system

may not be applicable without nuanced customization in another location. The capacity of people to tolerate carnivore-related risks or conflict is important for sustaining threatened species at a local scale (Carter et al., 2012). This has important implications for policies aimed at conflict mitigation and long-term conservation planning (Treves, 2009). This inter-disciplinary complexity (summarized by Macdonald, 2019), means that it can be difficult to understand what drives tolerance at a local scale. Therefore understanding the complexity of human tolerance towards carnivores, and coping mechanisms, are important for defining management policies (Treves, 2009).

The nature of human–carnivore interactions, rates of change in conflict frequency, management responses to mitigate conflict, proactive awareness campaigns, individual perceptions, and beliefs and strategies to cope with conflict can all influence tolerance (Dickman et al., 2011; Carter et al., 2012). Conservation management may be designed by drawing upon a combination of these factors (Hazzah et al., 2009). An understanding of what constitutes tolerance and how intolerance will be manifested is required to be able to integrate these myriad factors in carnivore conservation planning.

Tolerance can be interpreted in three ways: passive acceptance of a species can be an indication of tolerance (Bruskotter & Fulton, 2012), tolerance can be a responsive behaviour influenced in part by attitude (Gebresenbet et al., 2018), or tolerance can be the expression of attitudes and behavioural intention (Bruskotter et al., 2015). On the other hand, evidence of intolerant behaviour towards real and perceived threats from carnivores could be expressed as illegal retaliatory killing (Treves & Bruskotter, 2014).

Most studies have predicted tolerance based on the parameters of real or perceived conflict. For people sharing the Greater Gir landscape with Asiatic lions *Panthera leo leo*, the costs (livestock depredation and occasional attacks on people) appear to be greater than the potential benefits (livelihood and subsistence through forest resource extraction; Meena et al., 2014). Nevertheless, people are able to appreciate the ecosystem benefits they derive from the Gir Protected Area (Meena, 2012; Banerjee et al., 2013). This is further strengthened by a sense of pride in living alongside lions (Meena, 2012). In this landscape the lion is not persecuted, but rather is highly regarded and valued (Meena et al., 2014). Assuming tolerance to be the expression of attitudes and stated behaviour intention, we model the drivers of tolerant attitudes using the Asiatic lion in the Greater Gir landscape of India as a case study (Bruskotter et al., 2015).

The persistence of the Asiatic lion and its sympatry with the leopard *Panthera pardus* provides a contrast for examining the role of human tolerance for carnivore conservation approaches. The lion population is currently estimated to be > 500, having grown by 60% during 2005–2015 (Singh, 2017). However, the lions dispersing from the protected

area have been associated with attacks on both livestock and people (Meena et al., 2014), raising concerns for both human well-being and lion survival in the face of reprisals and accident-related mortality (Meena, 2012). This situation requires an improved understanding of the basis of human–lion coexistence in this landscape. Here we attempt to highlight the factors that are contributing to carnivore survival in a human-dominated landscape outside a protected area where tolerance towards the species is well established (Meena et al., 2014).

Attitudes are affective as well as interpretive cognitive processes derived from perceptions and beliefs. We explore a combination of the variables that predict self-reported tolerant attitudes of local people toward lions, and highlight factors that should be integrated into conservation interventions. We categorize human–wildlife conflict variables into six components: socio-demography, conflict experience, management intervention, knowledge, awareness, and religious association with lions. We specifically ask, what are the factors that are conducive to the survival of lions in the Greater Gir landscape in spite of the risks they pose, and does a similar tolerant attitude extend to leopards?

## Study area

The range of the Asiatic lion in the Greater Gir landscape extends across Amreli, Junagadh, Gir Somnath and Bhavanagar districts in the state of Gujarat in western India. We conducted the survey in Dhari Taluka sub-district, adjacent to the north-eastern boundary of the Gir Protected Area in Amreli district. This region is an important lion movement corridor (Meena et al., 2014). Millet, cotton, groundnuts, wheat, pulses and vegetables are commonly cultivated in this agropastoral landscape. A population of c. 300 lions lives in the Gir Wildlife Sanctuary and National Park within 1,800 km<sup>2</sup> of forest, and c. 200 lions occur in three subpopulations outside the protected area (Singh, 2017). The Greater Gir landscape also supports a population of c. 500 leopards (Singh, 2017). The widespread nilgai *Boselaphus tragocamelus* and wild pig *Sus scrofa* in this landscape are the main wild prey for dispersing carnivores (Singh, 2017). The Gujarat Forest Department is responsible for conservation of the Asiatic lion, which is listed in Schedule I of The Wild Life (Protection) Act, 1972.

## Methods

### Interview surveys

We surveyed 950 households in 21 villages in Dhari Taluka during July 2016–January 2017. We used a structured questionnaire survey consisting of both open-ended and fixed response questions on a binary or five-point Likert scale

(Supplementary Material 1). We chose the number of interviewees to sample across caste, class, age and gender, with respondents recruited by opportunistically approaching households whilst walking through a village. Circa 20% of the total households in a village were previously found to be representative of all strata within a village (Meena, 2012; Meena et al., 2014). Interviews were carried out by MV and a project assistant, in Gujarati. Each interview lasted for at least 15 minutes. The interview included questions framed to determine the context of human–wildlife conflict issues, opinions about lions and leopards, and information on the six major factors hypothesized to influence tolerant attitudes. Informed consent was obtained verbally from every participant before the interview, and participants were made aware of their rights to participate voluntarily or decline. All interviewees were informed of the purpose of the study and were assured their responses would be anonymized. We made clear that responses to all questions would remain confidential and would not be used for any other purpose. There were no questions that could be judged as sensitive (e.g. queries concerning illegal activity).

We collected information on the major concerns and priorities of residents in the context of other aspects of their agropastoral lifestyle. Respondents were asked to rank five challenges they faced in agriculture (onset of seasonal monsoon leading to variations in crop yield, fluctuating annual market value for crops) and as a result of proximity to forest (threat to human life because of carnivore presence, livestock depredation, crop loss to wild ungulates), from 1 (most problematic) to 5 (least problematic).

We posed three questions related to opinions on lions and leopards: (1) attitude (like, dislike, or indifferent), (2) salient emotion on encounter or sighting (negative: fear; positive: sense of pride, happiness, sense of security, or mixed emotions), (3) preferred management in village areas (no carnivores desired: no lions or leopards should be present in the village area; natural population: unregulated and free-ranging; regulated population: maintenance of limited numbers; larger population: desired larger carnivore populations; or larger population elsewhere but not in the village area). We also assessed attitude as behaviour intent and asked how lions and leopards moving outside the forest and into village areas should be managed: allow to move unrestrained, capture and relocation, or capture and retention in captivity.

### Factors influencing opinion

We developed a set of predictor variables indicating respondents' attitudes toward lions. There were six categories of covariates related to socio-demographic parameters, conflict experience (livestock depredation or close encounter with lions and leopards), Gujarat Forest Department management intervention and effectiveness, knowledge,

awareness (social and conflict trends) and religious association with lions (Supplementary Table 1). Respondents' association of lions with religion was solicited via an open-ended question and later categorized as: worship (as a form of god), positive association (religious sentiment or faith), popular belief (aware of prevalent religious association but respondent does not relate or subscribe to it), negative association (as an evil incarnation), other association (as wild animal, jewel of the forest, national animal, or king of the jungle), and no association (not aware of, or no opinion).

### Data analysis

To contextualize human–wildlife conflict, the ranked challenges were expressed as the frequency with which they were given a particular rank. If in the respondent's opinion any of the issues were not relevant (e.g. a shop owner who had no issues related to agriculture or a respondent who had no livestock) or if the respondent did not consider any one of the issues a problem (irrespective of having a negative effect), the issue was noted as 'not rated'. Opinions about lions and leopards were expressed as percentage of response in each category. We used  $\chi^2$  contingency tables to explore the relationship between categorical variables.

Emotions and attitudes were strongly correlated such that models using either as responses gave similar conclusions. We therefore chose stated attitudes as the principal response variable. We modeled the association between reported attitudes toward lions and the predictor variables using an ordinal response regression model. We built cumulative mixed-effect models using the *clmm2* function from the package *ordinal* (Christensen, 2015) in R 3.5.0 (R Core Team, 2017), and we computed the maximum likelihood estimates of parameters via adaptive Gauss–Hermite quadrature approximation (Christensen, 2015). We included village identity as a random factor to account for the clustering of respondents in villages. We firstly ran a model using only socio-demographic factors, to take advantage of the complete sample. We then fitted a model including other predictors for respondents who reported livestock ownership.

Two interaction terms were included on the basis of a priori hypotheses about the effect of age on attitude: that the effect of age could depend on whether or not a respondent had experienced livestock loss and had knowledge of lions. We used the *Anova.glm* function of the R package *RVAideMemoire* (Herve, 2018) to carry out likelihood ratio tests (permitting single tests for categorical variables with multiple levels), reporting the  $\chi^2$  values. Effects sizes for these models were visualized with the R package *effects* (Fox & Hong, 2009).

To explore links between attitudes and behavioural intent, we fitted a model with the ordinal attitude scale as a predictor. Whether or not a respondent opted for 'allowed

to move unrestrained' in response to how lions and leopards moving outside the forest and into village areas should be managed was treated as a binary response. The 'captured and relocated' and 'captured and retained in captivity' options were combined. For this we fitted mixed models, treating village as a random predictor, using the *R* package *lme4* (Bates et al., 2015). Graphical methods were used to check the validity of linear trends in the response with ordinal predictors (Johnson, 2009).

## Results

### Contextualizing human–wildlife conflict

Issues related to livestock loss to depredation and threat to human life from carnivores as a result of lion movement in village areas were not rated as significant concerns by 40 and 35% of respondents, respectively, irrespective of whether or not they owned livestock or of their experience of conflict (Fig. 1). With respect to concerns and priorities, crop loss to wild ungulates was ranked 1st by c. 60% of respondents, and 5th by <1%. Fluctuating market rates for crops and onset of seasonal monsoon and crop yield were not rated by 21 and 17% of respondents, respectively.

### Assessment of opinion

Attitude, salient emotion and preferred management regarding lions and leopards are summarized in Table 1. Responses related to attitude and salient emotion towards lions were linked. Of those respondents who reported a dislike of lions, 97.7% reported an emotion of fear and 1.7% reported pride. Amongst those who liked lions, 56.8% reported fear, 40.7% pride, and 2.5% security ( $\chi^2 = 94.3$ ,  $P < 0.001$ , using the subset reporting like or dislike and emotions fear or pride;  $n = 720$ , omitting the indifferent category). For leopards, reported attitudes and emotions were also linked; almost all respondents reporting dislike of leopards reported fear to be their principal emotion (97.1%). Of those who reported liking leopards, 71.0% reported fear and 29.0% pride ( $\chi^2 = 120.1$ ,  $P < 0.001$ , using the subset reporting like or dislike and emotions fear or pride,  $n = 905$ ). Respondents who were indifferent ( $n = 17$ ) were intermediate: 88.2% reported fear and 11.8% pride.

### Factors influencing opinion

Respondents were 15–82 years of age, of whom 20% were 15–30, 44% 31–50 and 36% > 51. The majority of interviews (97%) were with men as most women reported confining their activities to the vicinity of the household; 63% were farmers, 17% practiced both agriculture and other livelihood activities, and 20% were engaged in other livelihoods

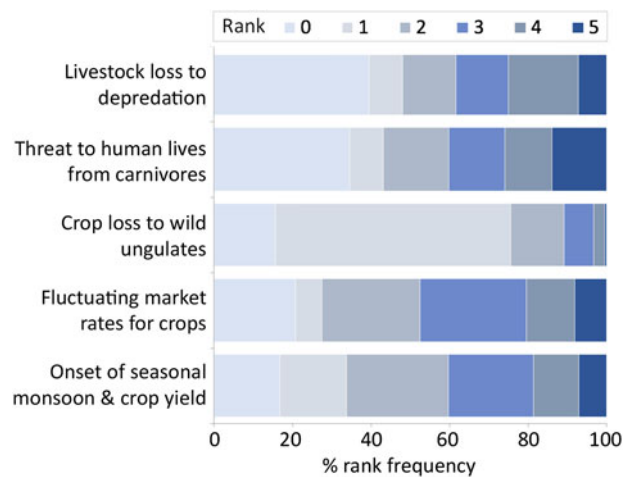


FIG. 1 Contextualizing human–wildlife conflict for people in Dhari Taluka, part of the Greater Gir landscape of western India, based on a questionnaire survey administered during July 2016–January 2017. The respondents ranked five issues related to agrarian livelihoods and proximity to forest, from 1 (most problematic) to 5 (least problematic). A rank of 0 indicates an issue was not rated, either because it did not apply to an individual (e.g. livestock loss to depredation is not applicable to somebody who does not own livestock) or when not rated as a problem by an individual despite having an effect. Rankings of the five issues are expressed as the per cent frequency with which each issue was assigned a particular rank by all respondents.

(animal husbandry, business and other salaried jobs). Over 60% of the respondents were farmers with medium to large land holdings. Most were Hindus (94%) and others were Muslims. The ethnic composition of Hindus was diverse, with 18 communities, dominated numerically by Patel (45%), Darbar (15%) and Maldhari (10%; including the subsects Ahir, Rabari and Bharwads).

Livestock was kept by 81.5% of the 950 households, largely for household consumption, with only 18% of livestock owners rearing livestock for commercial purposes. Of the 7,382 livestock kept by the 950 households, cattle (32.9%) were the dominant species, along with buffaloes (25.3%), goats (22.9%), sheep (18.8%) and horses (0.1%). Goats and sheep were reared mostly for commercial purposes. A mean of  $5.5 \pm SD 5.9$  cattle and buffalo combined were kept per household.

Forty-four per cent of the livestock owners had experienced livestock depredation in the previous 10 years, 36.7% to lions and 8.1% to leopards, and 1.8% had lost livestock to both predators. Of the 346 depredation incidents only 34.9% of livestock owners claimed monetary compensation for losses, of which 89 claims were completed or reimbursed (Table 2). In the previous 5 years there were 18 cases of injury to people by carnivores, of which nine were severe, but respondents reported 450 encounters with carnivores. In response to questions on social awareness, conflict perceptions and knowledge, people agreed overall that



TABLE 1 Per cent responses to three questions examining opinions regarding lions *Panthera leo leo* and leopards *Panthera pardus*, based on a questionnaire survey with 950 people in Dhari Taluka, India, during July 2016–January 2017.

Question category						
<b>Attitude</b>	Like	Dislike	Indifferent			
Lion	79.6	18.9	1.5			
Leopard	27.7	69.9	2.4			
<b>Salient emotion</b>	Fear	Pride	Happiness	Security	Mixed	
Lion	53.6	24.9	17.5	2.0	2.0	
Leopard	82.4	8.4	8.8	0.1	0.3	
<b>Preferred management</b>	No carnivores desired	Natural (unregulated)	Limited numbers (regulated)	Larger populations near villages	Larger populations elsewhere	No opinion
Lion	2.8	48.4	11.7	22.5	14.6	0
Leopard	23.7	42.7	9.6	7.9	14.3	1.8

carnivores and conflict had increased in the previous 10 years, but the majority of people did not have specific knowledge of lion status and population estimates. There was no strong religious association with lions.

#### Modeling predictors of attitudes toward lions

Based on individual responses, the model indicated factors that predicted positive or negative attitude toward lions (Table 3). The full output of mixed ordinal models is presented in Supplementary Table 1. Attitude to lions was more negative amongst older age groups (Supplementary Fig. 1a), among women, and among livestock owners who had a large number of livestock (Supplementary Fig. 1b) or had experienced depredation losses (Supplementary Fig. 1c). There was evidence for variation in attitude towards lions among communities (Supplementary Fig. 1d). People who perceived that human–wildlife conflict was increasing were more negative about lions (Supplementary Fig. 1e). Attitudes were not influenced by area of land owned or religious association with lions (Supplementary Table 1).

A significant interaction between the age and knowledge terms (Table 3) was explained by the age effect being less marked amongst the respondents who had no knowledge; the effect of knowledge was most clear in the youngest age class (Supplementary Fig. 1f). All respondents in the youngest age class who responded correctly to the knowledge question said they liked lions (Supplementary Fig. 1f). Respondents who were positive about cooperation between local people and the Gujarat Forest Department had a more positive attitude towards lions (Supplementary Fig. 1g) as were respondents who said they often had discussions concerning lions and other forest-related topics among themselves (Supplementary Fig. 1h). The link between attitude and awareness of the rescue and relocation efforts of the Gujarat Forest Department was weak. Models predicting attitude to leopards using demographic variables, conflict experience, social awareness, and management interventions indicated that older respondents and those with more livestock tended to hold more negative attitudes towards

leopards, and that there were differences among communities in their attitudes towards leopards (Supplementary Table 2, Supplementary Fig. 2 a–c).

#### Attitude as behavioural intent

For lions, 49.2% of respondents stated a preference for no intervention for lions detected near human settlements, 44.3% preferred capture and relocation, and 6.5% capture and retention in captivity. This pattern varied significantly with attitude ( $\chi^2 = 113.4$ ,  $P < 0.001$ , omitting the indifferent category). Of the people who liked lions, 57% preferred no intervention, 39% capture and relocation, and 4% capture and retention in captivity. For the people who disliked lions, the responses were 17.2, 65.6 and 17.3%, respectively. For those who were indifferent the responses were 36, 43 and 21%, respectively. The probability that a respondent favored no intervention increased with more positive attitudes to lions (logistic mixed model,  $PE = 0.99$ ,  $SE = 0.1$ ,  $z = -9.08$ ,  $P < 0.001$ ; Supplementary Fig. 3a).

For leopards, 42.5% of respondents stated a preference for no intervention if the animals were detected near human settlements. This pattern varied significantly with attitude (contingency test,  $\chi^2 = 23.3$ ,  $P < 0.001$ , omitting the indifferent category). Of the people who liked leopards, 51.2% stated their preference for no intervention; 46.2% opted for capture and relocation, and 2.7% preferred capture and retention in captivity. For the people who disliked leopards, the responses were 39.2, 50.2 and 10.5%, respectively. For those who were indifferent the responses were 34.8, 43 and 21%, respectively. The probability that a respondent favored no intervention for leopards increased with more positive attitudes (logistic mixed model,  $PE = 0.33$ ,  $SE = 0.08$ ,  $z = -4.1$ ,  $P < 0.001$ , Supplementary Fig. 3b). That the probability increases more steeply for lions (Supplementary Fig. 3a) than for leopards is demonstrated by the interaction term in a logistic mixed model including species and attitude as predictors (species  $\times$  attitude interaction:  $\chi^2 = 7.3$ ,  $P = 0.007$ , mixed model with village and respondent as random effects).

TABLE 2 Per cent responses to factors influencing local attitudes toward lions, based on a questionnaire survey of 950 people in Dhari Taluka, India, during July 2016–January 2017. The sample sizes for questions that were applicable for only a subset of the population are indicated in parentheses.

Survey question, by category	Response (%)					
<b>Conflict experience</b>	Lion	Leopard				
Have you experienced livestock depredation, & if so by which species? (n = 346)	82.6	17.4				
Have you had close encounters with lions or leopards? (n = 450)	66.0	34.0				
<b>Management intervention</b>						
Monetary compensation for losses (n = 89)	Poor	Fair	Good	Excellent		
How would you rate compensation amount against value of depredated livestock?	70.0	12.0	9.0	9.0		
How would you rate efficiency of processing of claims?	33.3	23.8	23.8	19.1		
Would you make the effort to communicate information related to forest/wildlife in your village/farm?	Yes	No	Unsure			
	82.0	11.0	7.0			
Should local people support the efforts of the Gujarat Forest Department in forest conservation?	Strongly agree	Agree	No opinion	Strongly disagree	Disagree	
	33.7	48.2	10.2	5.5	2.4	
<b>Social awareness</b>	I witnessed	I heard	Not aware	No incident	Do not know	
Are you aware of depredation incidents in the village in the previous year?	64.2	18.0	2.0	11.0	4.8	
Are you aware of the Gujarat Forest Department's animal rescue operations?	83.6	12.1	4.3			
How often to you discuss subjects related to forests & lions with friends & community members?	Never	Sometimes	Often			
	25.5	52.3	22.2			
<b>Conflict awareness</b> (trends for past 10 years)	Strongly agree	Agree	No opinion	Strongly disagree	Disagree	
There has been an increase in conflict (depredation & attacks)	61.5	21.6	9.1	7.5	0.3	
Conflict increase is a result of increased carnivore population	27.8	29.0	22.7	15.4	5.1	
Conflict increase is a result of increased human–livestock numbers	13.1	25.5	23.1	34.1	4.2	
Conflict is perceived to have increased as a result of media reporting	5.9	18.4	38.6	33.9	3.2	
Lion population trend in previous 10 years	Increased	Decreased	Remained same	Do not know		
	88.0	3.0	1.0	8.0		
<b>Knowledge about lions</b>	Aware	Partially aware	Unaware			
Global lion status & latest lion census estimate	13.0	36.0	51.0			
<b>Religious association with lions</b>	Positive association	Popular belief	Negative association	Other association	No association	No opinion
	37.0	7.0	2.0	6.0	46.0	2.0

## Discussion

### Cultural bias toward species

Our findings suggest lions are considered an integral part of the Greater Gir landscape. More people had positive attitudes towards lions (80%) than towards leopards (28%). Negative attitudes towards leopards were unrelated to the degree of livestock loss to the species (livestock depredation

by lions was greater than by leopards). Fear was reported to be the dominant emotion much less frequently for lions (54%), than for leopards (84%), and pride was more commonly reported for lions (25%) than for leopards (8%). People's perception of a particular species is not necessarily related to the nature of their interactions with it (Farhadinia et al., 2017). Although certain problematic species are tolerated and accepted, for other species there is less tolerance

TABLE 3 Summary of model outputs for relationship between socio-demographic factors, conflict experience, Gujarat Forest Department management, knowledge, social awareness and religion with self-reported attitude towards lions based on a questionnaire survey of 950 people in Dhari Taluka during July 2016–January 2017.

Variable	Effect of predictor on attitude to lions	Ordinal regression
<b>Socio-demographic parameters</b>		
Age	More negative in older age groups <sup>1,2</sup>	$\chi^2_{[1]} = 12.7, P < 0.001$
Gender	More positive amongst men <sup>1</sup>	$\chi^2_{[1]} = 3.5, P = 0.06$
Livestock keeping	More negative with greater livestock holding <sup>1</sup>	$\chi^2_{[1]} = 3.2, P = 0.07$
Land-holding status	None <sup>1</sup>	$\chi^2_{[1]} = 0.1, P = 0.73$
Community	Varied between communities <sup>1,2</sup>	$\chi^2_{[9]} = 29.0, P < 0.001$
<b>Conflict experience</b>		
Livestock depredation by lions	More negative with greater livestock loss <sup>1,2</sup>	$\chi^2_{[1]} = 4.7, P = 0.02$
Direct encounter with carnivores	None <sup>1</sup>	$\chi^2_{[1]} = 0.6, P = 0.43$
Livestock depredation by leopards	None	$\chi^2_{[1]} = 0.7, P = 0.40$
<b>Gujarat Forest Department management</b>		
People's participation in Forest Department's conservation goals	More positive amongst those responding 'Yes, people must cooperate in conservation efforts' than amongst those responding 'No, people must not cooperate in conservation efforts' <sup>1,2</sup>	$\chi^2_{[1]} = 35.0, P < 0.001$
<b>Knowledge</b>		
Global status of lions	None <sup>1</sup>	$\chi^2_{[1]} = 2.0, P = 0.15$
Conflict has increased in the previous 10 years	More negative amongst those who agreed <sup>1,2</sup>	$\chi^2_{[1]} = 3.8, P = 0.05$
Knowledge of 2015 lion census estimate	More positive amongst those who were aware <sup>1</sup>	$\chi^2_{[1]} = 15.7, P < 0.001$
Interaction: knowledge & respondent age	Knowledge effect more marked among younger age category	$\chi^2_{[1]} = 7.7, P = 0.006$
<b>Social awareness</b>		
Participation in social discussions on lions & forest topics	More positive amongst those who participated <sup>1,2</sup>	$\chi^2_{[1]} = 5.9, P = 0.01$
Awareness about wild animal rescue and relocation by Gujarat Forest Department	No evidence <sup>1</sup>	$\chi^2_{[1]} = 1.8, P = 0.15$
<b>Religion</b>		
Religious association with lions	No association with attitude <sup>1</sup>	$\chi^2_{[4]} = 6.3, P = 0.18$

<sup>1</sup>Ordinal model outputs for prediction of lion attitude (Supplementary Table 1).

<sup>2</sup>Supplementary Fig. 1.

irrespective of the extent of conflict (Kaltenbon et al., 2006; Saraswat et al., 2015; Farhadinia et al., 2017). Attitudes towards the snow leopard *Panthera uncia* in the Trans-Himalaya of India were more positive than towards the wolf *Canis lupus* and this relationship was not correlated with the amount of economic damage attributed to the species (Suryawanshi et al., 2014). Cultural bias for charismatic species can thus dominate the effect of other predictors and it is therefore important in conservation planning to incorporate such variability in attitudes toward sympatric species (Suryawanshi et al., 2014).

#### Factors influencing attitudes towards lions

When a carnivore species is found to be living in close proximity to human habitations and threatens human safety its acceptability declines (Kleiven et al., 2004). Furthermore, when a given species causes economic loss its acceptability declines to the extent that it becomes vulnerable to direct persecution (Kleiven et al., 2004). An opinion driven by fear of encountering a potentially dangerous carnivore

species almost on a daily basis may be different from the perception of the species in general terms. In our study, women, and communities such as Devipujars residing on the periphery of villages and therefore more vulnerable to carnivore attacks, expressed negative attitudes towards lions and leopards. Livestock owners who experienced livestock loss expressed more negative attitudes toward lions. Farmers rated monetary losses resulting from crop damage by wild ungulate species more problematic than any potential threat to their personal safety posed by carnivores (Fig. 1). Thus, monetary cost caused farmers to perceive species causing damage differently from those that posed a threat (Goodale et al., 2015). Overall respondents acknowledged the enhanced crop productivity from the ecosystem services received as a consequence of their proximity to Gir protected areas, and also the role of the lion as an apex predator (Meena, 2012).

We found that attitudes were linked to behavioural intention: respondents with positive attitudes toward lions were more likely to favour no intervention rather than capture and release for lions moving through village areas.

Respondents were of the opinion that it was as much the lion's home as it was theirs. This is in contrast to people opting for 'not on my land' in spite of expressing consideration for carnivore conservation in other scenarios (Zimmerman et al., 2005). Positive attitudes towards lions were similar to those recorded towards predators in other studies and were not necessarily related to benefits or social status (Zimmerman et al., 2005). Younger respondents expressed more positive attitudes and were also better informed about the movements of lions, the threatened status of the species and human–wildlife conflict issues. The opinion of elders in the community was expected to be rooted in cultural beliefs and traditions: older respondents showed a distinct indifference to lions and were particularly negative towards them if they had suffered livestock loss. The land ownership status of respondents was also not important as a predictor of attitude. Frequent community discussions indicated an interest in lions and forest-related topics, and such individuals had a positive attitude toward lions (Table 3). As age, awareness and social discussions significantly influenced positive attitudes, conservation awareness campaigns could further strengthen this goodwill towards lions.

#### Human–wildlife conflict management

Overall, interventions by the Gujarat Forest Department in mitigating conflict via financial compensation and prompt response to carnivore-related problems were not a predictor of people's attitudes toward lions, at least for the observed level of conflict. This also indicates that the negative attitudes arising from depredation loss is directed towards lions rather than towards the Gujarat Forest Department. Therefore, improved management efforts should focus on reducing losses through better livestock protection measures. Such engagement could also help allay the underlying sense of fear expressed even by the majority of people who liked lions. Crop protection measures should be a key issue to be addressed to secure local support for conservation. Individuals who expressed disinclination to involve themselves in the conservation efforts of the Gujarat Forest Department had a negative attitude towards lions (Table 3, Supplementary Fig. 2g). Whether this is a result of interpersonal relationships with field staff needs to be examined and, if so, rectified.

Monetary compensation does not necessarily resolve conflict related to attacks on people or livestock but, by alleviating the losses incurred, such a scheme is likely to promote tolerance amongst people inhabiting human–wildlife interface areas (Madhusudan, 2003). The efficacy of compensation for depredation losses, property damage and human injury in human–wildlife conflict mitigation has been debated (Mishra et al., 2003; Bulte & Rondeau, 2005; Dickman et al., 2011; Ravenelle & Nyhus, 2017). For compensation to be considered as an effective conservation tool, the

entire process of verification, registration and approval of a claim has to be efficient. For example, in Bhadra Tiger Reserve, southern India, people were less critical of the fact that the compensation scheme underestimated their livestock losses to large carnivores than they were of the bureaucratic procedures involved (Madhusudan, 2003). In our study area, respondents were appreciative of the commitment shown by the staff in processing their claims but were critical of the value compensated, indicating the efficacy of any monetary compensation scheme has to be frequently re-evaluated (Table 2).

Translocation as a conservation tool for dealing with problem carnivores has been criticized as it results in escalation of conflict at release sites and is ineffective in conflict mitigation (Athreya et al., 2011). In Gir, the rescue of distressed wild animals (trapped, or fallen into open wells), relocation of problem animals perceived as a threat to human safety, and treatment of injured or disease stricken animals is undertaken by the Gujarat Forest Department. In most instances the managers are under pressure to act swiftly in the best interests of both people and wildlife, to pre-empt aggressive retaliation by people. They can achieve two things through these efforts. Firstly, they can ensure the safety of animals by capturing them. Secondly, when villagers gather to witness challenging capture operations undertaken by Gujarat Forest Department staff there is an opportunity for the staff to interact closely with local people, build trusting relationships and facilitate exchange of information with regards to the status of wild animals moving unrestrained in village areas (Table 1; Meena et al., 2014). Although local people widely appreciated these efforts, such interventions were not a strong predictor of attitudes toward lions.

#### Cultural tolerance

Religious affiliations, cultural norms, beliefs and reverence toward certain species can determine the nature of people's interactions with wildlife, interpretation of problems arising from such interactions and their manner of dealing with human–wildlife conflict (Hazzah et al., 2009; Bhatia et al., 2017; Gebresenbet et al., 2018). A positive cultural affinity with animals and their natural environment works largely in favour of wildlife conservation in India (Khoshoo, 1997; Krishna, 2010). However, we found no evidence that religious association with Hindu deities or reverence toward lions determined either attitudes towards lions or the manner of dealing with conflict issues (Table 3). Rather, in this landscape there is a history of coexistence of people with lions. Almost all (94%) respondents' families had been resident in the area for several generations and for 90% livestock rearing is a traditional practice. Communities such as the Darbars consider their fearless affinity for lions as being related to their own regal heritage. Sentiments of this nature lead to a sense of pride, and



identification with lions. Pastoral communities such as the Maldharis have been settled in this region for c. 200 years and have a history of coexistence with lions. With this comes an acceptance of events such as depredation as being inevitable. Responses by interviewees such as ‘Lions do not eat grass’ or ‘Lions will have to hunt and kill for survival’ reflected these sentiments (Meena, 2012). Lions sometimes even enter people’s houses and kill livestock. The loss notwithstanding, carcasses of killed livestock are moved to the village perimeter or an open area, where the lion(s) can feed undisturbed. People were also of the opinion that dynamic factors such as crop yields and profits from farming tend to be beneficial in one year and unfavourable in another. This philosophical acceptance of circumstances was reflected in the fact that only 17 and 7% of the respondents who were predominantly farmers rated seasonal monsoon and fluctuating market rates, respectively, as their primary problem (Fig. 1).

Cultural acceptance of predation, and people’s regard for both lions and for their own livestock, are equally important drivers of this tolerant coexistence (Kolipaka et al., 2015). For example, only 35% of people claimed compensation for depredation losses to which they were entitled. Others claimed to have a sentimental aversion to claiming such compensation. In one of the villages, the money obtained as compensation for depredation losses is donated to the local *gaushala* (cattle shelter). Setting unproductive livestock free to graze in the common village grounds instead of selling them off for monetary gains is another culturally grounded practice that is based on compassion for all life forms. Actions such as these are prevalent in most parts of India (Kolipaka et al., 2015). Therefore, if we consider a community’s overall cultural ethos towards nature rather than focus on people’s attitudes towards a particular species and the species’ positive and negative influence on the individual, the persistence of wildlife and their coexistence with people in India can be better understood.

As a result of historical coexistence and absence of deliberate persecution, lions have also developed a tolerant attitude towards people (Rangarajan, 2013). Thus, applying a similar reasoning, the survival of lions has been attributed to their lack of fear and acceptance of people (Rangarajan, 2013). Understanding these nuances in a culture of coexistence with wildlife is key for human–wildlife conflict management.

By identifying the factors contributing to human–lion coexistence at the interface of the Gir protected areas and human settlements, we emphasize the breadth of factors that must be taken into account, and integrated, during conservation planning. Upholding factors promoting positive attitudes is as important as addressing factors creating negative attitudes. Our survey emphasizes the importance of conservation awareness programmes to mobilize the interest of local youth and uphold people’s high regard for lions. Balancing cultural tolerance mechanisms and reducing economic losses

caused by wild animals is a great challenge but something that must be achieved to conserve both the lions and leopards coexisting with people in the Greater Gir landscape.

**Acknowledgements** We thank the Gujarat Forest Department for their support, the people of the study area for their time and participation in the survey, P. Noronha and A.B. Naik for their involvement in data collection and compilation, and H. Bauer for his comments on the text. This project was funded by donations to WildCRU.

**Author contributions** Study design: MV, AZ; fieldwork: MV; data analysis: MV, PJ; writing: all authors.

**Conflicts of interest** None.

**Ethical standards** This research abided by the *Oryx* guidelines on ethical standards and had the necessary approvals and permits from the Gujarat Forest Department, India. The study complies with the criteria of the British Sociological Association Statement of Ethical Practice. The research did not involve experimentation with animals or collection of specimens.

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