

Fear, ecocentricity and religion – intangible factors matter for human-lion coexistence

ABSTRACT

Conflict with humans is one of the major threats facing the world's remaining large carnivore populations, and understanding human attitudes is key to improving coexistence. We use a socio-ecological model to understand local attitudes towards coexisting with lions. We investigate the importance of a range of tangible and intangible factors on attitudes, including the costs and benefits of wildlife presence, emotion, culture, religion, vulnerability, risk perception, notions of responsibility and personal value orientations. This is for the purpose of effectively tailoring conservation efforts, but also for ethical policymaking. We found that intangible factors (such as fear and ecocentric values) are as important, if not more important, than tangible factors (such as livestock losses) for understanding attitudes. This was based on the effect sizes of these variables. The degree to which participants' fear of lions interfered with their daily activities was the most influential variable. The degree to which benefits accrue to households from the nearby protected area was also highly influential, along with numbers of livestock lost, number of dependants, ecocentric value-orientation, and participation in conflict mitigation programmes. Contrary to what is often assumed, metrics of livestock loss did not dominate attitudes to coexistence with lions. Furthermore, we show that socio-economic variables may appear important when studied in isolation, but their effect may disappear when controlling for variables related to beliefs, perceptions and past experiences. This raises questions about the widespread reliance on socio-economic variables in the field of human-wildlife conflict and coexistence. To facilitate coexistence with large carnivores, we recommend measures that reduce fear (both through education and through protective measures that reduce the need to be fearful), reduction of livestock losses and ensuring local communities experience relevant benefits from conservation. Ecocentric values also

emerged as influential, highlighting the need to develop conservation initiatives which are tailored with local values.

INTRODUCTION

The neighbourly relations between wildlife and the communities that live alongside them are often strained. Understanding the determinants of coexistence requires exploration of intangible factors, which the field of human-wildlife conflict and coexistence is calling for with increasing fervour. Most large carnivores have suffered significant population declines and range contractions (Ripple et al., 2014), and lions in particular have experienced a 92% reduction in their historic range (Bauer et al., 2016). Human-lion conflict is among the top threats to lion populations (Funston et al., 2016). Across the wide range of human-wildlife conflicts, humans are the only constants and effective conservation depends on understanding the thoughts and actions of the people involved (St John et al., 2013).

The amount of damage that carnivores inflict often influences the extent to which people tolerate them. However, direct damage is not the only determinant of hostility, and is not necessarily even the main driver, so reducing it may not reduce hostility (Dickman, 2010). Pooley et al. (2017) recognise the same phenomenon and conclude that there is too much focus on negative impacts, oversimplified assumptions that levels of conflict relate proportionately to levels of damage, and technical fixes that fail due to a failure to engage local stakeholders or address hidden costs.

Rational choice theory has been found to poorly explain human-carnivore interactions (Gebresenbet et al., 2018). To mitigate conflict, we need to understand the attitudes of the people involved and the complex web of socio-economic factors, past experiences, culture, beliefs and values that influence those attitudes (Dietsch et al., 2019). This has led to calls for greater focus on the intangible aspects of conflict and coexistence, e.g. Kansky and Knight (2014). Attitudes are often a

strong predictor of intention to behave in a certain way (Fulton et al., 1996) and can therefore provide insights on people's willingness to coexist with wildlife. However, there is far from an automatic link between attitudes and actions (Dickman and Hazzah, 2016). Factors outside the individual (e.g. social context) have a strong influence on people's behaviour beyond the effect of internal factors that drive attitudes (Heberlein, 2012). However, in this study we were not just interested in specific behaviours. This work has the dual aim of casting light on the importance of intangible factors, thereby informing effective conservation efforts, and understanding the viewpoints of the communities for their own sake. The second aim is of equal importance. This relates to concepts of environmental justice (Lecuyer et al., 2019). The recognition of stakeholders' identity and viewpoints has been shown to be an integral part of environmental justice for stakeholders in carnivore management (Jacobsen and Linnell, 2016).

In this paper, we will use attitude as defined by Kansky et al. 2014, based on the work of (Fishbein and Ajzen, 2011): "Attitudes can be defined as a disposition or tendency to respond with some degree of favorableness, or not, to a psychological object, the psychological object being any discernible aspect of an individual's world including an object, a person, an issue, or a behaviour" (Kansky et al., 2014).

We investigate how a wide range of factors relate to the willingness of stakeholders to coexist with lions in Zimbabwe, using a structured questionnaire. These include socio-economic and demographic attributes as well as key indicators of the impact of lions (e.g. livestock loss). We also explore how emotions (such as fear), culture, religion, vulnerability, risk perception, notions of responsibility and ecocentric value orientations affect attitude. The aspect of ecocentric values evaluated in this study was the belief that components of nature (specifically lions) have an intrinsic right to exist (Washington et al., 2017). Fear is a complex emotion and people are likely to have different thresholds for how they delineate such emotions. We therefore employed a situationally specific indicator of fear, asking survey participants to what extent fear of lions interfere with their daily

lives. We incorporate ecological data on predation to create a socio-ecological model, and we include evaluation of the effectiveness of conflict mitigation activities in the area. Our hypotheses were A) Intangible factors are among the most influential variables associated with attitude to coexistence with lions. B) Variables that are indicators of higher risk and vulnerability to livestock depredation are associated with more negative attitudes to coexistence with lions. C) Predictions of attitude using models that include variables pertaining to beliefs and past experiences will substantially outperform models based on socio-economic variables alone. D) We test the novel hypothesis that lack of ownership of wealth leads to discounting of livestock damages.

METHODS

Study site

The study area encompassed 20 agro-pastoral villages in the Mabale area located just outside of Hwange National Park in Zimbabwe. Lions that move into inhabited areas outside the park pose a threat to livestock and are vulnerable to retaliatory killings. Since 2007, the Trans-Kalahari Predator Programme (TKPP) has been running conflict mitigation activities, currently consisting of two main activities. The community guardian programme employs people from the local communities to advise villages on livestock protection measures and assist with chasing lions found close to human habitation back into the protected area (Petracca et al., 2019). The project also runs a programme that provides mobile bomas to communities. These “bomas” are enclosures for protecting livestock, particularly during the night. They consist of PVC canvas sheets that are used to construct a fence around the cattle. Some villages only have community guardians, some have both guardians and mobile bomas and some have neither (Loveridge and Hunt, 2016).

94 Survey design and data collection

95 The interview questions were translated into Ndebele, Nambya and Tonga languages, with content-
96 validation tests for every question. The survey went through three rounds of piloting. Interviews
97 were carried out by a team of six native speakers. All interviewers came from the greater Hwange
98 area in order to encourage trust and ensure culturally appropriate behaviour. Prior informed
99 consent was obtained from each individual according to the approved guidelines of Oxford
100 University's Research Ethics committee (Ref. no. R49682/RE001). Answers were recorded using the
101 software Qualtrics (Qualtrics, 2017).

102 The villages were randomly selected from the Mabale area within 30km of the border of the national
103 park. The 30km cut-off was chosen because that corresponds with the appropriate scale of lion
104 ranges in this area (though dispersing lions may move further, dispersal events are irregular). We
105 interviewed every person in every household in the target villages whenever possible.

106 Variable choice

107 The response variable was a Likert-type item ranging from "very negative" to "very positive" on a
108 five-point scale in response to the question "How do you feel about having lions in your area?"

109 The independent variables were chosen by reviewing existing literature and through in-depth
110 qualitative interviews with villagers from the relevant communities. *A priori* hypotheses for every
111 variable can be found in Table S1 (Supplementary materials). Ecological data on lion depredation
112 events collected by the TKPP were incorporated along with the social survey data. The depredation
113 data consist of the number of livestock killed by lions confirmed by TKPP staff within the area of
114 each village, and were incorporated in the analysis as a village-level variable (referred to as the
115 conflict level of the village).

Due to the attention afforded to livestock losses in the literature, we included variables relating to several aspects of livestock loss, risks and vulnerability. We included both losses at the level of the individual and the conflict level of the village (the average annual number of livestock that were killed by lions based on data collected by the TKPP). To determine which aspects of individual vulnerability and risk are important, we included information on whether respondents owned any livestock, how many livestock they owned (in case attitude showed a trend with livestock ownership rather than a binary effect), how dependent they were on livestock for income (indicated by the proportion of their total wealth that consists of livestock) and total wealth (wealthier people are hypothesised to be better able to absorb losses of livestock). The amount of wealth an individual possessed in the form of livestock was calculated based on the market value of the livestock the household owned, divided by the number of individuals in the household to derive a per-person figure. The total wealth measures the total annual value of the person's crop production, livestock, formal employment and informal work. All types of livestock were included, except in the variable describing the number of livestock owned, where poultry were excluded.

Choice of models

We used the `clmm` function in the package "ordinal" (Christensen, 2018) in R version R-3.5.3 (R Core Team, 2019) to fit ordinal logistic regression mixed models, treating "village" as a random variable to account for the spatial clustering of respondents in each village.

We created models for three different purposes (Table 1). Attitude to coexisting with lions is the response variable in each model.

1. *Comprehensive model*: Investigating plausible effects of a wide range of variables on attitude to coexisting with lions.

2. *Management model:* For the purposes of practical conservation management in the areas surrounding Hwange National Park, we constructed a model that included only variables that can be readily observed or that are currently being recorded in the area. This is a predictive model that can be used by conservation managers to tailor the targeting of conservation programmes.
3. *Thematic models:* We constructed three thematic models to compare the explanatory power (adjusting for parsimony) of different kinds of variables: one model contained socio-economic variables, one model contained variables pertaining to beliefs and perceptions, and one model contained variables describing past experiences with lions or with lion conservation. The relative performance of the three thematic models in predicting the response was quantified using AICc as in Lindsey et al. (2017) (Table S11, Supplementary materials).

There were no problematic levels of collinearity between variables included in the same model (Tables S2 – S6, Supplementary materials).

Assumption testing

We tested the proportional odds assumption of ordinal models both graphically and statistically (Liu and Zhang, 2018) and neither revealed any problematic breaches of the proportional odds assumption. We also tested whether the logit link function was appropriate by comparing QQ plots for models with different link functions.

Nested mixed models and clustering

Individuals that share the same homestead are not independent samples, so to check for any clustering effect we created a nested version of every model, where individuals are nested within

homesteads which are nested within villages, and used a likelihood ratio test to see if the nested models differed significantly from the non-nested models. They did not differ ($p>0.7$).

RESULTS

A total of 1482 people participated in the survey, and 1478 remained after excluding incomplete entries. Forty-four percent of the participants were male and 56% female. Fifty percent of participants attached moderate or greater importance to traditional religion. The median attitude score for coexisting with lions was 'negative', on a scale ranging from very negative to very positive. Seventy-eight percent of people stated that there were no positive aspects of having lions in their area. Thirty-nine percent of participants stated they had experienced livestock loss to lions, 60% had never lost livestock to lions (the remainder were unsure). Ninety percent of people owned livestock, the mean number of livestock lost to lions in the last three years was 2. The median personal wealth was US\$1059. Seventy-four percent of people were covered by the mobile boma or community guardian programme, or both. Fifty-two percent of participants had never seen a lion but 43% of participants personally knew someone who had been attacked by a lion. Sixty-four percent of participants thought lions came into village lands every week or more often. The median response to the question of to what degree fear of lions interferes with their daily activities was "Severely interferes" (38% of respondents). Thirty-one percent of participants perceived there to be some benefits to their household from the presence of the national park. Eighty-three percent of participants thought that lions have the right to exist.

Comprehensive model

There was evidence that women's attitudes were slightly more negative than those of men. There were differences in attitude among ethnicities, with Tonga being most negative. Older people were more negative, and higher levels of education were associated with more negative attitudes.

Respondents who had lost more livestock to lions in the last three years were more negative, as were those who had spent a higher the proportion of their life in Hwange. Respondents who reported seeing lions more often were more negative. Respondents who perceived that lions enter village lands at higher frequency had more negative attitudes, as did respondents who personally knew someone who has been attacked by a lion. Respondents who reported that fear of lions interferes with their daily activities to a high degree were more negative (Table 2).

Conversely, the number of dependants a person provides for was associated with more positive attitudes, the more importance a person places on traditional religion (animism and ancestor worship) the more positive they were, and people who perceive more benefits accruing to their household from the presence of Hwange National Park were more positive. Higher levels of ecocentricity were associated with more positive attitudes. Participation in the conservation programmes of the TKPP seemed to be having a positive effect on attitudes. People who had access to community guardians were more positive than people who were not covered by either programme, while people who had access to both community guardians and mobile bomas were the most positive (Table 2).

Of the 15 factors with robust evidence for a relationship with attitudes towards coexisting with lions, five related to tangible variables (whether objective or perceived): number of livestock lost, whether someone they personally knew had been attacked by lions, perceived frequency of lions entering the village, how often they have seen lions, and whether they participated in the community guardian or mobile boma programmes. Four variables related to intangible factors: fear (as measured by degree of interference of fear on daily activities), ecocentric values, traditional religion and how rooted the individual was in the Hwange area (indicated by the proportion of life spent in Hwange). One variable, the degree to which the household benefits from the national park, might contain a mix of tangible and intangible values. The remaining five variables related to demographic characteristics: age, gender, education, ethnicity and number of dependants.

Several factors that have been found to be influential on attitudes in other systems did not show a relationship with attitude to coexistence with lions. There was no evidence for any association between attitudes and whether or not the person owned livestock, the number of livestock owned, degree of dependence on livestock for income, the conflict level in the village area and whether or not the person blames someone else for their livestock losses. Some personal characteristics were unrelated to attitude: health, material satisfaction, wealth and perceived relative wealth. Similarly, variables relating to costs and benefits from wildlife presence; being employed in wildlife-related work or experience of wildlife-related harm (other than lions) were unrelated to attitude. Frequency of participation in religious activities was not associated with attitude (Table 2).

Effect sizes in the comprehensive model

Table 3 presents average effect sizes for the explanatory variables associated with attitude to coexistence with lions. This is the average of the differences in effect size between the highest and lowest end of the range (made positive for the purposes of averaging) at every level of the response variable. Among the variables with above average effect sizes (the average effect size was 0.05), two related to tangible factors: number of livestock lost and participation in the community guardian and mobile boma programmes. Two related to intangible factors: ecocentricity and the interference of fear. One captured both tangible and intangible benefits: benefits to the household from the presence of the national park. The last variable was a demographic characteristic: number of dependants.

Management model

The evidence emerging from this model was, as expected, similar to that observed in the comprehensive model. Ethnicity was found to be associated with attitudes to coexistence with lions, older people were found to be more negative, and the number of livestock lost displayed a negative

relationship with attitude. People who were not participating in either the mobile bomas or the community guardian programme were more negative. There was no evidence for the conflict level of the village or gender being useful predictors of attitudes (Table S10, Supplementary Information).

Thematic models

We compared three thematic models: one containing socio-economic variables, one model with variables pertaining to beliefs and perceptions, and one based on past experiences with lions and conservation (Table S7, S8 and S9, Supplementary materials). The beliefs and perceptions model was the best performing thematic model, while the comprehensive model was the overall best performing model (Table S11, Supplementary materials).

DISCUSSION

Our findings lend support to calls for increased focus on the more intangible factors associated with conflict and coexistence, and question the supremacy of material costs and benefits.

Our comprehensive model shows that intangible factors are as important as tangible factors, if not more important. A sizeable portion of the 15 variables with robust evidence for a relationship with attitudes towards coexisting with lions related to intangible factors. Five related to tangible factors, four related to intangible factors, while one variable plausibly contained a mix of tangible and intangible values. The remaining five variables related to demographic characteristics. The strength of the effects of these variables further support the importance of including intangible factors to understand attitudes to human-wildlife coexistence. As many intangible as tangible factors were in the top tier of effect sizes (fear and ecocentricity were the most influential intangible variables). The degree to which fear affects respondent's daily activities had the strongest effect of all variables by a large margin (Table 3). The effect size for fear was clearly larger than that of the tangible livestock

loss, while the effect size of ecocentricity was only slightly lower than that of livestock loss. We measured the level of fear by asking to what degree fear of lions interferes with the respondents' daily activities, as fear is a multidimensional concept so the question should be situationally specific to ensure comparability between respondents. The question captures the direct psychological cost of fear but also the indirect opportunity costs resulting from feelings of fear. It is possible that some respondents carried out daily activities without interference out of necessity, so the effect of fear might even be an underestimation, and it does not capture every aspect of fear.

Fear constitutes a cost (Johansson et al., 2016), and our results lend support to some of the conclusions reached in the meta-analysis by Kansky et al. (2014) which found tangible costs and benefits to be of lower importance than expected, and that intangible costs was the most important category to explain attitudes. However, some of the variables with robust evidence for association with attitudes in our study do not directly relate to costs or benefits. Instead they relate to the world-view and values of the person (traditional religion and ecocentricity), or could plausibly be related to world view, values and beliefs (age and ethnicity).

One of the variables among those with the highest effect sizes was composed of a mix of tangible and intangible values and requires a more complex interpretation. The variable pertaining to the perceived benefits to the household from the presence of the national park was composed of both tangible and intangible value. During the qualitative interviews, participants named both tangible benefits, such as tourism and employment, and intangible benefits, such as maintenance of lions for their existence value. However, though the effect of such benefits was high, the number of people perceiving such benefits was low: only 31% of participants perceived there to be any benefits.

Only one socio-economic characteristic displayed an above average effect size: number of dependants. Most of the socio-economic variables displayed higher effect sizes in the model that included only socio-economic variables than they did when part of the comprehensive model (Table

S12, Supplementary materials). Furthermore, in the model with only socio-economic variables, some variables appeared significant (the person's total wealth, proportion of non-animal wealth, and satisfaction with material circumstances) that were not significant when controlling for a wider range of factors in the comprehensive model (Table 2, and Table S7, Supplementary materials). This raises questions about the prevalence of socio-economic variables in studies attempting to understand human-wildlife relationships, and show that it is important to only use such models for predictive purposes to avoid falling to the temptation of concluding that socio-economic variables explain underlying mechanisms that shape attitudes.

To illustrate the misleading results of the focus on socio-economic variables that has been predominant in the human-wildlife field for much of its history, we compared the performance of three thematic models: one model containing socio-economic variables, one using variables pertaining to beliefs and perceptions, and a third containing variables describing past experiences with lions or with lion conservation. Of the three, the model containing only variables relating to beliefs and perceptions performed best (Table S11, Supplementary Information). If someone wishing to predict attitudes to lions were to focus on just one type of variable, focusing on beliefs and perceptions would inform conservation efforts more effectively than socio-economics. However, the most informative approach is, of course, to incorporate a range of variables of different types, and our comprehensive model far outperformed either one of the thematic models, so we focus on the results of this model (Table 2).

Since livestock losses are traditionally believed to be key to human-carnivore conflict, we aimed to disentangle different aspects of livestock loss and livestock ownership with the comprehensive model. We hypothesised that factors that reflect the risk of livestock loss or vulnerability to livestock loss would be influential. Previous studies have found conflicting results regarding the influence of livestock variables, perhaps due to differing choices in how to define the livestock variable used in their models. Koziarski et al. (2016) found no effect of livestock ownership, while Tessema et al.

(2010) found that owning fewer livestock was associated with positive attitudes, and Mitchell et al. (2019) found attitudes to lions to be in proportion to their involvement in livestock predation.

The psychological relationship between owning livestock and attitude towards lions has not previously been explored comprehensively. We hypothesised that the relationship might plausibly operate in a linear way that scales with the number of livestock owned or lost to predation, or as a categorical mental state (whether or not the person owns livestock and whether the person has ever lost livestock). Only one linear measure, number of livestock lost over the last 3 years, was associated with attitude. The effect of this variable on attitude was strong, only exceeded by the effect of fear on people's daily activities, while being similar to the effects of perceived benefits from the national park, the number of dependants and ecocentricity. The overall conflict level of the village was not associated with attitude, indicating that personal losses are more likely drivers of attitudes. A previous study in Hwange found no relationship between livestock losses and desired change in lion population numbers when looking at livestock losses incurred over the last year (Western et al., 2019), indicating that such effects may operate over a longer time-frame. We also hypothesised that risk and vulnerability might affect attitudes to coexisting with lions, but variables relating to an individual's risk (whether respondents owned any livestock, how many livestock they owned) or vulnerability to livestock losses (how dependent they were on livestock for income and their total wealth) were not found to be associated with attitude.

Two variables with evidence for a relationship with attitude related to the dimension of time: age and the proportion of the respondent's life spent in the area around Hwange National Park. We used the latter as an indicator of how much of the person's life experiences had been shaped by living alongside lions in this area. Both were associated with more negative attitudes to coexistence. The age variable on its own would be difficult to interpret: the cause of the negative effect could either be that increased time lived alongside lions induces more negative attitudes, or that younger generations hold more positive views on lions. However, when seen in context of the variable

describing the proportion of life spent near Hwange National Park and the negative effect of the frequency of seeing lions, our interpretation is that increased exposure to lions induces more negative attitudes. Possibly, the mechanism for this is the accumulation of personal experiences and stories of attack and livestock loss creating a social environment that is hostile to lions. Mkonyi et al. (2017) found that residency time was associated with higher levels of self-reported depredation in Tanzania.

One of the influential variables in the comprehensive model, the number of dependants, had an effect that was contrary to our expectations. We hypothesised that a higher number of dependants would lead to higher vulnerability to lion attack, and therefore more negative attitudes. However, attitudes were more positive among respondents with more dependants (Table S17, Supplementary materials). This could be at least partly explained by the observation that one of the few benefits of lions that people expressed in qualitative interviews was the desire for lions to exist for children to see and know.

The factors that were not found to be associated with attitudes towards coexistence are also of considerable interest. We tested several wealth variables: absolute wealth, satisfaction with own material circumstances, and perceived relative wealth compared to the individual's neighbours. The latter variable was included as an alternative wealth metric as the econometric literature frequently finds that the perceived level of wealth relative to a person's community is more influential on attitudes and mental states than actual wealth (Luttmer, 2005). There was no evidence for an association with these wealth variables. Similarly, employment in wildlife work is often believed to improve attitudes towards wildlife, but we did not find any evidence for that here. We also tested whether blame and perceived responsibility for livestock losses affected people's attitudes. There was no robust evidence that people who assigned responsibility for livestock losses to someone else (e.g. the government, the national park or conservationists) were more negative to coexisting with lions.

Physical vulnerability has been offered as an explanation for the greater prevalence of negative attitudes towards carnivores among women and elderly people that has been demonstrated elsewhere (Røskaft et al., 2003). We tested this by including a metric of physical condition. We also hypothesised that experiences of damage caused by other wildlife could lead to a spill-over effect of intolerance towards lions. We formed the novel hypothesis that lack of ownership of household wealth would be associated with less negative attitudes towards lions, as an individual might discount possible losses to lions in proportion to the benefits they would actually be able to access from the value of the livestock. Ownership of a resource has been shown in other contexts to affect attitudes (Mbaiwa and Stronza, 2011). None of these three hypotheses were supported by our results.

Project evaluation

In response to the calls for increased evidence-based evaluation of conservation practices (Sutherland et al., 2004), we explicitly incorporated project evaluation into this investigation. The TKPP runs two conflict mitigation programmes with the intention of improving attitudes towards coexistence with lions. We found evidence for a relationship between attitudes to coexisting with lions and participation in these programmes. There was some evidence that people that participate in only the community guardian programme were more positive than those who did not participate in either programme and very strong evidence that people who participated in both were more positive to lions than people who didn't participate in either one. This does not unequivocally prove causation, as there is the potential of a self-selection effect where villages with people that have more positive attitudes are more likely to participate in the mobile bomas programme. However, the locations for the community guardian programme were selected purely based on spatial location and conflict level (for which control variables are included in the model) so there was no scope for self-selection. The positive association between participating in these programmes and attitudes is supported by the findings of Sibanda et al. (*accepted*) in the Hwange area.

378 The comprehensive model aims to achieve a nuanced understanding of the range of variables that
379 are associated with attitudes towards coexisting with lions. Observational studies cannot determine
380 causality, but there are other strands of evidence supporting plausible links here. In contrast, our
381 management model is explicitly pragmatic and aims to inform conservation practitioners by allowing
382 them to predict attitudes towards coexistence based on observable variables. This aims to help
383 inform the engagement with key stakeholders with particularly negative attitudes to lion presence.
384 Age, ethnicity, programme participation and numbers of livestock lost to lion depredation emerged
385 as useful predictors.

386 To conclude, our results show that intangible factors are important to understand attitudes towards
387 coexisting with dangerous carnivores. They are at least as influential, if not more, as the socio-
388 economic variables and livestock loss variables that have conventionally been assumed to be the
389 main factors shaping attitudes in the field of human-wildlife conflict for much of its history.
390 Furthermore, the focus on costs and benefits (whether tangible or intangible) should be tempered
391 with greater inclusion of variables explicitly relating to values and beliefs. Our results carry
392 implications for practical conservation policy. The effect of fear on people's daily life proved to be
393 among the strongest correlates of people's attitude towards this large carnivore. Johansson et al.
394 (2016) review the evidence on interventions aimed at reducing fear of large carnivores and find that
395 the evidence is scarce and contradictory. We recommend that mitigating fear, through education
396 about the risk posed by lions (which is low in this area) and through practical safety measures to
397 reduce the risk of attacks and minimise opportunity costs, should be a priority. Livestock loss does
398 matter, but losses to the individual rather than the conflict level of the area shaped attitudes.
399 Reduction of livestock loss should therefore remain a priority. A strong association was found
400 between positive attitudes towards lions and the perception of benefits accruing from the national
401 park, so ensuring that local stakeholders benefit from the presence of the protected area should
402 continue to be an important goal. People with an ecocentric value orientation were much more

403 positive towards coexistence with lions, but we know little about what shapes ecocentric attitudes in
404 relation to lions. This influential piece of the attitude puzzle deserves further scrutiny.

405 Additional information on data exploration, assumption testing, variable choice, a priori hypotheses
406 and effects sizes can be found in online appendices. The authors are solely responsible for the
407 content and functionality of these materials. Queries (other than absence of the material) should be
408 directed to the corresponding author.

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Table 1. Variable types, question wording, answer scales and model composition (CM= Comprehensive model, SEM = Socio-economic model, BPM = Beliefs and perceptions model, MM = Management model).

Variable	Answer scale	CM	SEM	PEM	BPM	MM
Response variable: Attitude to coexistence with lions: “How do you feel about having lions in your area?”	Ordinal categorical: <i>Very negative (46%), Quite negative (35%), Indifferent (11%), Quite positive (7%), Very positive (1%)</i>	✓	✓	✓	✓	✓
Random variable: Name of village	Nominal categorical	✓	✓	✓	✓	✓
Gender	Nominal categorical: <i>Male (44%), Female (56%)</i>	✓	✓			✓
Ethnicity: “What is your mother tongue?”	Nominal categorical: <i>Ndbele, Nambya, Tonga, Other</i>	✓	✓			✓
Education: “What is your level of education?”	Ordinal categorical: <i>None (5%), Primary (33%), Secondary (57%), Tertiary (5%)</i>	✓	✓			
Age: How old are you?	Continuous numeric (range = 76)	✓	✓			✓
Number of dependants: “How many children or elderly people who are past working age, or sick/disabled people who cannot work do you provide for?”	Continuous numeric (range = 13)	✓	✓			
Physical condition: “Considering the last 12 months, how are you feeling physically?”	Ordinal categorical: <i>0 (Very unwell, 6%), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Very well, 37%)</i>	✓	✓			
Employment in wildlife work: “Do you or anyone in your household work for Hwange National Park or The Hwange Lion Project?”	Nominal categorical: <i>Yes (21%), No (79%)</i>	✓	✓			
Total wealth (US\$)	Continuous numeric: <i>Sum of individual's wealth from all sources; livestock, crops, employment and informal work</i>	✓	✓			

	(range = 15306)				
Whether own livestock: “Do you or anyone in your household own livestock (cattle, goats, poultry and so on)?”	Nominal categorical: <i>Yes (90%), No (10%)</i>	✓	✓		
Number of livestock owned, excluding poultry: “What livestock does your household own? And how many?”	Continuous numeric (range = 29)	✓	✓		
Proportion of non-animal wealth: Proportion of wealth derived from non-animal sources	Continuous numeric (range = 0.98)	✓	✓		
Satisfaction with material circumstances: “How satisfied are you with your current standard of living (material circumstances)?”	Ordinal categorical: <i>0 (Extremely dissatisfied, 12%), 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (Extremely satisfied, 12%)</i>	✓	✓		
Ownership of wealth: “In your household, who makes most decisions on how money is spent?”	Nominal categorical: <i>Me (28%), Someone else (32%), Equally shared with someone else (40%)</i>	✓	✓		
Number of livestock lost to lions: “How many livestock have you lost to lions in the last 3 years?”	Continuous numeric (range = 58)	✓	✓	✓	✓
Frequency of seeing lions: “Have you ever seen a lion before, if so how many times?”	Ordinal categorical: <i>Never (51%), One time (18%), A couple of times (13%), Many times (18%)</i>	✓		✓	
Personally know someone attacked by lion: “Do you know personally anyone who has been attacked by a lion?”	Nominal categorical: <i>Yes (43%), No (57%)</i>	✓		✓	
Participation in the project’s conflict mitigation programmes: Whether have bomas, guardians, both or neither	Nominal categorical: <i>Guardians only (70%), Bomas and guardians (4%), Neither (26%)</i>	✓		✓	✓
Proportion of life spent in Hwange	Continuous numeric: <i>Age divided by years lived in Hwange (range = 0.99)</i>	✓		✓	

Conflict level: The number of livestock lost and injured per village (statistics collected by Trans-Kalahari Predator Programme)	Continuous numeric (range = 137)	✓	✓	✓
Experience of other wildlife damage: “Have you suffered any of the following to yourself or in the close family last 12 months? Crop raiding (by elephants, baboons, quelea birds, bush pigs, cattle or similar)”	Nominal categorical: <i>Yes (66%), no (34%)</i>	✓	✓	
Level of fear of lions: “To what degree does fear of lions interfere with your daily activities? (such as going to school, fetching water, going to visit friends or relatives, or other activities)”	Ordinal categorical: <i>Doesn’t interfere at all (12%), Barely interferes (9%), Moderately interferes (20%), Severely interferes (21%), Very severely interferes (38%)</i>	✓		✓
Perceived frequency of lion incursion onto village land: “How often do you think lions come onto your village lands?”	Ordinal categorical: <i>Never (7%), A few times per year (10%), Every month (19%), Every week (61%), Every day (3%)</i>	✓		✓
Ecocentric values regarding lions: “To what extent do you agree with the following statement: lions have the right to exist”	Ordinal categorical: <i>Strongly disagree (3%), Somewhat disagree (4%), Neither agree nor disagree (10%), Somewhat agree (51%), Strongly agree (32%)</i>	✓		✓
Degree of religious observance: “How often do you attend church or other religious ceremonies?”	Ordinal categorical: <i>Never (9%), Rarely (9%), Once a month (2%), Several times a month (5%), Once a week (53%), Several times per week (22%)</i>	✓		✓
Belief in traditional religion: “How important do you think traditional ceremonies (such as rainmaking, ukuthethela and traditional memorial ceremonies) are for the wellbeing of your community?”	Ordinal categorical: <i>Not important at all (41%), Somewhat important (8%), Moderately important (8%), Very important (24%), Extremely important (19%)</i>	✓		✓
External responsibility for risk: “Who do you think is responsible for your losses to predation?”	Open question categorised into a binary nominal categorical variable: <i>Somebody else is responsible (69%), Nobody else is responsible (31%)</i>	✓		✓
Whether respondent has ever lost livestock to lions: “Have you ever lost livestock to lions?”	Nominal categorical: <i>Yes (39%), No (60%), Not sure (1%)</i>	✓		

Perceived degree of benefits accruing from the protected area: "To what degree do you feel that your household benefits from the presence of Hwange National Park?"

Ordinal categorical: *Don't benefit at all (69%), Benefit a little (11%), Moderately benefits (12%), Benefit strongly (6%), Very strongly benefits (2%)*



Perceived relative wealth: "How do you feel your wealth compares with the rest of your village?"

Ordinal categorical: *A lot worse (5%), A bit worse (22%), About the same (22%), A bit better (49%), A lot better (2%)*

Table 2. Coefficients, SE and p-values of the comprehensive attitude model. “.” Indicates very low significance level (0.1), “*” indicates low level (0.05), “**” indicates intermediate level (0.01), and “***” indicates high significance level (0.001). The response variable was a Likert-type item ranging from “very negative” to “very positive” on a five-point scale in response to the question “How do you feel about having lions in your area?”

Variable	Estimate	SE	P-value	*
Gender Female (reference level: “male”)	-0.25	0.13	0.06	.
Ethnicity Nambya (reference level: “Ndebele”)	0.04	0.18	0.81	
Ethnicity Tonga	-0.53	0.20	0.01	**
Ethnicity other	-0.01	0.25	0.98	
Age	-0.01	0.00	0.00	**
Owns livestock (reference level: “does not own livestock”)	-0.27	0.24	0.25	
Number of livestock lost	-0.03	0.02	0.04	*
Education	-0.41	0.22	0.07	.
Physical condition	-0.28	0.21	0.18	
Total wealth	-1.45	2.79	0.60	
Number of livestock owned	0.03	0.02	0.30	
Proportion of non-animal wealth	0.21	0.27	0.44	
Satisfaction with material circumstances	-0.35	0.22	0.10	
Perceived relative wealth	-0.06	0.20	0.77	
Conflict level in village	0.00	0.00	0.95	
Employment in wildlife work (reference level: “not employed in wildlife work”)	-0.18	0.14	0.22	

No ownership of wealth (reference level: "full ownership of wealth)	0.04	0.16	0.81	
Partial ownership of wealth	0.02	0.15	0.88	
Number of dependants	0.07	0.03	0.03	*
Proportion of life spent in Hwange	-0.44	0.16	0.01	**
Programme participation: only guardians (reference level: "Both guardians and bomas")	-0.52	0.27	0.05	.
Programme participation: neither guardians or bomas (reference level: "Both guardians and bomas")	-1.08	0.31	0.00	***
Frequency of seeing lions	-0.30	0.12	0.01	*
Do not personally know someone who has been attacked by lion (reference level: "personally know someone")	0.29	0.13	0.02	*
Experienced other wildlife-related harm (reference level: "not experienced other wildlife-related harm)	-0.16	0.12	0.16	
Perceived household benefits from national park	0.69	0.18	0.00	***
Fear	-1.39	0.14	< 2e-16	***
Ecocentricity	0.76	0.20	0.00	***
Frequency of participation in religious activities	-0.18	0.16	0.25	
Belief in traditional religion	0.19	0.11	0.09	.
Nobody is responsible for losses to lions (reference level: "someone else is responsible for losses to lions")	0.18	0.12	0.13	
Perceived frequency of lions entering village lands	-0.47	0.22	0.04	*
Whether respondent has ever lost livestock to lions	0.04	0.14	0.77	

Table 3. Average effect size of explanatory variables across all levels of the response variable (attitude to coexistence with lions) within the comprehensive model. Ordered from highest to lowest.

Explanatory variable	Average effect size
Fear of lions interferes with daily activities	0.15
Participation in the project's conflict mitigation programmes	0.09
Number of livestock lost to lions	0.07
Number of dependants	0.07
Perceived degree of benefits accruing from the protected area	0.07
Ecocentric values regarding lions	0.06
Perceived frequency of lion incursion onto village land	0.05
Age	0.05
Proportion of life spent in Hwange	0.03
Education	0.03
Frequency of seeing lions	0.03
Personally know someone attacked by lion	0.02
Gender	0.02
Belief in traditional religion	0.02
Ethnicity	0.00