



# Emotions and Cultural Importance Predict the Acceptance of Large Carnivore Management Strategies by Maasai Pastoralists

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Management strategies to reduce human-carnivore conflict are most effective when accepted by local communities. Previous studies have suggested that the acceptance depends on emotions toward carnivores, the cultural importance of carnivores, and livestock depredation, and that it may vary depending on the types of strategies and carnivores involved. However, no study so far considered these factors simultaneously to compare their influence on the acceptance of management strategies. We quantified the predictive potential of these factors on the acceptance of three management strategies frequently applied to mitigate human-carnivore conflict: no action, relocation, and lethal control. We interviewed 100 members of the Maasai community in Ngorongoro Conservation Area in Tanzania. We used structured, closed questionnaires and focused on the three large carnivores involved in the most depredation regionally: spotted hyenas (*Crocuta crocuta*), lions (*Panthera leo*), and leopards (*Panthera pardus*). We found that the majority of respondents accepted no action and rejected relocation and lethal control for all three carnivores. The acceptance of the management strategies was strongly influenced by the emotion joy and by the cultural importance of carnivores, and the effects of joy and cultural importance were stronger than the effect of livestock depredation. We conclude that authorities should evaluate the emotions and cultural importance that local communities associate with carnivores when seeking to gain acceptance of management strategies and account for differences between species. Finally, we recommend that future human-carnivore coexistence studies should consider the socio-psychology of local communities and be done longitudinally to detect shifts in cultural, emotional, and ecological factors over time.

**Keywords:** large carnivores, emotions, human dimensions, livestock depredation, human-wildlife conflict, non-weird people, culture, pastoralism

## INTRODUCTION

Local communities play a crucial role in conservation and determine whether wildlife can persist in shared landscapes (Kiss, 1990) and in protected areas adjacent to human settlements (Emerton and Mfunda, 1999; Mwakatobe et al., 2014). Fortress conservation, whereby local communities are expelled and excluded from a protected area's resources, has been suggested to be ineffective at reducing human-carnivore conflict (see glossary in **Table 1**) due to its adversarial nature and displacement of stakeholders (Hulme and Murphree, 1999; Galvin and Haller, 2008). In multi-use landscapes, where human communities reside alongside wildlife, neglecting the need for community support can exacerbate conflict, whereas implementing management strategies that communities accept can ameliorate conflict, enhance tolerance, and benefit wildlife (Catalano et al., 2019). Accordingly, it is important for authorities to seek community acceptance to ensure the sustainability and effectiveness of management strategies (**Table 1**).

Areas with large carnivores and pastoralists are of particular interest in human-wildlife conflict studies due to the potential for livestock depredation (Bagchi and Mishra, 2006) and attacks on humans (Shepherd et al., 2014). Despite these challenges, large carnivores are among the most culturally important and emotionally evocative animals to people who live alongside them (Bruskotter et al., 2017; Albert et al., 2018). Previous studies separately examined the effect of the emotions a species elicits, its importance to the local community's culture (hereafter

“cultural importance”) (**Table 1**), and the amount of livestock depredation it causes on the acceptance of management strategies to reduce conflict between humans and large carnivores. Negative emotions toward wildlife have been suggested to predict acceptance of management strategies that can kill or hurt them, whereas positive emotions have been suggested to predict acceptance of protective management strategies (Jacobs et al., 2014; Sponarski et al., 2015). In addition, the cultural importance placed on wildlife has been suggested to have a positive relationship with conservation-oriented management strategies (Frank, 2016). Other studies found that livestock depredation by large carnivores can predict whether people accept relocation and lethal control (Kaczensky, 1999; Gusset et al., 2009; **Table 1**). Many studies focused on one of the three factors and may have linked them to the acceptance of different management strategies, but did not compare them directly. It therefore remains unclear whether one factor is more influential than the other and should be prioritized for conflict mitigation.

We simultaneously assessed emotions, cultural importance, and livestock depredation to determine which has the greater predictive potential among the Maasai community in the Ngorongoro Conservation Area (NCA), Tanzania. We assessed whether the predictors differ for three large carnivore species—spotted hyenas (hereafter “hyenas”), lions, and leopards—to find the mechanism underlying the acceptance of three management strategies. These species were chosen because they are the primary livestock predators in Tanzania (Kissui, 2008; Mkonyi et al., 2017) and can pose a direct threat to human lives (Peterhans

**TABLE 1** | Glossary of main concepts as applied in this study.

Concept	Definition	References
Acceptance	The degree to which someone agrees with, supports, or tolerates a situation or concept on a discrete scale or continuum. When applied to our seven-point scale, it describes cases where a respondent gave a score of > 4.	Treves and Naughton-Treves, 2005
Coexistence	A state in which humans and large carnivores occur in shared landscapes where human interactions with carnivores are governed by institutions that ensure long-term carnivore persistence, social legitimacy, and tolerable levels of risk.	Carter and Linnell, 2016
Cultural importance	The significance that a human community or ethnic group places on or associates with a wild animal; the degree to which the animal plays a role in the social practices, traditions, and/or rituals therein.	Schwartz, 2006
Disgust	An emotion in which a person feels intensely repulsed by the exposure to or the thoughts of a stimulus and wants it to be kept far away.	Rozin et al., 1999
Emotion	Transient, discrete neurological state in an individual brought on by external or internal stimuli. Associated with behavioral responses, physiological conditions, and indicative of a degree of pleasure or displeasure.	Ekman, 1999
Fear	An emotion in which a person feels threatened or intimidated by a stimulus out of a sense of danger.	Lang, 1985
Human-carnivore conflict	Interactions between humans and large carnivores that are deemed problematic, e.g., livestock depredation or man-eating.	Broekhuis et al., 2017
Joy	An emotion in which a person feels happy and positive due to a stimulus.	Watkins et al., 2018
Lethal control	The killing of a wild animal in an effort to reduce the number of wild animals and mitigate human-wildlife conflict, and/or protect domestic animals to improve human livelihoods.	Treves and Naughton-Treves, 2005
Management strategy	A policy implemented by a local governing body or authority to mitigate conflict between humans and carnivores.	Treves and Karanth, 2003
No action	Letting wild animals exist in their natural state without persecution, i.e., maintaining the conservation status quo.	Harcourt et al., 1986
Relocation	Moving a wild animal deemed as a nuisance to human livelihoods to another location in order to mitigate human-wildlife conflict.	McCoy and Berry, 2008
Tolerance	Human willingness to share landscapes with large carnivores.	Lischka et al., 2019

and Gnoske, 2001). Several studies have also suggested that, in other communities, there are differences in the emotions that people have toward the species (Sibanda et al., 2020), the cultural importance the species have (Gebresenbet et al., 2018), the extent of livestock depredation the species cause (Okello et al., 2014; Lichtenfeld et al., 2015), and how people want them managed (Mitchell et al., 2019). Each variable involves different psychological levels and pathways: emotions are linked to affective pathways (inferring feelings or emotions), cultural importance to cognitive pathways (inferring thoughts or beliefs; Healey and Grossman, 2018), and livestock depredation is largely external to individual control. By simultaneously investigating the predictive potential of these variables on the three carnivores, we can disentangle their respective effects, assess whether the differences hold true among the NCA Maasai, and understand the mechanisms that shape acceptance across the large carnivore guild. We studied the acceptance of no action, relocation, and lethal control, three management strategies commonly applied where large carnivores and humans co-occur (Linnell et al., 1997; Treves and Karanth, 2003; Karanth and Gopal, 2005; **Table 1**). All three management strategies have a precedent for being applied in the NCA and are within the mandate of the Ngorongoro Conservation Area Authority, the local governing body (Ikanda and Packer, 2008). Other management strategies for large carnivores (e.g., compensation, improved construction of livestock corrals, or accompanying livestock on foot) have also been applied in the NCA, but we opted to select these three as they are the most commonly used in our study area and are more widely applicable to other study areas, irrespective of their expected effectiveness (Van Eeden et al., 2018).

Previous studies have suggested that animals can trigger emotions in people that can predict the acceptance of management strategies (Gore et al., 2009; Jacobs, 2009). For example, the positive emotion joy (**Table 1**) predicted the acceptance of the protection of chipmunks in Italy (Cerri et al., 2020). Negative emotions can also predict management strategy acceptance. Disgust and fear (**Table 1**) toward carnivores have been suggested to undermine conservation efforts and be more significant drivers of human-carnivore conflict than livestock depredation (Dickman, 2010). In communities bordering Iguazu National Park, Brazil, fear of pumas (*Puma concolor*) was found to be lower than fear of jaguars (*Panthera onca*); the presence of jaguars was rejected while the presence of pumas was accepted (Conforti and de Azevedo, 2003). Lions were found to bring negative emotions among farmers in Zimbabwe which in turn predicted how accepting they were of protective management strategies toward lions (Sibanda et al., 2020). Hyenas tend to bring about negative emotions across human communities, which in turn may drive a desire to see them killed (Glickman, 1995). We predicted that joy would be a negative predictor of relocation and lethal control, and a positive predictor of the acceptance of no action. In contrast, we predicted that disgust and fear would be positive predictors of relocation and lethal control and negative predictors of no action.

The cultural importance of a wildlife species can have ramifications on how likely people are to accept different management strategies (Dickman, 2010). The more culturally

important or iconic a species is, the more likely a community is to accept protective management strategies for the species and the less likely they are to accept lethal control or other invasive management strategies. The high cultural importance of the lion has been suggested to have led to a general acceptance of lion conservation among the Maasai (Hazzah et al., 2019). High cultural importance placed on blackbuck antelope (*Antilope cervicapra*) among the Bishnoi in India was also found to predict their acceptance of conservation of that species (Hall and Chhangani, 2015). In Australia, cultural importance was found to be a negative predictor for the acceptance of lethal control of koalas (*Phascolarctos cinereus*) (Drijfhout et al., 2020). Communities also may place different cultural importance on different species of large carnivore. For example, a study in Kenya found that leopards were more culturally important to the Samburu community than African wild dogs, which in turn predicted the differing acceptance of the protection of the two species (Mitchell et al., 2019). Thus, to understand the relationship between cultural importance and the acceptance of different management strategies for wildlife, it is important to recognize inter-specific differences in perception. We predicted that cultural importance would be a positive predictor of acceptance of no action and a negative predictor of acceptance of relocation and lethal control.

The focus of human-carnivore conflict studies has traditionally been livestock depredation, which has also been suggested to predict the acceptance of management strategies. Depredation was found to have a positive correlation with lethal control of carnivores in South Africa (Daly et al., 2006). After disease, hyenas were found to be the second-most important source of livestock loss, and communities which suffered more livestock depredation by carnivores were more likely to accept lethal control in Tanzania (Nyahongo, 2007). Livestock depredation was also a positive predictor of acceptance of lethal control of Brazilian carnivores (Engel et al., 2016). We predicted that reported livestock depredation, i.e., perceived conflict, would be a significant negative predictor of the acceptance of no action and a significant positive predictor of the acceptance of relocation and lethal control.

## MATERIALS AND METHODS

### Study Area

This study took place in the NCA located in Tanzania (03°12'36"S 35°27'36"E; **Figure 1**). The NCA is a multi-use protected area and United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Site noted for its high density of large mammals and popularity as a tourist destination (Charnley, 2005). It is inhabited by members of the Maasai tribe, a semi-nomadic pastoralist ethnic group that ranges from central Kenya to southern Tanzania (Fratkin, 2001). The NCA has a double mandate to conserve wildlife while protecting the interests of the Maasai (Charnley, 2005). Within the NCA is the Ngorongoro Crater, a 300 km<sup>2</sup> volcanic caldera with high densities of both hyenas and lions on the Crater floor and leopards along the rim forests (Packer et al., 1991;

Höner et al., 2012). The wider NCA also supports populations of hyenas, lions, and leopards. The Maasai and cattle populations in the NCA have grown from ~8,000 and 162,000 upon the establishment of the NCA in 1959 to ~93,000 and 243,000, respectively, as of 2017, putting them at increased risk of conflict with carnivores (National Bureau of Statistics Tanzania, 2017).

## Survey

Our survey instrument included five sections with closed questions. Section 1 focused on livestock depredation. Respondents were asked to report the average number of cattle, sheep, goats, and donkeys that they lost annually over the past 3 years due to depredation by hyenas, lions, and leopards and to drought/disease. Section 2 focused on a set of Wildlife Value Orientations (Manfredo et al., 2009). Sections 3–5 were used to score the cultural importance of, emotions (joy, disgust, and fear) toward, and the acceptance of three management strategies (no action, relocation, and lethal control) for each carnivore. Sections 2–5 relied on the usage of a discrete, numeric scale, where respondents would respond to a prompt and give a score between 1 (strongly disagree/reject) and 7 (strongly agree/accept). Section 6 focused on socio-demographic factors. Due to the Cronbach's Alpha (internal consistency) scores for the domination ( $\alpha = 0.15$ ) and mutualism ( $\alpha = 0.67$ ) dimensions of Wildlife Value Orientations falling below the critical threshold of 0.70, they were not included in our study. Furthermore, other prompts in the questionnaire were not included in the analyses for this study; they were not the focus of this comparative study on the predictive potential of different and often separately tested variables.

We first tested the survey instrument and explored the suitability of using selected items with the Maasai in a pilot survey conducted in February 2018 with 20 participants in Ngorongoro ward (**Supplementary Material**, Appendix A). The main survey (**Supplementary Material**, Appendix B) was then undertaken in March 2019 with 100 respondents. Respondents who participated in the pilot survey were not interviewed again for the main survey. The beginning and end time, ward, and geographic coordinates were noted for each questionnaire while further information such as the respondents' names were not included to maintain anonymity.

To accurately represent the local community, the 100 questionnaires were split between 50 men and 50 women and categorized into the following age sets: *endasati* ( $n = 25$ ) and *siangiki* (25) for elder and young women, respectively, and *ilmoruak* ( $n = 17$ ), *korianga* ( $n = 17$ ), and *morani* ( $n = 16$ ) for elder, middle-aged, and young men, respectively (McCabe et al., 2014; National Bureau of Statistics Tanzania, 2017). On each survey day, we visited pre-selected wards (**Figure 1**) and walked through the villages until an individual suspected to be of a target demographic was randomly sighted and approached between 08:00 h and 18:00 h. The aim of the survey was introduced and respondents were asked if they consented to participation and to state their age class and gender. Each respondent represented a single household. Owing to low literacy amongst the Maasai in the NCA (Goldman and Milliard, 2014), questionnaire items

were read aloud, translated into Maa—their native language—and responses again translated from Maa to English, then recorded on a printed questionnaire copy. Participation by respondents was voluntary and unpaid. Each respondent was then presented with photographs of the three carnivores in this study as well as the African wild dog (*Lycaon pictus*), cheetah (*Acinonyx jubatus*), and striped hyena (*Hyaena hyaena*), three carnivores that are transient in the parts of the NCA we covered (Kennedy and Kennedy, 2014). Respondents were asked to name the carnivores; all 100 respondents accurately identified the carnivores.

## Quantification of Livestock Depredation

We quantified herd size and livestock loss based on the number of heads of each species of livestock owned by each respondent and on the number of heads that died. Total financial loss incurred by each respondent was calculated by multiplying the number of heads of the livestock species lost by their per capita financial value on the local market. At the time of the study, NCA market prices for cattle, sheep, goats, and donkeys were TSH 400 000 (USD 174), TSH 110 000 (USD 48), TSH 110 000 (USD 48), and TSH 200 000 (USD 87), respectively. Proportional financial loss was then calculated by dividing the total financial value lost to the particular carnivore divided by the financial value of the livestock owned by the respondent prior to the loss. We used proportional financial loss (hereafter “livestock depredation”) instead of the raw number of livestock heads that died as a predictor because (i) the market value differs between livestock species and may impact the perception of livestock depredation by respondents, (ii) herd size varies greatly in the NCA (this study; National Bureau of Statistics Tanzania, 2017), and (iii) the relative cost of livestock depredation may matter more than the absolute cost in shaping the perception of an experience as negative (Mkonyi et al., 2017). For an overview of the number of heads of the different livestock species that were killed by the different carnivores and the ensuing financial costs, see **Supplementary Table 1**.

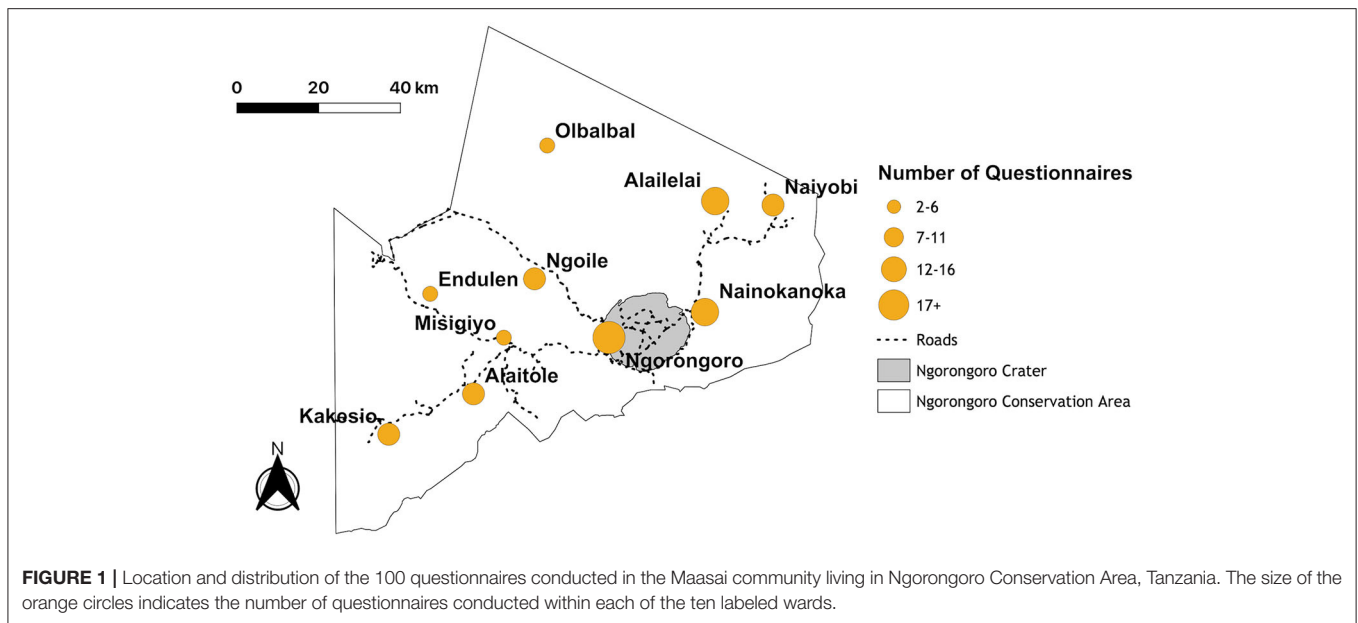
## Data Analyses

Statistical analyses were conducted in R version 4.0.3 (R Core Team, 2020). The threshold for statistical significance was set to  $\alpha = 0.05$ , and data are presented as mean  $\pm$  S.E. unless stated otherwise.

We compared the scores for the emotions of joy, disgust, and fear each carnivore elicited and their cultural importance using Friedman rank sum tests and Dunn *post-hoc* pairwise multiple comparisons with Bonferroni corrected p-values (package “dunn.test”; Dinno, 2017). Responses to the prompts on emotions, cultural importance, and the acceptance of management strategies were plotted as diverging stacked bar plots (package “likert”; Bryer and Speerschneider, 2016).

The livestock depredation caused by each carnivore (independent variable with three levels: hyena, lion, and leopard) was compared using a generalized linear mixed effects model (GLMM), with a beta distribution and logit link (package “glmmTMB”; Brooks et al., 2017; Douma and Weedon, 2019). Proportions (for the response variable, livestock depredation)





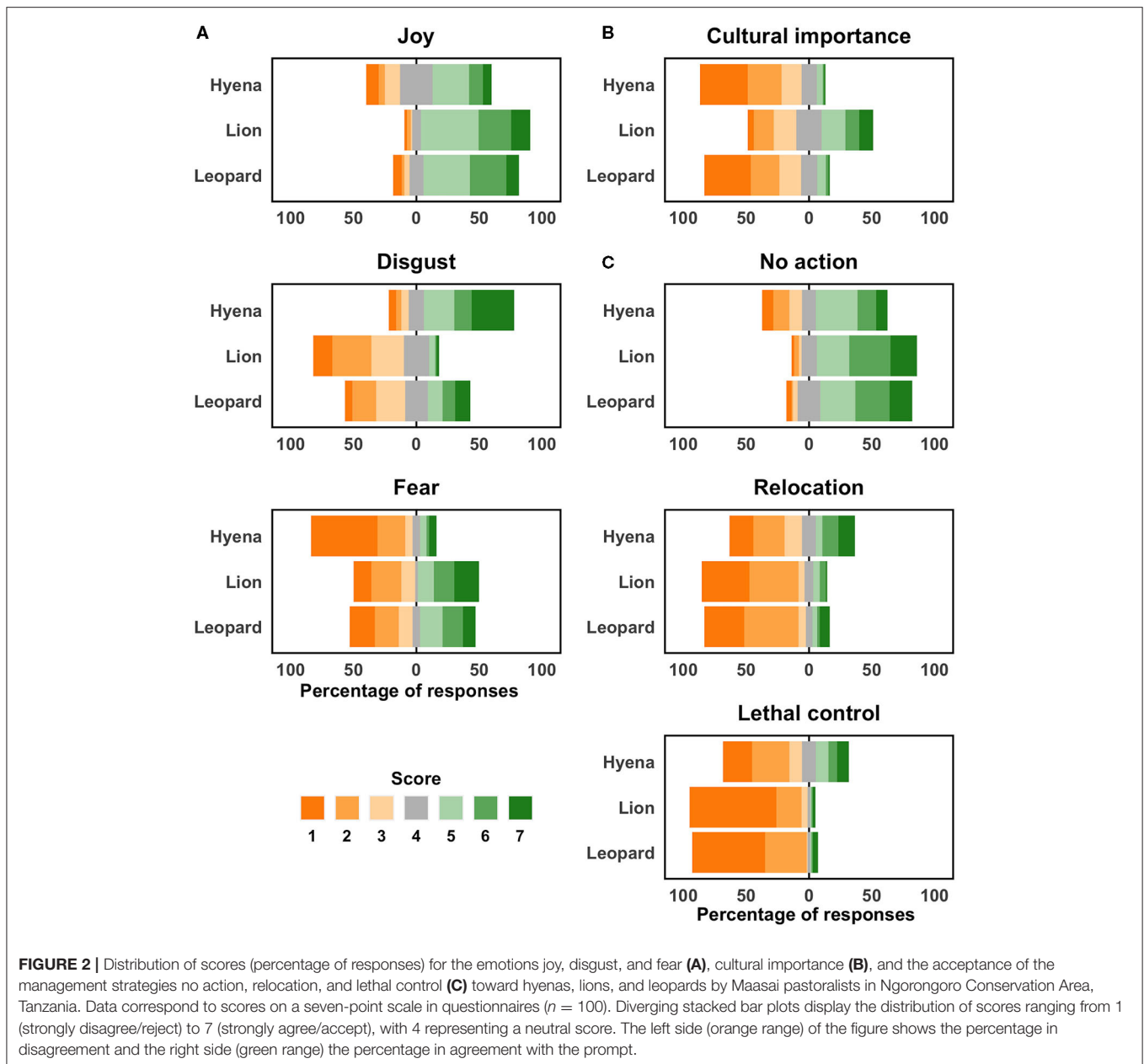
were transformed using the formula for beta distributions with values that include 0 and/or 1:  $y^*(n - 1) + 0.5/n$ , where  $y$  is the original proportion and  $n$  is the sample size (100 respondents \* 3 carnivores = 300) (Cribari-Neto and Zeileis, 2009). Because each respondent was assigned a value for livestock depredation pertaining to each carnivore, data included repeated measures. We therefore included the unique identifier for each respondent as a random factor.

The influence of the type of management strategy (no action, relocation, lethal control), the carnivore species (hyena, lion, leopard), emotions (joy, disgust, fear), cultural importance, and livestock depredation on the acceptance scores was tested using an ordinal logistic regression (OLR) model (function “clmm” in package “ordinal”; Christensen, 2019). We included an interaction term between management strategy and all other covariates to disentangle and quantify the effects of the predictors. The identity of the respondent (100 levels) was included as a random factor.

To avoid multicollinearity, numeric predictors were centered at their means using function “center.numeric” from the package “psycholing” (Fraundorf, 2020). All predictors fell below the critical variance inflation factor (VIF) threshold of 10 (package “HH”; James et al., 2013; Heiberger, 2020). Note that most studies involving a Likert-type dependent variable, i.e., a score on a discrete ordinal scale, traditionally conduct ordinary least-squares regressions (OLS) (Bishop and Herron, 2015; Bürkner and Vuorre, 2019). When applied to ordinal scores, metric models such as OLS assume that spacing between each score is the same, e.g., that a switch from 1 to 2 involves the same cognitive process as a switch from score 4–5 on a seven-point scale. This assumption is likely to be violated (Liddell and Kruschke, 2018). OLR, which allows for cognitive flexibility and account for the ordered nature of Likert-type data, are therefore more appropriate (Harrell, 2015).

The significance of the effects of each focal predictor and the interaction terms on acceptance was assessed using likelihood ratio tests (function “anova” in package “stats”; R Core Team, 2020). The likelihood ratio tests determined the marginal contribution of the focal predictor to the full model by comparing the fit of the full model with that of a reduced model with the focal predictor removed.

Both the GLMM and OLR models generated estimates as log(odds) which we converted to odds ratios and 95% confidence intervals using the function “exp(confint(model))” for ease of interpretation. Odds ratios > 1 and odds ratios < 1 indicate a relative increase and decrease, respectively, in the likelihood of the dependent variable to increase by one unit when the predictor variable increases by one unit. For example, if the odds ratio for a given predictor in the OLR is 1.50, then a one-unit increase in the predictor (e.g., from 4 to 5) leads to the probability of an increase (e.g., from score 4 to score 5) in acceptance being 50% higher when all other variables in the OLR are held constant. In the case of the livestock depredation GLMM, a one-unit “increase” in the predictor refers to a switching of the carnivore species—the reference species was set as the hyena, so a one-unit “increase” in this model refers to a shift in the predictor from hyena to lion or leopard. The OR expressed therefore refers to the odds of livestock depredation increasing when hyenas are replaced by lions or leopards. An OR > 1 would therefore mean that the focal species causes more livestock depredation than hyenas, and the opposite would be true for an OR < 1. Further information on how to construct and interpret OLR using the “clmm” function can be found in Lorenzo-Arribas (2019, p. 57–71). Cumulative predicted probabilities of acceptance (score > 4) of the management strategies as a function of the different predictors were calculated based on the OLR with the package “emmeans” (Lenth, 2021) and then plotted using the package “ggplot2” (Wickham, 2016).



## RESULTS

### Emotions

47% of respondents felt joy toward hyenas (score  $> 4$ ), compared to 87% for lions and 76% for leopards (Figure 2A). 72% of respondents found hyenas disgusting (score  $> 4$ ), compared to 8% for lions and 34% for leopards. 13% of respondents feared hyenas (score  $> 4$ ), in contrast to 49% for lions and 44% for leopards. Scores for the emotions differed significantly between carnivores (Friedman test; joy:  $\chi^2 = 41.58$ ,  $df = 2$ ,  $p < 0.001$ ; disgust:  $\chi^2 = 88.10$ ,  $df = 2$ ,  $p < 0.001$ ; fear:  $\chi^2 = 70.54$ ,  $df = 2$ ,  $p < 0.001$ ). Hyenas brought less joy (median<sub>hyena</sub> = 4.0) than both lions (median<sub>lion</sub> = 5.0,  $p < 0.001$ ) and leopards (median<sub>leopard</sub> = 5.0,  $p < 0.001$ ). There was no difference in joy

toward lions and leopards ( $p = 0.26$ ). Respondents felt greater disgust toward hyenas (median<sub>hyena</sub> = 5.0) than to both lions (median<sub>lion</sub> = 3.0;  $p < 0.001$ ) and leopards (median<sub>leopard</sub> = 4.0;  $p < 0.001$ ), and greater disgust toward leopards than lions ( $p < 0.001$ ). Hyenas were feared less (median<sub>hyena</sub> = 1.0) than both lions (median<sub>lion</sub> = 4.0,  $p < 0.001$ ) and leopards (median<sub>leopard</sub> = 3.5,  $p < 0.001$ ), whereas fear of lions and leopards did not significantly differ ( $p = 0.39$ ).

### Cultural Importance

7% of respondents found hyenas culturally important (score  $> 4$ ), compared to 41% for lions and 10% for leopards (Figure 2B). Respondents attributed different cultural importance to the

carnivores ( $\chi^2 = 90.08$ ,  $df = 2$ ,  $p < 0.001$ ). Hyenas were seen as culturally unimportant overall (median<sub>hyena</sub> = 2.0) and less culturally important than lions, which were seen as neither culturally important or unimportant (median<sub>lion</sub> = 4.0;  $p < 0.001$ ). There was no difference in cultural importance between hyenas and leopards (median<sub>leopard</sub> = 2.0;  $p = 0.85$ ). Leopards were seen as less culturally important than lions ( $p < 0.001$ ).

## Livestock Composition and Depredation

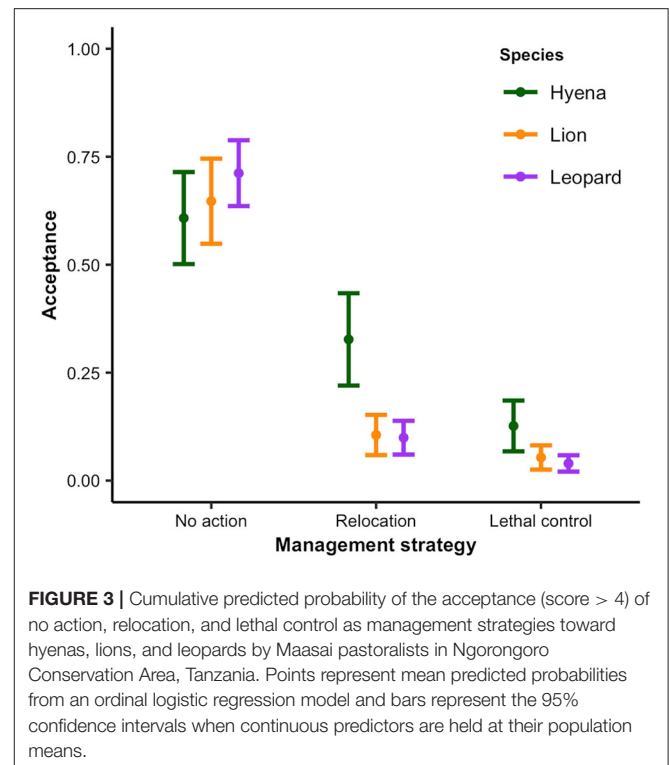
All respondents belonged to a household that owned livestock, with a mean of  $137.4 \pm 26.8$  heads of livestock per household. Nearly all respondents (97%) owned herds that were composed of at least two species. Respondents owned a mean of  $40.2 \pm 5.4$  cattle,  $70.9 \pm 20.4$  sheep,  $23.0 \pm 3.6$  goats, and  $3.3 \pm 0.5$  donkeys. The carnivores differed in the livestock depredation they caused. Compared to hyenas (beta GLMM; OR = 0.14, CI<sub>95%</sub> = 0.11–0.16,  $p < 0.001$ ), both lions (OR = 0.25, CI<sub>95%</sub> = 0.19–0.33,  $p < 0.001$ ) and leopards (OR = 0.35, CI<sub>95%</sub> = 0.27–0.45,  $p < 0.001$ ) caused less livestock depredation. Lions also caused less livestock depredation than leopards (OR = 0.72, CI<sub>95%</sub> = 0.55–0.94,  $p = 0.016$ ). Hyenas accounted for a mean of  $13.4 \pm 1.3\%$  of livestock depredation, lions  $1.9 \pm 0.3\%$ , and leopards  $4.1 \pm 0.7\%$  (Supplementary Figure 1).

## Acceptance of Management Strategies

The majority of respondents accepted (score >4) no action for all three carnivores (hyenas: 57%, lions: 80%, leopards: 73%; Figure 2C). In contrast, both relocation and lethal control were mostly rejected (relocation: hyenas: 31%, lions: 11%, leopards: 14%; lethal control: 26%, 4%, and 6%).

Management strategy (OLR, likelihood ratio test; LR = 563.22,  $p < 0.001$ ) and carnivore species (LR = 36.82,  $p < 0.001$ ) had significant effects on acceptance scores (Figure 3; Table 2). Acceptance of no action was similar for all three carnivore species. In contrast, acceptance scores of relocation and lethal control were higher for hyenas than for lions and leopards (Supplementary Tables 2, 3). There was no difference in acceptance scores of relocation and lethal control between lions and leopards (Supplementary Table 4).

Emotions had a significant effect on the acceptance score of management strategies (LR = 97.80,  $p < 0.001$ ). Joy had a strong effect (LR = 68.31,  $p < 0.001$ ), disgust a weak effect (LR = 7.20,  $p = 0.066$ ) and fear no effect (LR = 3.94,  $p = 0.27$ ) (Table 2; Figure 4A). The effect of joy differed between the management strategies (Table 2). It had a strong, positive effect on the acceptance of no action and a negative effect on the acceptance of relocation and lethal control. When the joy score changed from 1 to 7, predicted acceptance changed from 27% (CI<sub>95%</sub>: 14–40%) to 83% (CI<sub>95%</sub>: 77–89%) for no action, from 26% (CI<sub>95%</sub>: 14–39%) to 14% (CI<sub>95%</sub>: 8–19%) for relocation and 37% (CI<sub>95%</sub>: 21–53%) to 2% (CI<sub>95%</sub>: 1–4%) for lethal control (Figure 4A). The effect of disgust also differed between the management strategies (Table 2). It had no significant effect on the acceptance of no action and relocation but a weak, positive effect on the acceptance of lethal control. When the disgust score changed from 1 to 7, predicted acceptance changed from 71% (CI<sub>95%</sub>: 61–80%) to 60% (CI<sub>95%</sub>: 49–71%) for no action, from 15% (CI<sub>95%</sub>: 8–21%) to 21%



**FIGURE 3** | Cumulative predicted probability of the acceptance (score > 4) of no action, relocation, and lethal control as management strategies toward hyenas, lions, and leopards by Maasai pastoralists in Ngorongoro Conservation Area, Tanzania. Points represent mean predicted probabilities from an ordinal logistic regression model and bars represent the 95% confidence intervals when continuous predictors are held at their population means.

(CI<sub>95%</sub>: 14–29%) for relocation and 5% (CI<sub>95%</sub>: 2–7%) to 12% (CI<sub>95%</sub>: 6–17%) for lethal control (Figure 4A).

Cultural importance had a significant effect on the acceptance of management strategies (LR = 20.39,  $p < 0.001$ ; Table 2). It was positive for no action and weakly negative for relocation and lethal control. When the score for cultural importance changed from 1 to 7, predicted acceptance changed from 58% (CI<sub>95%</sub>: 50–66%) to 79% (69–89%) for no action, from 23% (CI<sub>95%</sub>: 17–29%) to 9% (CI<sub>95%</sub>: 4–15%) for relocation, and from 11% (CI<sub>95%</sub>: 7–15%) to 3% (CI<sub>95%</sub>: 1–5%) for lethal control (Figure 4B).

Livestock depredation had a significant effect on the acceptance of management strategies (LR = 14.17,  $p = 0.003$ ; Table 2). It had no effect on no action and lethal control but a negative effect on relocation. When proportional financial loss (livestock depredation) changed from 0.0 to 0.8, predicted acceptance changed from 65% (CI<sub>95%</sub>: 59–71%) to 73% (CI<sub>95%</sub>: 40–100%) for no action, from 22% (CI<sub>95%</sub>: 17–27%) to 1% (CI<sub>95%</sub>: 0–2%) for relocation and 8% (CI<sub>95%</sub>: 5–11%) to 0% (CI<sub>95%</sub>: 0–1%) for lethal control (Figure 4C).

## DISCUSSION

Our results suggest that the Maasai pastoralists living in the NCA are generally against the relocation and lethal control of large carnivores. Our results further suggest that the acceptance of management strategies is strongly influenced by emotions and cultural importance and that emotions and cultural importance are stronger predictors of the acceptance of management strategies than livestock depredation. These

**TABLE 2** | Variation in acceptance scores by Maasai pastoralists as a function of management strategies, carnivore species, emotions, cultural importance, and livestock depredation.

Predictor	OR	CI <sub>95%</sub>	p
<b>Threshold coefficients</b>			
1 2	0.04	0.03–0.07	-
2 3	0.21	0.13–0.33	-
3 4	0.34	0.21–0.53	-
4 5	0.65	0.41–1.01	-
5 6	1.71	1.10–2.68	-
6 7	5.62	3.48–9.06	-
<b>Management strategies</b>			
Relocation	<b>0.31</b>	<b>0.17–0.59</b>	<b>&lt;0.001</b>
Lethal control	<b>0.09</b>	<b>0.05–0.18</b>	<b>&lt;0.001</b>
<b>Species</b>			
Lion	1.18	0.60–2.37	0.64
Leopard	1.59	0.89–2.85	0.12
<b>Emotions</b>			
Joy	<b>1.55</b>	<b>1.31–1.82</b>	<b>&lt;0.001</b>
Disgust	0.92	0.81–1.06	0.24
Fear	1.03	0.93–1.14	0.59
Cultural importance	<b>1.19</b>	<b>1.04–1.36</b>	<b>0.013</b>
Livestock depredation	1.57	0.17–14.97	0.70
<b>Interaction terms</b>			
Relocation*Lion	<b>0.21</b>	<b>0.07–0.57</b>	<b>0.002</b>
Lethal control*Lion	<b>0.33</b>	<b>0.11–0.96</b>	<b>0.042</b>
Relocation*Leopard	<b>0.14</b>	<b>0.06–0.34</b>	<b>&lt;0.001</b>
Lethal control*Leopard	<b>0.18</b>	<b>0.07–0.44</b>	<b>&lt;0.001</b>
Relocation*Joy	<b>0.56</b>	<b>0.44–0.71</b>	<b>&lt;0.001</b>
Lethal control*Joy	<b>0.37</b>	<b>0.29–0.48</b>	<b>&lt;0.001</b>
Relocation*Disgust	1.18	0.97–1.44	0.10
Lethal control*Disgust	<b>1.28</b>	<b>1.05–1.57</b>	<b>0.017</b>
Relocation*Fear	1.05	0.91–1.21	0.53
Lethal control*Fear	0.90	0.76–1.05	0.17
Relocation*Cultural importance	<b>0.70</b>	<b>0.57–0.85</b>	<b>&lt;0.001</b>
Lethal control*Cultural importance	<b>0.67</b>	<b>0.54–0.83</b>	<b>&lt;0.001</b>
Relocation*Livestock depredation	<b>0.01</b>	<b>0.00–0.19</b>	<b>0.003</b>
Lethal control*Livestock depredation	0.22	0.01–6.59	0.39

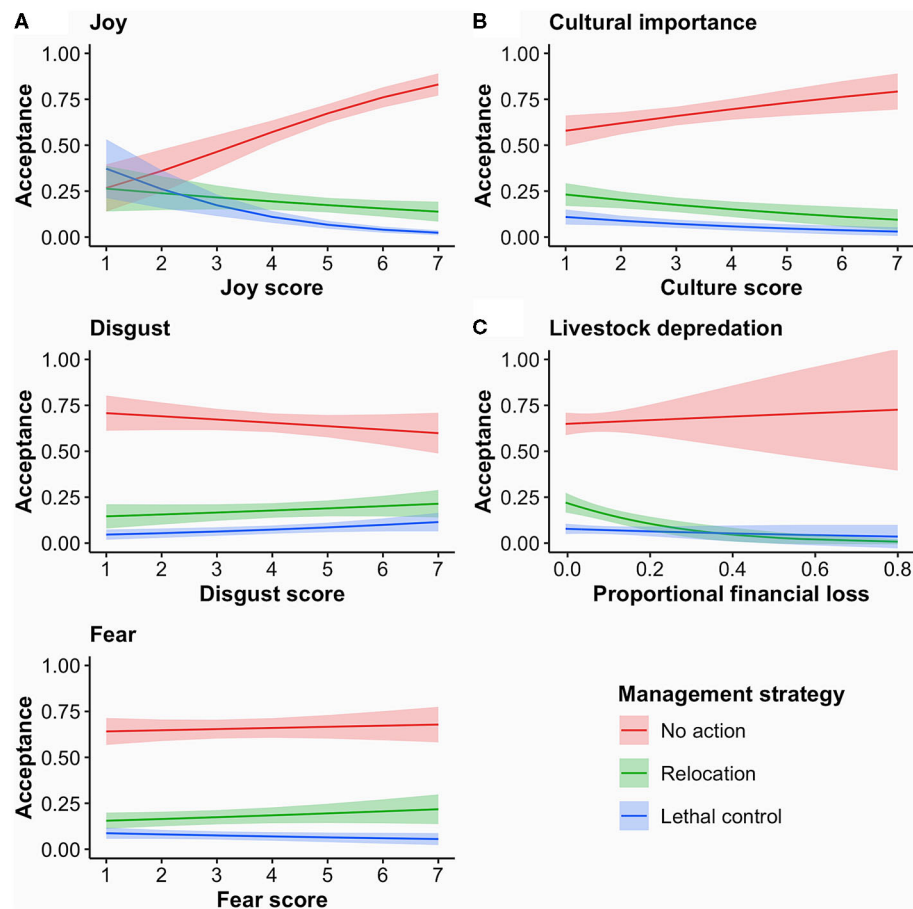
Shown are the odds ratios (OR), their associated 95% confidence intervals (CI<sub>95%</sub>), and p-values for each predictor, as derived from an ordinal logistic regression model (individual-level random effect variance = 0.07). OR > 1 and OR < 1 indicate a relative increase and decrease, respectively, in the acceptance score associated with a 1-unit increase or shift in the focal predictor when all other covariates are held constant at their population mean or reference level. The reference carnivore species is the hyena and the reference management strategy is no action. Threshold coefficients refer to the cumulative probability that an acceptance score is at or below the threshold cut point, e.g., the OR for the threshold 2|3 compares the probability of the acceptance score falling within the range of 1–2 to the probability of the acceptance score falling within the range of 3–7. Data in bold were deemed significant ( $p < 0.05$ ).

variables had the most significant results and had large effect sizes. The effect of emotions was mostly driven by joy: a positive effect on no action and a negative effect on relocation and lethal control, as predicted. The effects of the positive emotion joy are consistent with previous findings that suggested that joy is connected to a desire not to see animals killed or moved (Sponarski et al., 2015). Disgust had only a weak effect and fear had no significant effect on the acceptance of management strategies. The effect of cultural importance was positive for no action and negative for relocation and lethal control, as predicted. Despite controlling for several important

predictors in our model, there was a significant difference in the acceptance of relocation and lethal control between the carnivores. These differences warrant further investigation to identify additional drivers of the inter-specific variation in acceptance of invasive management strategies within the large carnivore guild.

The key role of emotions and cultural importance as predictors of the acceptance of management strategies has potential conservation implications and applications. Being cognitive and affective variables, they are influenced by shifts in external factors. For emotions, our findings may facilitate





**FIGURE 4 |** Cumulative predicted probability of the acceptance (score > 4) of no action, relocation, and lethal control as management strategies toward hyenas, lions, and leopards by Maasai pastoralists in Ngorongoro Conservation Area, Tanzania. Plots show how emotions (A), cultural importance (B), and livestock depredation (C) influenced the acceptance of the management strategies. For emotions and cultural importance, scores range from 1 (strongly disagree/reject) to 7 (strongly agree/accept), with 4 representing a neutral score. For livestock depredation, the x-axis is limited to the range of observed values (0.0–0.8). Lines represent mean predicted probabilities from an ordinal logistic regression model and shading represents the 95% confidence intervals when continuous predictors are held at their population means and using the mean effect of the carnivore species.

local authorities' investment in outreach initiatives. We found that the positive emotion joy was a more important predictor of management strategy acceptance than the more negative emotions disgust and fear; we recommend an increased emphasis on positive emotions rather than the traditional focus on negative emotions toward wildlife (Espinosa and Jacobson, 2012). Education and awareness about predators can sometimes ameliorate negative emotions (Bruskotter and Wilson, 2014; Lyngdoh et al., 2017) and mitigate conflict due to improved knowledge of the risks and drivers of conflict (Treves and Karanth, 2003). As charismatic species such as lions continue to be represented positively, emotions toward these animals remain positive while negatively represented species continue to be subject to negative emotions (Albert et al., 2018). To incite change, it may be fruitful to depict hyenas positively in the NCA. For example, mentioning the value of social support in hyena society (Vulllioud et al., 2019) may place them in a positive light due to the Maasai community's strong family focus

(Kipuri, 2020) and further reduce the acceptance of relocation or lethal control of hyenas. Moreover, ecosystem services that hyenas provide as predators and scavengers may contribute to the control of diseases (O'Bryan et al., 2018) by reducing disease transmission within livestock herds and between wild herbivores and livestock (Stronen et al., 2007). This could also be highlighted as a benefit of having hyenas around. Such efforts can be put into place at workshops and outreach efforts for schoolchildren in order to instill positive emotions toward carnivores in Maasai community members from a young age (Mkonyi et al., 2017). There is a precedent for the efficacy of such efforts elsewhere, with children (Johansson et al., 2016) and adults alike (Breuer et al., 2020). The efficacy of such efforts can be enhanced by involving societal "influencers," e.g., elders with considerable reach and power (Verissimo et al., 2019). Regardless, such efforts should only be done with collaborative, enthusiastic involvement from the community side and in a way that benefits local stakeholders (Berkes, 2004).

Regarding cultural importance, intergenerational change and concurrent sedentarism has been suggested to result in increased acceptance for wildlife conservation (Lavery et al., 2019). However, it may also lead to reduced physical, spiritual, or emotional contact with wildlife, e.g., by losing touch with traditional values and practices that bring humans and wildlife closer together. For example, lion killing by *moranis*, in a symbolic coming-of-age ceremony, has become rarer (Western et al., 2019) and may have reduced the importance of lions over time. This may explain the “neutral” median score lions received for cultural importance. In the NCA, the Maasai are required to live a traditional semi-nomadic lifestyle to protect wildlife habitats (Lawuo et al., 2014), which may limit shifts in the cultural importance of different carnivores. Capitalizing on the knowledge of the cultural importance of different carnivores and its predictive potential would enable authorities to influence the acceptance of different management strategies by easing or tightening current rules about lifestyles that are in place. It would therefore be prudent to collect long-term data on local scores for the cultural importance of wildlife to detect shifts over time, compare cultural importance scores between older and younger generations, and assess how scores change with different policies. It may also help to identify where and to what extent different management strategies will be accepted and be effective at limiting conflict, e.g., as with the Lion Guardians model in Kenya (Hazzah et al., 2019).

In contrast to our predictions, livestock depredation was only a significant predictor for the acceptance of relocation, and the relationship was negative. While this result may seem surprising, given that many Maasai are wholly dependent on their livestock (McCabe et al., 2014), several explanations may be valid. Firstly, with increasing livestock depredation, the predicted acceptance of relocation decreased to a point where it was strongly rejected. This may indicate that following higher rates of livestock depredation, the Maasai become wary of management strategies such as relocation which risk having the carnivores return again (McCoy and Berry, 2008). Secondly, disease and drought were much greater sources of livestock loss than livestock depredation by all three carnivores combined, which may buffer the effect of livestock depredation. It also may be partly due to the fact that the tourism industry is a source of employment for the Maasai community and may further mask the effects of livestock depredation (Homewood and Rodgers, 2004; Melita, 2014). It is also plausible that the Maasai in the NCA are accustomed to livestock depredation as an aspect of day-to-day life, as it has been unavoidable for generations. For instance, there may be an interplay between historical livestock depredation by hyenas and the negative emotions associated with them; once these long-term trends become entrenched in local perceptions, they may mask the effect of recent livestock depredation itself and instead be picked up by emotions. A similar result was found in Bangladesh, where livestock owners that were subject to the greatest perceived conflict with tigers (*Panthera tigris*) were the most tolerant of tigers; the authors posited that a greater focus on socio-psychological drivers of tolerance would have been useful to disentangle the effects of livestock depredation and other factors (Inskip et al., 2016). This lies in contrast to a study in

Namibia which found that farmers tolerated carnivores the most in areas where livestock depredation was the lowest (Lindsey et al., 2013). However, the study did not assess how values or emotions that were already in place may have predicted tolerance or the acceptance of management strategies. We contend it is crucial to simultaneously consider socio-psychological factors such as emotions and cultural importance along with livestock depredation to assess which is more important as predictors of the acceptance of management strategies (Jacobsen et al., 2020). Further examination of the acceptance of other management strategies which we did not include but can also promote coexistence, such as improving livestock corrals or compensation schemes, may improve understanding of the predictive potential of livestock depredation in comparison to other factors.

It is worth recognizing that our approach—to begin by asking about livestock depredation and then going into emotions, cultural importance, and management strategies—may have introduced a bias by having respondents associating the carnivores with livestock loss. Despite this possibility, we argue that any potential effect was not severe, owing to the fact that the respondents displayed a general acceptance of no action toward the carnivores in our study, a rejection of relocation and lethal control, and views that are in accord with other studies on Maasai-carnivore relationships (Kissui, 2008; Goldman, 2011). Furthermore, livestock depredation ended up being a weak predictor, and only for one management strategy, despite being introduced first.

In summary, this study demonstrates the importance of assessing emotions and cultural importance in human-carnivore conflict studies and the importance of accounting for potential variations in acceptance of different management strategies and species. Our findings have affirmed the role of positive emotions in relation to human relationships with wildlife (Buijs and Jacobs, 2021) and confirmed the importance of considering both affective and cognitive factors (Dechner, 2021). They also question the widespread view that livestock depredation is the most important issue to focus on in human-carnivore studies. Further, we have highlighted the importance of considering the different emotions that people have toward species within the same guild—cultural and psychological factors may play a role. Specifically to the Maasai, we have underpinned the importance of different carnivores to their culture and their acceptance of different strategies, forming a basis for coexistence based on various factors. Because the effects of the factors may be direct and indirect (Teixeira et al., 2020), investigating these relationships may disentangle effects and help understand the complex processes associated with tolerance of wildlife and how human cognitions interact with ecological dimensions. In particular, it would be important to understand the interplay between the different factors in order to detect any mediating effects between predictors and their relationship with the acceptance of management strategies. Human-carnivore conflict remains a challenging and complex issue, but understanding the best predictors of the acceptance of management strategies paves the way for authorities to implement locally-accepted initiatives geared toward coexistence between people and wildlife.

## DATA AVAILABILITY STATEMENT

The original contributions presented in this study are publicly available. This data can be found here: <https://doi.org/10.6084/m9.figshare.14780058>.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Tanzania Wildlife Research Institute, the Tanzania Commission for Science and Technology, and the Internal Committee for Ethics and Animal Welfare of the Leibniz Institute for Zoo and Wildlife Research under approval number 2018-01-03. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

Conceptualization: AD, ED, MJ, TS, and OH. Methodology: AD, ED, MJ, JN, TS, and OH. Formal analysis: AD and TS. Investigation: AD and JN. Resources: JN and OH. Data curation: AD. Writing of original draft: AD, ED, TS, and OH. Review and editing of draft: AD, ED, MJ, TS, and OH. Supervision: TS and OH. Project administration: AD, JN, and OH. Funding acquisition: AD and OH. All authors contributed to the article and approved the submitted version.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcosc.2021.691975/full#supplementary-material>

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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