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Carnivores, culture and 'contagious conflict': Multiple factors influence perceived problems with carnivores in Tanzania's Ruaha landscape

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ABSTRACT

Resolving human-wildlife conflict is a conservation priority, but effective mitigation requires in-depth understanding of the complexity and relative importance of conflict drivers. We conducted 262 semi-structured interviews with villagers around Tanzania's Ruaha National Park. The surveys provided data on respondents' perceived problems with wildlife, knowledge, reported killing of carnivores, and their socio-economic characteristics. 98.5% of people perceived a problem with wildlife, and respondents viewed large carnivores as significantly more problematic than other species, due to the threats they posed to livestock and humans. Despite this, only 7.3% of people admitted to having killed any large carnivores. Depredation was widespread, having affected 61.1% of households, but was less important than other forms of stock loss – monthly recall data revealed 1.2% of stock were predated, compared to 9.1% lost to disease and 2.8% to theft. Although experience of depredation significantly predicted negative attitudes towards carnivores, it was not the most important factor. The study raises the possibility of 'contagious conflict', where perceived problems with one group of species were strongly associated with perceived problems with others. Furthermore, factors such as ethnic group and religious beliefs were significant predictors of perceived problems. This study suggests that effective conflict mitigation should involve measures to improve attitudes towards a broad range of species, rather than a single taxon, and that action should be taken to also address the social and cultural drivers of conflict, rather than merely focusing upon reducing wildlife damage.

1. Introduction

Human-wildlife conflict is a pressing conservation issue and can have extremely damaging impacts both on human communities and wildlife populations (Loveridge et al., 2010; Thirgood et al., 2005). This conflict has been defined by the World Wide Fund for Nature (WWF) as 'any interaction between humans and wildlife that results in negative impacts on human social, economic or cultural life, on the conservation of wildlife populations, or on the environment' (WWF, 2005), which covers a very broad range of scenarios. Here, we consider three key aspects of conflict: how problematic people consider wildlife to be; the damage reportedly imposed by wildlife on people; and the reported killing of wildlife by people. Large carnivores such as lions (*Panthera leo*), spotted hyaenas (*Crocuta crocuta*), grizzly bears (*Ursus arctos*) and grey wolves (*Canis lupus*) tend to cause particularly intense conflict, as they pose a severe, direct threat to peoples' livestock (which are often vital economic and social assets) as well as to humans themselves (Holmern et al., 2007; Loe and Roskaft, 2004; Packer et al., 2005; Sommers et al., 2010). Such species can have devastating impacts, as even relatively low levels of stock loss can impose intolerable costs on poor households (Jackson et al., 2010; Yirga and Bauer, 2010). People commonly respond to this threat by killing problematic wildlife, either pre-emptively or in response to damage (Thirgood et al., 2005). Conflict with humans has been one of the key drivers of widespread large carnivore declines (Woodroffe et al., 2005), and has been highlighted as the main threat facing remaining lion populations in East Africa (Frank et al., 2006), as well as a significant threat to species such as African wild dogs (*Lycaon pictus*) and leopards (*Panthera pardus*) (Ray et al., 2005).

Mitigating conflict is therefore a priority for large carnivore conservation (IUCN, 2006, 2007a; Ray et al., 2005). However, effective

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mitigation relies upon an in-depth understanding of the magnitude and drivers of human-wildlife conflict at a local level – for instance, if antagonism towards a species actually reflects hostility towards protected areas, the government or other groups, then reducing damage caused by that species is unlikely to significantly reduce conflict (Knight, 2000). Despite increasing recognition of this need to understand the complexities of conflict (Dickman, 2010), there is a paucity of data on the extent and drivers of conflict in many important wildlife areas. For instance, Tanzania's Rungwa-Ruaha region, which includes the Ruaha National Park (at 20,300 km^2, the largest National Park in Tanzania), is one of the most important areas in the world for wildlife: it is a priority landscape for threatened species such as the African elephant (*Loxodonta africana*) (Stephenson and Ntiamoa-Baidu, 2010), harbours two Important Bird Areas (WCS, 2005) and is a hotspot for carnivore biodiversity (Mills et al., 2001). It supports over 10% of the world's remaining lions (Riggio et al., 2013), one of only four cheetah (*Acinonyx jubatus*) populations in East Africa numbering over 200 adults (IUCN, 2007a), the world's third biggest population of African wild dogs (IUCN, 2007a; IUCN, 2007b), and important populations of leopards and spotted hyaenas. This landscape includes a mosaic of land-uses, including the Park, Game Reserves, Wildlife Management Areas and village land, with anecdotal evidence of intense human-carnivore conflict and frequent carnivore killing. As conflict on reserve boundaries can have significant impacts even on populations within protected areas (Woodroffe and Frank, 2005), it is crucial to determine the intensity and drivers of human-wildlife conflict in important, reserve-adjacent areas such as this one. We examined local attitudes towards wildlife on village land in the Ruaha landscape, as well as the degree of damage caused by carnivores and the level of reported carnivore killing, and investigated which factors were linked to more negative attitudes. We hypothesised that people would perceive wildlife, particularly carnivores, in the Ruaha landscape to be problematic, and the degree of perceived problems would be affected by personal experiences, particularly depredation. However, given widespread local antagonism towards Ruaha National Park, particularly from pastoralists (Dickman, 2009), we also hypothesised that socio-economic factors, such as ethnic group and vulnerability, would also affect how problematic people viewed wildlife to be. Our goal was to test these two hypotheses and use the results to help guide future conservation approaches in this globally important landscape. Furthermore, this study can act as a valuable model, by highlighting some of the rarely-considered social factors which may affect attitudes towards wildlife in the many other locations where conflict is a major conservation issue.

2. Materials and methods

2.1. Study area

The study was conducted on village land associated with the Pawaga-Idodi Wildlife Management Area (PI-WMA), a 750 km^2 area adjoining the south-eastern border of Tanzania's Ruaha National Park (RNP) (Fig. 1). This area is part of the Rungwa-Ruaha region, which covers over 45,000 km^2 and encompasses the 20,300 km^2 RNP and its adjacent Game Reserves as well as the PI-WMA and village land, which provides vital dry season habitat for many of RNP's species (Dickman, 2005). All 22 villages close to Ruaha are located in the 750 km^2 area mentioned above, and surveys were conducted in 19 of them to provide a representative sample. Survey households were located from 07°19′S to 07°36′S and from 35°05′E to 35°29′E. The Ruaha landscape is one of outstanding biodiversity and species endemism (WCS, 2005) and is within one of the 'Global 200' ecoregions (Olson and Dinerstein, 1998). It has further ecological significance as the only protected area system representing the transition between the East African *Acacia-Commiphora* zone to the southern African *Brachystegia* or Miombo zone (Williams, 1999). The climate is semi-arid to arid, with approximately 500 mm of rainfall annually, while the vegetation is a mix of East African semi-arid savannah and Zambezian *miombo* woodland (Sosovele and Ngwale, 2002).

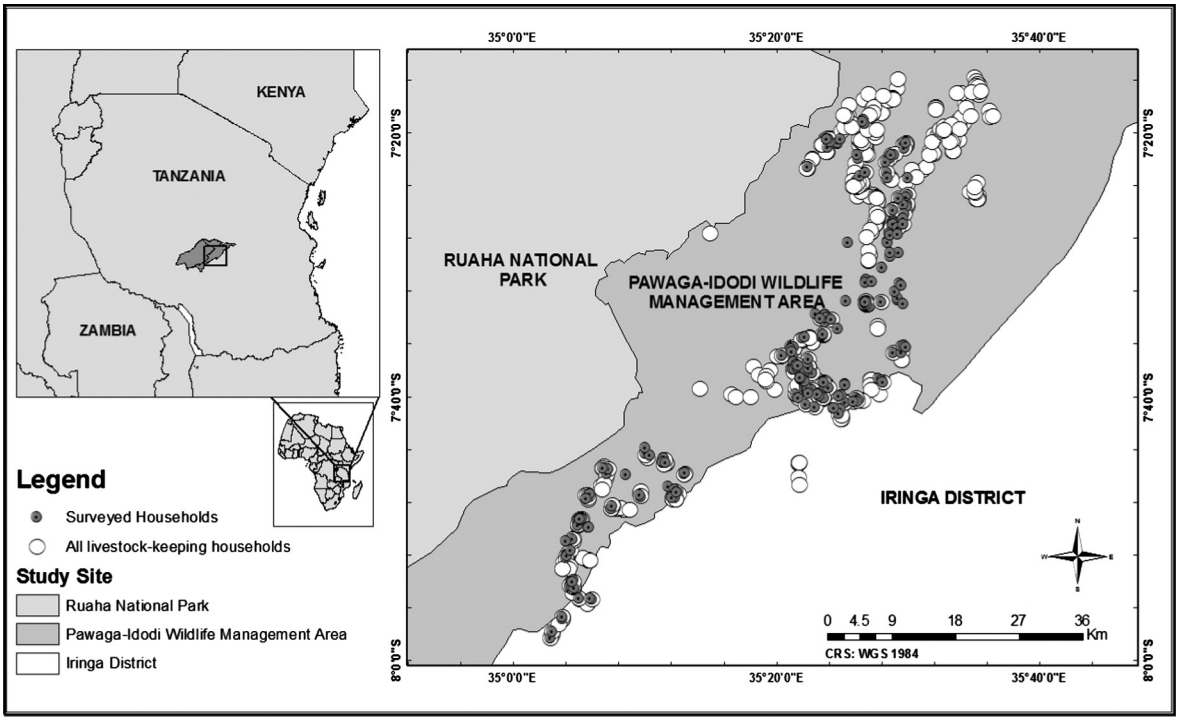

Fig. 1. Map of the study area, showing the surveyed households (n = 262) as dark circles and all livestock-keeping households (n = 516) as white circles.

2.2. Interview methods and survey design

Following Maddox (2002), data were collected using a semi-structured survey (Dickman, 2009), pre-tested on 25 people to ensure clarity before use. The survey assessed peoples' perceptions of wildlife, particularly five large carnivores (lion, leopard, cheetah, African wild dog and spotted hyaena). These species were examined in more detail due to their tendency to cause intense conflict, as well as their conservation concern, although respondents were not informed of this interest in large carnivores. The survey covered five main areas: (i) socio-economic characteristics of respondents, including income sources and livestock transactions over the previous full calendar month; (ii) interviewees' perceptions and knowledge of wildlife; (iii) large carnivore sightings, attacks and population trends; (iv) actions taken to control carnivores; and (v) details of livestock husbandry techniques. This paper reports on results from (i) to (iv). Surveys were administered in person by AD and a Tanzanian assistant, and took approximately 1 h. They were conducted in Swahili – although many pastoralists spoke other languages as their first language, they were all fluent in Swahili, and both the pre-testing and main survey revealed that there were no problems with understanding the survey when conducted in Swahili. The sampling unit was the household, with interviews restricted to one respondent per household. Households were randomly selected for surveying, based upon maps of all households provided by the village councils, with the aim of surveying at least 50% of households from each of the target ethnic groups (two pastoralist groups, the Barabaig and Maasai, and two agro-pastoralist groups, the Hehe and Bena). The most senior household member present was asked to participate – no-one refused, and all interviewees were adults ($\geqslant$18 years old).

Peoples' perceptions of wildlife are likely to be influenced by the threat posed by wildlife, and their vulnerability to the impacts of any wildlife damage (Dickman, 2010). Households are particularly vulnerable to carnivore attacks if they are poor, have no livestock elsewhere, and are purely reliant upon livestock. Therefore, a vulnerability score was calculated for each respondent, allocating a score of 1 for each of the following factors: (i) owning fewer stock than the study mean, (ii) having no stock elsewhere, and (iii) having no cash income or being solely reliant upon livestock for cash income. Respondents were therefore scored on a scale of 0–3, from lowest to highest vulnerability.

To assess knowledge and perceived problems with wildlife, respondents were shown 20 photographs of wildlife species (19 Tanzanian species and a tiger (*Panthera tigris*), included to test respondent reliability). People were asked whether they knew the species shown, and correct identification of Tanzanian species was used as an index of wildlife knowledge. Once people were clear about the species, they were asked whether it occurred within a day's walk of their household, and if so, following Maddox (2002), whether it caused them no problem, a small problem or a big problem. Responses were scored as follows: no problem = 0, small problem = 1 and big problem = 2. This 3-point scale was used to enable later comparisons with results from Maddox (2002) from around Serengeti National Park, as well as those from (Msuha, 2009), who used the same method around Tarangire National Park. What constituted a 'large' or 'small' problem was undefined, in order to allow subsequent analysis of the perceived magnitude and nature of problems caused by large carnivores. Two scores were calculated and used as dependent variables for regression analyses – a perceived problem score for large carnivores (the mean problem score across the focal large carnivores known to occur in the area), and a perceived problem score for 'other wildlife' (the mean problem score across all other species occurring around the household).

2.3. Data analysis

Data were analysed using Statistical Packages for the Social Sciences (SPSS) PC version 18.0 (SPSS Inc., Chicago, USA). Data were tested for normality using the Kolmogorov-Smirnov test, with univariate tests including the Mann Whitney U test, Kruskal-Wallis, and Chi-square. All tests were two-tailed, with significance at $P < 0.05$. For the hierarchical cluster analysis, variables were converted into *z*-scores and a between-groups linkage method was used to determine clusters, based on the minimum squared Euclidean distance. Prior to running regression analyses, diagnostic tests were performed to check for outliers, collinearity, influential observations, and heteroscedasticity (Fox, 1997). Four cases exceeded normal levels and were removed to avoid skewing regression coefficient estimates. Based on *a-priori* hypotheses, the following uncorrelated variables were considered as potential drivers of the perceived problem score for large carnivores: age, religion, distance from RNP, reported attack history (the number of carnivore species they had suffered attacks from), attitudes toward lions, perceived problem score for 'other wildlife', and vulnerability. When the perceived problems score for other wildlife was analysed, religion was replaced with the correlated variable of ethnic group, while 'other wildlife' perceived problem score was replaced with large carnivore perceived problem score; additionally, two variables were excluded as they were not relevant – reported attack history and attitudes toward lions (Table 1). Wildlife knowledge was also considered as a likely predictor of perceived problem scores, but was strongly correlated with ethnic group and distance to RNP, so was not included in the model.

3. Results

3.1. Respondent demographics

262 respondents were interviewed across 19 villages, covering 71.8% of livestock-keeping households from the four target tribes in those villages, and 50.8% of all livestock-keeping households (Fig. 1). Just over half (56.9%) respondents were traditional

Table 1
Variables considered as predictors during the linear regression models for perceived problems with large carnivores and 'other wildlife'.

Predictors	Explanations	Variable type
Ethnic group	Does the respondent belong to a traditional pastoralist ethnic group?	Two categories: 0 = No, 1 = Yes
Religion	Follow a formal religion rather than traditional beliefs?	Two categories: 0 = No, 1 = Yes
Lion Attitude	Does the respondent want lions to decline or disappear?	Two categories: 0 = No, 1 = Yes
Vulnerability score	Score of 1 for each of the following vulnerability factors – (i) owns less livestock than mean, (ii) has no livestock elsewhere, and (iii) is solely reliant upon livestock	Three categories: 1 = Low, 2 = Med, 3 = High (0 was a possible category but was not reported by anyone)
Age	Respondent's age (years)	Continuous: (18–84)
Distance to RNP	Distance to Ruaha National Park (km)	Continuous: (4.3–30)
Attack history	No. of carnivore species reported to have attacked livestock	Three categories: 0 = None, 1 = One species, 2 = More than 1 large carnivore species

pastoralists (40.5% Maasai, 16.4% Barabaig), while 43.2% were agro-pastoralists (23.7% Hehe, and 19.5% Bena). The majority of interviewees (77.1%) were male, and respondent ages ranged from 18 to 84 years old, with a mean of 40. The respondent was head of the household in 61.5% of cases. Survey households were located a mean of 18.5 km from the RNP boundary (range 4.3–30.4 km). Respondents had lived at their current household for a mean of 10.4 years (range 0–61 years).

Data on religious affiliation was collected from 243 respondents – 66.3% were Christian, 2.1% were Muslim, and 31.7% maintained traditional beliefs rather than adhering to a specific religion, with pastoralists significantly more likely to report traditional beliefs than other groups ($\chi^2 = 43.0$, df = 1, $P < 0.001$). Although the question was open-ended, none of the respondents reported mixed religious affiliations. Almost all respondents (97.3%) reported having some form of cash income. Of these, 51.4% had one source of income, 47.8% had two, and 0.8% had three. The most common source of income was livestock – 96.9% of respondents with income generated it this way, followed by growing crops (49.8%). 237 people had one major source of income – for 69.0% it was livestock, for 23.5% it was crops, and for one (0.4%) it was selling alcohol. Only five people (1.9% of all respondents) received any tourism- or wildlife-related income.

3.2. Stock holdings, vulnerability and reported levels and causes of stock loss

All respondents kept livestock, with a mean of 96 head of stock per household (range 2–526) and 25,129 livestock owned across all respondents. Households owned a mean of 44 cattle (range 0–300), 50 smallstock (range 0–437) and one donkey (range 0–17) at the start of the month prior to the survey. In addition, people had a mean of 2 dogs (range 0–12), with a mean of 39 head of stock per dog (range 1–175). Livestock holdings were not equally distributed across households – 6.1% of households ($n = 16$) owned over a quarter (26.2%) of all stock, while 18.3% of households ($n = 46$) owned over half (50.4%) the stock. Respondents' vulnerability scores ranged from 1 to 3 (on a possible scale of 0–3), with a mean across all households of 2.07 ($s = 0.74$).

The survey timings meant that monthly stock loss data represented all months apart from September, October and November, and included data from both the dry and rainy seasons. However, it should be noted that each respondent was only asked about the previous month's loss, so this restricted period limits how well the data could be extrapolated to annual or longer-term patterns of loss. There was a high rate of stock turnover, with respondents reporting that they had used (i.e. sold, slaughtered or given away) a mean of 13.4% of their livestock during the preceding month, and had lost a further 13.9% to theft, depredation, disease and other causes (Table 2). Stock loss was a major issue – on average, respondents reported losing 1.2 head of stock for every one used (Table 2). However, the ratio of loss to use varied according to livestock type – cattle were the only stock type where more animals were typically used rather than lost, while loss exceeded use for smallstock, donkeys, and overall livestock. Disease was the greatest cause of loss, reportedly killing a mean of 9.1% of the herd over the month, followed by theft (2.8%). Overall, depredation was a relatively minor cause of loss, with 1.2% of the herd reportedly lost to predators during the month. However, a few respondents (4.2%) reported losing over 10% of their stock to depredation, with the maximum reported loss 21.4%. Other causes, such as starvation, accidents and death during parturition, together accounted for 0.73% of the herd. When villagers were questioned about causes of loss according to livestock type, disease reportedly accounted for the highest percentage of cattle and smallstock loss, but predation was the major cause of donkey loss (Table 2).

Table 2
One-month recall data for the magnitude and reasons for stock loss and use for the full month preceding the survey.

		Cattle				Smallstock				Donkeys				Overall			
		Number		% of herd size		Number		% of herd size		Number		% of herd size		Number		% of herd size	
		x	S	x	s	x	s	x	S	x	S	x	s	x	s	x	s
Stock uses	Sold	3.26	5.22	9.16	17.00	4.97	6.66	11.62	17.91	0.06	0.37	2.82	16.67	7.52	10.03	9.65	14.43
	Slaughtered	0.23	0.88	0.83	5.57	1.72	2.88	4.42	8.13	0.00	0.00	0.00	0.00	1.78	3.12	2.45	4.75
	Given away	0.48	2.06	1.03	4.91	0.55	1.53	1.39	4.01	0.08	0.50	3.46	24.03	0.97	2.73	1.28	4.12
All stock uses		**3.97**	**6.35**	**11.00**	**19.79**	**7.27**	**9.26**	**17.42**	**24.68**	**0.17**	**0.67**	**7.43**	**31.34**	**10.27**	**13.25**	**13.37**	**18.73**
Stock losses	Stolen	0.89	4.78	2.33	19.78	1.44	4.07	3.70	12.81	0.04	0.26	3.02	23.78	2.14	7.35	2.84	14.05
	Killed by predators	0.26	1.10	0.33	1.37	1.07	3.03	2.19	6.80	0.12	0.47	2.39	9.41	1.24	3.52	1.25	3.45
	Died from disease	1.36	3.54	3.06	7.80	7.95	19.09	13.29	24.78	0.06	0.28	1.29	6.85	8.56	18.96	9.07	17.16
	Died from other causes	0.29	1.35	0.74	2.68	0.36	1.85	0.91	4.14	0.03	0.17	0.44	2.59	0.58	2.17	0.73	2.21
All stock losses		**2.80**	**7.44**	**6.45**	**22.43**	**10.82**	**21.28**	**20.09**	**30.76**	**0.27**	**0.63**	**8.03**	**28.00**	**12.52**	**22.97**	**13.89**	**23.95**
Ratio stock loss: use		**0.71**	–	**0.59**	–	**1.49**	–	**1.15**	–	**1.59**	–	**1.08**	–	**1.22**	–	**1.04**	–

Bold values show overall loss and use, regardless of cause.

Table 3
Respondents' knowledge of local species, their perceptions of problems, and reasons for considering each species problematic.

Species	% Respondents correctly identifying species	% Respondents saying species occurs around their household	% Respondents living alongside species who say it is a problem	% Respondents living alongside species who say it is a big problem	% Reasons given for considering species problematic			
					Threat to stock	Threat to crops	Threat to humans	Disease risk
Spotted hyaena	72.8	90.4	92.0	77.9	94.5	0	5.5	0
Lion	97.0	81.6	87.8	74.2	81.6	0	18.4	0
Cheetah	24.3	55.6	82.4	57.6	96.3	0	3.7	0
Leopard	88.6	77.2	81.1	59.7	94	0	6.0	0
African wild dog	69.3	70.1	80.7	56.1	98.6	0	1.4	0
Snake	90.6	84.7	78.2	45.5	75.1	0	24.9	0
Jackal	48.0	87.9	76.2	45.2	100	0	0	0
Crocodile	96.0	48.4	75.6	43.9	47.1	0	52.9	0
Elephant	99.0	63.0	68.5	52.7	0	82.8	16.4	0.9
Serval	7.9	61.9	66.3	27.9	100	0	0	0
Hippo	87.6	51.2	62.5	43.0	0	77.6	22.4	0
Warthog	71.8	81.2	53.1	34.0	0	100	0	0
Buffalo	90.1	46.9	35.0	11.7	2.2	26.7	68.9	2.2
Zebra	98.5	48.8	0.8	0	0	100	0	0
Impala	92.6	86.9	0.4	0	0	100	0	0
Giraffe	97.5	59.3	0	0	0	0	0	0

3.3. Wildlife knowledge

No respondents claimed to know the tiger, while respondents correctly identified between 3 and 16 of the Tanzanian species shown (mean 11.8). Species were more likely to be recognised if they were large-bodied ($U = 67.0$, $P = 0.035$) and group-living ($U = 72.0$, $P = 0.021$). There was slightly higher recognition of species which pose a danger to humans ($U = 68.0$, $P = 0.048$). Being nocturnal did not affect species recognition ($U = 54.0$, $P = 0.409$). The most well-known species was the elephant, with 99% of people correctly identifying it, while the least-recognised was the serval (*Felis serval*), with 7.9% of people correctly identifying it (Table 3). Amongst large carnivores, the cheetah was the least well-known, with less than a quarter of people (24.3%, $n = 49$) people correctly identifying it – of those who were confused, 90% initially thought it was a leopard. Men exhibited significantly higher wildlife knowledge (identifying a mean of 12 species correctly) than women, who recognised a mean of 10 species ($z = -5.36$, $P < 0.001$). Pastoralists had higher wildlife knowledge than other respondents ($z = 3.54$, $P < 0.001$), as did people who lived closer to RNP ($r_s = -0.15$, $P = 0.031$).

3.4. Perceived problems with wildlife

Respondents reported a mean of 10 local survey species occurring around their households (range 1–16), with reported species occurrence declining with distance from RNP ($r_s = -0.231$, $n = 261$, $P < 0.001$). Nearly everyone (98.5%, $n = 258$) reported having a problem with at least one local wildlife species, with 89.3% ($n = 234$) reporting a big problem with at least one species. Respondents viewed a mean of 60% (range 0–100%) of survey species around their household as problematic, while 40.3% (range 0–100%) reportedly caused big problems. The reasons for viewing species as problematic are shown in Table 3.

The mean perceived problem score for all species across all respondents was 1.0 ($s = 0.42$), with significant variation between species (KW $\chi^2 = 1031$, df = 15, $P < 0.001$; Table 4). Large carnivores comprised the five top-ranking species (mean score = 1.5), with spotted hyaena the highest, and giraffe (*Giraffa camelopardalis*) the lowest. However, when people were asked to choose the single most problematic species, lions were most commonly cited (42.9% of people), while spotted hyaenas came second (25.6%) – all other species were chosen by under 6% of respondents. The reason for lions being chosen above spotted hyaenas was because they reportedly posed a particular threat to cattle (which have high economic and cultural value), whereas spotted hyaenas were perceived as more of a threat to less-valued smallstock. Interestingly, people with greater wildlife knowledge tended to report higher perceived problems with wildlife ($r_s = 0.26$, $P < 0.0001$).

Table 4
Perceived problem scores for each of the 16 local survey species.

Species	n	Perceived problem scores			
		Minimum	Maximum	Mean	Std. deviation
Giraffe	153	0	0	.00	.000
Impala	225	0	1	.00	.067
Zebra	127	0	1	.01	.089
Buffalo	120	0	2	.47	.697
Warthog	194	0	2	.87	.893
Serval	104	0	2	.94	.786
Hippo	128	0	2	1.05	.899
Crocodile	123	0	2	1.20	.806
Elephant	165	0	2	1.21	.896
Jackal	210	0	2	1.21	.805
Snake	211	0	2	1.24	.787
African wild dog	171	0	2	1.37	.789
Cheetah	125	0	2	1.40	.773
Leopard	196	0	2	1.41	.789
Lion	213	0	2	1.62	.694
Spotted hyaena	226	0	2	1.70	.609

Hierarchical cluster analysis revealed four main clusters of species in terms of degree of perceived problems (Fig. 2). These were (1) species which caused very little or no conflict; (2) species which posed a high threat to crops and/or humans; (3) species which posed a small or medium threat to crops or smallstock; and (4) species which posed a high threat to livestock and/or humans; Fig. 2).

3.5. Perceived problems with large carnivores

Respondents reported a mean of 3.6 large carnivore species around their household (range 0–5). Unlike wildlife in general, there was no statistically significant decline in large carnivore occurrence with distance from RNP ($r_s = -0.11$, $n = 261$, $P = 0.065$). On average, 3.2 (84%) of local large carnivore species were deemed to pose a problem (range 0 -5 species, 0–100%), while 2.5 (62.9%) were considered a big problem (range 0 -5 species, 0–100%). Despite the relatively low reported rate of depredation, nearly all respondents living alongside large carnivores (94.0%,

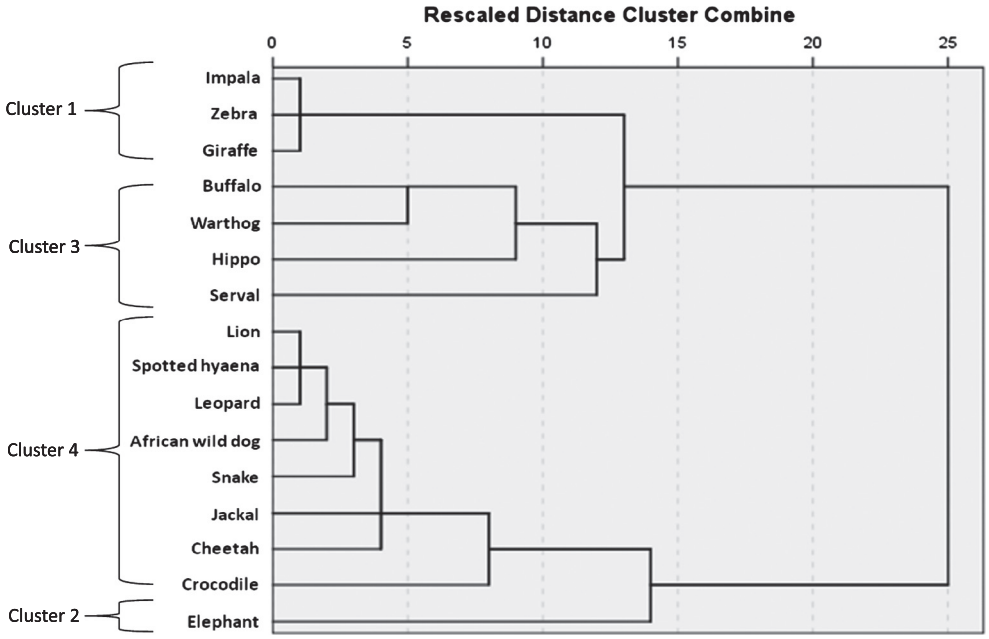

Fig. 2. Clusters of species according to their perceived problem scores.

$n = 233$) reported a problem with at least one species, and 89.3% ($n = 234$) reported a big problem with at least one. Two-thirds of respondents (69%, $n = 171$) viewed all local large carnivores as a problem, while over a third (36.3%, $n = 90$) viewed them all as a big problem.

Large carnivores had significantly higher perceived problem scores than other species ($z = 21.0$, $P < 0.001$), with a mean score of 1.47 ($s = 0.58$) compared to 0.76 ($s = 0.44$) for other species. As with other wildlife species, higher perceived problem scores were linked to greater wildlife knowledge ($r_s = 0.30$, $P < 0.001$). There was significant variation in perceived problem scores between large carnivore species (KW $\chi^2 = 35.2$, df = 4, $P < 0.001$, Table 4), with higher perceived problems reported with lions and leopards. Perceived problem scores were highly correlated across all five species – if someone viewed one large carnivore as problematic, they were likely to view the others in the same way. Amongst respondents living alongside more than one species of large carnivore, 44% ($n = 100$) gave all species the same problem score. These respondents appeared to base their scoring on the more problematic species, as they gave carnivores significantly higher mean scores than other respondents ($U = 10399$, $P < 0.001$) despite suffering no greater depredation ($U = 3594$, $P = 0.250$).

Respondents were asked what they thought had happened to large carnivores in their area since they had arrived (a mean of 13.2 years amongst those who estimated changes in populations). For the big cats, around three-quarters of people thought they had declined (76.4% said this for cheetah, 74.5% for leopard and 70.2% for lion), but this figure was slightly higher for African wild dogs (84.1%) and lower for spotted hyaenas (57.0%). Regarding desired future trends, most people wanted large carnivores to decrease or disappear – 64% of respondents said this for spotted hyaenas, 57.2% for lion, 56.6% for African wild dog, 55.7% for cheetah and 52.1% for leopard. For 73% of respondents ($n = 184$) what they wanted to happen for one carnivore species, they also wanted for the others, and despite significant variation in perceived problem scores, there was no significant difference between large carnivore species in terms of how many people wanted them to decrease ($\chi^2 = 2.50$, df = 4, $P = 0.644$) or disappear ($\chi^2 = 3.88$, df = 4, $P = 0.423$).

3.6. Direct experience with large carnivores

Most respondents (79.8%, $n = 209$) reported having personally seen one of the large carnivores – the most commonly observed species was the spotted hyaena, seen by 60.3% of people ($n = 158$), followed by lion (53.8%, $n = 141$), African wild dog (38.9%, $n = 102$), leopard (37.0%, $n = 97$) and then cheetah (23.3%, $n = 61$). On average, respondents had seen two large carnivore species (range 0–5) with a mean time since the last sighting of 2.0 years (range 1–27 years). Overall, 61.6% ($n = 344$) of carnivore sightings were negative (i.e. involved the carnivore directly threatening livestock or humans) rather than neutral (no direct threat perceived), and 62.2% of people ($n = 163$) reported having experienced a negative sighting of at least one large carnivore. The likelihood of experiencing a negative sighting varied significantly by species ($\chi^2 = 23.3$, df = 4, $P < 0.001$) – 74.5% of spotted hyaena sightings were negative, compared to 62.1% for lion, 60.3% for cheetah, 58.3% for leopard, and 45.1% for African wild dogs – the only species where more sightings were classed as neutral than negative.

Nearly two-thirds of the respondents (61.1%, $n = 160$) had, at some point, reportedly experienced livestock depredation by large carnivores. Amongst these, 36% had suffered attack by one species, 27% by two, 19% by three, 13% by four, and 6% by all five. Mean time since last attack was 2.9 years (range 0–27 years). The most common species to have attacked stock was the spotted hyaena, with 42.4% ($n = 111$) of respondents reporting attacks. The next most common was the lion, with 36.6% ($n = 96$) of people reporting depredation, followed by leopard (24%, $n = 63$), African wild dog (19.1%, $n = 50$) and finally cheetah (16.4%, $n = 43$).

Human attacks by large carnivores were reported from 11 households (4.2%), resulting in 5 people killed and 15 injured. Mean time since attack was 8.2 years (range 1–27 years). Lions caused most human attacks (64%, $n = 7$), followed by spotted hyaenas (27%, $n = 3$) and then leopards (9%, $n = 1$). In nearly half the cases (46%, $n = 5$), the victim was killed, and in the remainder they were injured – all fatal cases were lion attacks, with 72% of lion attacks ($n = 5$) resulting in fatalities. The majority of attacks on humans (64%, $n = 7$) occurred at night, and 82% occurred out in

Table 5
Parameter estimates of variables in linear regression models used to predict respondents' perceived problems with (a) large carnivores and (b) other wildlife.

	Unstandardized coefficients		Standardized coefficients	*t*	Sig.
	B	Std. error	Beta		
Large carnivore perceived problem model					
(Constant)	1.155	0.188		6.149	0.000
Perceived problem score for 'other wildlife'	0.464	0.08	0.346	5.779	**0.000**
Attack history	0.173	0.039	0.271	4.457	**0.000**
Religion	0.239	0.075	0.199	3.195	**0.002**
Lion Attitude	0.142	0.067	0.127	2.117	**0.035**
Distance RNP	−0.01	0.005	−0.125	−2.006	**0.046**
Vulnerability score	−0.072	0.048	−0.09	−1.493	0.137
Age	−0.002	0.002	−0.052	−0.882	0.379
Model Fit: All predictors ($r^2 = 0.279$, $F = 11.37$, $P \leqslant 0.0001$)					
'Other wildlife' perceived problem model					
(Constant)	−0.045	0.151		−0.299	0.765
Perceived problem score for large carnivores	0.242	0.045	0.33	5.405	**0.000**
Ethnic group	0.148	0.053	0.177	2.771	**0.006**
Distance RNP	0.011	0.004	0.173	2.83	**0.005**
Age	0.002	0.002	0.082	1.358	0.176
Vulnerability score	0.027	0.036	0.046	0.768	0.443
Model Fit: All predictors ($r^2 = 0.177$, $F = 10.12$, $P \leqslant 0.0001$)					

Bold values indicate significant predictors.

the bush, although one (9%) occurred in the livestock enclosure and one (9%) took place when a hyaena entered a house. The lion and leopard attacks all involved a single victim, but all hyaena attacks involved multiple victims – in one case 2 people, another 3 and in another 7 (when the hyaena entered the house). Victims were sleeping (46%, $n = 5$), guarding livestock (36%, $n = 4$), guarding crops (9%, $n = 1$) or chasing off predators (9%, $n = 1$). Attacks did not show a clear seasonal pattern, with 55% occurring in the rainy season and 45% in the dry season. The attacks involved adult victims in 46% ($n = 5$) of cases, children in 36% ($n = 4$), and both adults and children in the remaining 18% ($n = 2$). The majority of incidents (82%, $n = 9$) involved male victims.

Despite the conflict, very few people (7.3%, $n = 19$) openly admitted to ever having killed a large carnivore – this could well have been biased by respondents feeling unable to be open about carnivore killings, especially given the fact that one of the surveyors was an expatriate. The 19 respondents who did admit to such killings reported 27 carnivore-killing incidents, resulting in 33 carnivores killed (13 spotted hyaenas, 12 lions, 5 African wild dogs and 3 leopards).

3.7. Key determinants of perceived problems with large carnivores and other wildlife

Linear regression, combining eight non-collinear predictors, revealed the strongest predictor of people's perceived problem with large carnivores was the intensity of perceived problems with other wildlife (Table 5). The next most important factor was reported attack history, with people who had experienced depredation by more than one carnivore species reporting particularly intense problems. Religion emerged as another significant predictor, with adherence to formal religions rather than traditional beliefs associated with higher perceived problems with carnivores. This was particularly interesting given that religious respondents lost significantly fewer livestock to depredation than other respondents ($U = 2802$, $P = 0.006$). Wanting lions to decline or disappear, and living close to RNP, were both predictors of greater perceived problems with large carnivores. Respondent age and vulnerability were not significant predictors.

When examining perceived problems with other species, the strongest predictor was intensity of perceived problems with large carnivores, even when combined with four other predictors (Table 5). Ethnic group was another significant factor, with people from traditionally pastoralist groups reporting higher problem scores both for large carnivores ($U = 9760$, $P \leqslant 0.0001$) and other wildlife ($U = 9923$, $P = 0.013$). Distance to the Park was also significant, but, contrary to what was found with large carnivores, perceived problems with other species actually increased with distance from RNP. Respondents' age and vulnerability did not contribute significantly to predicting problem scores.

4. Discussion

This study revealed a widespread perception that wildlife caused problems on village land in the Ruaha landscape, with nearly everyone reporting some kind of problem. The main reason given for perceiving a problem was the direct threat posed by wildlife to humans or their assets. Large carnivores were viewed as particularly problematic, due to the perceived risk to livestock and humans, with lions viewed as the single most problematic species due to their predation upon culturally and economically valuable cattle. Most respondents wanted large carnivores to decline or disappear, which is unsurprising as people in these communities rely heavily upon livestock for wealth and status. Although this result is to be expected, it is concerning given the importance of the Ruaha area for these species, and especially because anecdotal evidence here suggests that large carnivore populations have already declined over the past decade. This is particularly worrying in the case of endangered African wild dogs, as nearly 85% of people reported a decline in their populations locally, with a strong desire for them to decrease further or disappear.

Although issues such as livestock depredation and attacks upon humans emerged as key reasons for people perceiving large carnivores as problematic, there was little evidence for significant damage. Human attacks were very rare, but nevertheless, such incidents obviously result in severe animosity and widespread fear (Knight, 2000). Reducing human attacks further could potentially improve attitudes, but the impact may be low as stories of attacks tend to be widely recounted for many years, leading to a 'hyper-awareness' of risk (Dickman, 2010). Depredation (based on monthly recall figures) reportedly accounted for less than 1.3% of herd size – far less than losses to other causes such as disease or

even theft, similar to what has been found elsewhere (Mazzolli et al., 2002). However, experience of depredation was widespread, and even a few losses can have significant impacts on poor households (Jackson et al., 2010; Yirga and Bauer, 2010). Furthermore, the small but potential risk of devastating depredation (as seen with the few people who lost over 10% of their herd) is likely to be enough to drive the perception that carnivores are a major problem. Having experienced depredation – especially by more than one large carnivore species – was, unsurprisingly, a significant predictor of perceiving a problem, so reducing carnivore attacks should undoubtedly be a key element of conflict resolution.

However, the situation is complex and has multiple components. Interestingly, perceived problems with wildlife in general and carnivores in particular were strong predictors of one another, suggesting a 'contagious' element of conflict. An initial explanation that the same people, probably living in a wildlife-rich area, may experience more problems with multiple species, was not supported by this study. Carnivores were perceived as more problematic amongst people living close to the Park, while other wildlife was viewed as more problematic amongst people living further from it. However, people may share common experiences which increase perceptions of problems with all wildlife, such as perceived disempowerment regarding wildlife use, poor relationships with the Park, and a lack of benefits from wildlife – this is certainly conceivable here, as less than 2% of all respondents received any wildlife-related income. Furthermore, people are often influenced by other peoples' views – instead of being individualistic, attitudes (particularly about emotionally-charged issues) are often based upon a shared, socially constructed model (Degoey, 2000). Therefore, someone else's problems with carnivores or other species might heighten a respondent's antagonism, even towards species that they have not directly experienced problems with. Alternatively, directly experiencing problems with one group of species (e.g. crop loss from herbivores) could increase someone's vulnerability towards the impacts of any further wildlife damage, reducing their tolerance and increasing their antagonism towards even relatively small amounts of damage.

Regardless of the exact mechanism, the finding that negative perceptions of one group of species were strongly associated with negative perceptions of other species deserves further investigation. 'Contagious' conflict has been explored in other disciplines, such as warfare, rebellion and justice (Danneman and Ritter, 2014; De Maio, 2010; Degoey, 2000; Fox, 2004), but its occurrence and mechanisms have not yet been investigated in human-wildlife conflict. A contagious element of conflict raises important issues for management. For example, it is possible that dealing with one issue – such as reducing depredation – could help improve attitudes towards wildlife in general, but conversely, reducing attacks may not significantly improve views towards carnivores unless conflict with other wildlife is also lessened. In such circumstances, conflict mitigation should ideally not be taxon-specific, but should consider how views towards wildlife in general can be improved. Moreover, there appeared to be some degree of contagion even within a taxon: conflict scores across carnivores were highly correlated, with people who assigned them all the same score tending to view them as more problematic than others, suggesting they were biased by the more problematic species. Therefore, if a problem caused by one species reduces tolerance for another species, then species which do not cause much damage may benefit from improving attitudes towards other, more problematic species. Improving knowledge might also reduce this contagious effect, because if people struggle to differentiate between carnivore species, a species which has never caused problems could be viewed as problematic purely due to confusion with another species – this certainly seems likely for the cheetah, which was confused with the more problematic leopard by 90% of respondents.

However, as has been found elsewhere (Kansky et al., 2014), perceptions of problems were certainly not only about wildlife damage – cultural factors such as religious beliefs and ethnicity were also important. It was interesting that adherence to a formal religion was linked to higher reported problems with carnivores, as a similar pattern has been documented in Kenya, with religious (especially evangelical) Maasai more likely to kill lions (Hazzah et al., 2009). This influence of organised religion is not restricted to Africa: in the US, the rise of conservative (often evangelical) Christian groups has been linked to reduced environmental protection (Barlow, 1996), while in Japan, Shinto and Buddhist beliefs often lead to somewhat contradictory views - killing animals is discouraged, but death and destruction are seen as inevitable, so people often do not prevent killings, and instead appease the animal's spirits through rites and prayers (Knight, 2007). Without long-term data, it is unclear whether religious conversion itself in this study somehow heightens perceptions of problems, or whether religious people just happened to be those who experienced greater problems. However, people who convert to external religions may often be those who are marginal and lack power within their society (Platteau, 2010), and such people are also likely to be vulnerable to wildlife damage and unlikely to receive any local benefits. It is uncertain if that is the mechanism here, but this relationship between conflict and religion is worthy of future study, particularly as religious conversion is a cause of huge social change in Tanzania and elsewhere (Fischer, 2011).

Religious affiliation was linked to ethnic group, and this latter variable proved a strong predictor of perceived problems with 'other wildlife', with people from traditional pastoralist groups reporting significantly more problems than others. Given the strong cultural and emotional links that pastoralists have with their cattle (Galaty, 1982), pastoralists would be expected to view carnivores as particularly problematic, but it was interesting that the same pattern also emerged for other species. However, pastoralists are often disempowered and marginalised, struggling to maintain their lifestyles amidst growing pressure on their land from expanding farmlands and protected areas, so they may feel particularly antagonistic towards what may be perceived as the 'Government's' wildlife causing them problems. Engaging pastoralists, and making them central to wildlife conservation discussions and actions, is likely to be an important step in improving attitudes towards wildlife in this area.

Despite the majority of people reporting problems with carnivores, there was very little reported carnivore killing, which is unsurprising as killing carnivores without clear evidence of a threat (or using means such as poison) is illegal and therefore unlikely to be reported (St John et al., 2011). Furthermore, the presence of outsiders, such as an expatriate at the survey, may have contributed to people being less open about the real levels of killing, due to the fear of possible consequences. Although it is conceivable that carnivore killing is indeed low despite peoples' negative perceptions, because there is considerable debate about the extent to which attitudes actually predict behaviour (St John et al., 2011), several recent studies have demonstrated that negative attitudes towards carnivores do predict carnivore killing (Hazzah et al., submitted for publication; St John et al., 2011). Therefore, the results presented here, showing that carnivores are viewed as problematic and that people want them to decline, is a cause for concern. Furthermore, there is anecdotal evidence of high rates of killing – particularly of lions – on village land around Ruaha, so there is a pressing need to build trust and develop a better understanding of the drivers of conflict and whether it poses a significant conservation threat in this landscape. If it does, then effective mitigation strategies should be developed – based upon this study, those should include reducing livestock depredation, engaging pastoralist groups, examining the role of religion and possibly

working with religious leaders, providing relevant benefits from wildlife presence, and reducing problems with other species as well as with large carnivores. In addition, improving livestock husbandry and veterinary care should be considered, as this would reduce losses to disease, improve household economic security and potentially reduce antagonism towards any remaining depredation incidents. Overall, this study highlights the fact that conflict is rarely a single-taxon, single-issue problem, that only multi-faceted, interdisciplinary approaches which consider social and cultural drivers as well as wildlife damage, are likely to result in effective mitigation.

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