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## **A culture of tolerance: large carnivore coexistence in the Kafa highlands, Ethiopia**

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A culture of tolerance: large carnivore coexistence in the Kafa highlands, Ethiopia

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We assessed livestock loss to lions *Panthera leo* and leopards *P. pardus* in the Adiyo and Gimbo districts in Kafa Biosphere Reserve (KBR), Ethiopia. We quantified its economic impact, conducted household and group interviews and explored potential solutions with local people. A total of 350 lion and 62 leopard attacks occurred in the five year period of 2009 to 2013. Households that suffered livestock attacks lost an average of \$287 and \$310 in 2012 and 2013, respectively. Although lion attacks are more frequent than leopard attacks, our qualitative data show that tolerance for the former is higher because lions are culturally more respected. We describe how depredation is culturally mitigated and how retaliatory killing is avoided. This remarkable tolerance may suggest that these carnivores may persist in their highland refugium, opening an arena for conservation that is not strictly linked to protected areas or to classic economics.

## Introduction

Wildlife is in crisis globally, mainly due to growth of human population and consumption (Baillie JEM, 2010). Carnivores are particularly affected due to their spatial and dietary requirements, leading to low density and high conflict (Ripple et al., 2014). Carnivores appear to be recovering in developed countries (Chapron et al., 2014), but in Africa carnivore populations are largely declining (Woodroffe & Sillero-Zubiri, 2012; Bauer et al., 2015a). Where carnivores and people coexist, competition for resources is likely to lead to conflict, whereby carnivore attacks on humans or livestock often motivate retaliatory or indiscriminate killing (Hazzah et al., 2014). Whether that motivation leads to action depends on various factors, tolerance is an important factor. Tolerance has been defined by some as an attitude (Manfredo & Dayer, 2004; Treves, 2012) but many scholars define it as a behaviour (Bruskotter & Fulton, 2012, Bruskotter et al., 2015). We adopt the later definition of tolerance as behaviour because tolerating carnivore attacks is a behavioural result of an individual's attitude given that the individual has the opportunity to act in a certain way (Manfredo et al., 2003; Ajzen & Fishbein, 2005).

Conflicts are the result of complex social and ecological interactions that vary in space and over time (Treves et al., 2006; Ale et al., 2007; Dickman et al., 2011; Schuette et al., 2013). The outcome of conflict is determined by perceptions, norms, attitudes and intentions (Marchini & Macdonald, 2012), but most literature focuses on costs and benefits for local people (Dickman et al., 2011). Literature from southern Africa generally suggests that depredation and retaliation are directly related, by inferring that people kill carnivores to maximize livestock-related profits (Marker et al., 2003; Hemson et al., 2009). In South Africa there is low tolerance for depredation and reserves with lions are fenced (Packer et al., 2013). Retaliatory killing is explained by rational choice theorists taking humans are self-centred beings focused on maximizing their immediate outcomes (Ostrom, 1998). Literature from East Africa partially follows this paradigm, but other work describes how people and wildlife are integrated in landscapes and determinants of coexistence are not only economic but also cultural (Romañach et al., 2007; Hazzah et al., 2009; Goldman et al., 2010; Hazzah et al. 2014; Blackburn et al., 2016). As a result, retaliatory killing only occurs if depredation exceeds tolerance, whereby tolerance is culturally determined and may vary in space and over time. In that context, carnivore conservation hinges on mitigation to reduce losses or compensation to buy tolerance for losses, or both (Kissui, 2008; Ogada et al., 2003; Dickman et al., 2011; Lichtenfeld et al., 2014; Bauer et al., 2015b).

In West, Central and the Horn of Africa the significance of livestock goes far beyond its economic productivity and contributes to human careers within their cultural community (Moritz, 2013). Sogbohossou et al. (2011) and Tumenta et al. (2013) give examples of the economic approach to conflict management in Benin and Cameroon, respectively. However, in a review Bauer et al. (2010) add that the most common mitigation measure universally practiced throughout West and Central Africa is the use of

magic, a combination of traditional cultural and religious practices, e.g. incantations by a professional ‘marabout’, the use of amulets or the practice of voodoo. In Ethiopia, research showed that spotted hyaenas (*Crocuta crocuta*) depend on church forests for daytime cover and adapt their diet during Christian fasting periods, adding a religious dimension to the economic and cultural aspects of coexistence (Yirga et al., 2012). Yirga et al. (2013; 2014) also reported high tolerance and close coexistence, and Baynes-Rock (2015) described how spotted hyaenas in the eastern Ethiopian town of Harar have even become part of the community. However, little is known about lions in Ethiopia (Gebresenbet et al., 2009).

We investigated conflict with large carnivores, especially lions and leopards, in the moist montane forest ecosystem of Kafa Biosphere Reserve (KBR), in the southwest of Ethiopia. The habitat occupied by lions within KBR is very unusual; anecdotal information suggests that they were extirpated from the savannas at lower altitudes and the montane coffee and bamboo forests at around 3,000m asl in the margins of their former distribution have now become their core refugium (NABU, 2016). Considerable local and international interest in the conservation of this particular biosphere has led to the creation of a ‘lion fund’ that aims to promote coexistence and address depredation.

We studied conflicts with lions and leopards in two districts using both quantitative (household survey) and qualitative approaches (Focus Group Discussion (FGD)) (Krueger & Casey, 2000; Williams, 2003; Krosnick & Presser, 2010). Incorporating the FGD helped to include the voices of different social groups (mainly females and the youth), which otherwise might not have been captured. A case study of a particular depredation incident added further insight into local coping mechanisms that would not have been uncovered through quantitative research. Our objective was to assess the economic impact of predation on livestock and to understand local perceptions and attitudes to large carnivores. We analysed the results in the context of local cultural and religious practice and used qualitative information to explain why depredation does not lead to retaliatory killings, and to explore elements of culture and religion that influence the complex relationship between predation on livestock, attitudes and behaviour.

## Methods

### Study area

The KBR was established in 2010, covering an area of 7,500 km<sup>2</sup> out of which 47% is forest (Dresen, 2011), with an altitude ranging from 400 to 3100m asl (Pratihast et al., 2014). The reserve harbours moist montane forest habitats, with trees of wild coffee *Coffea arabica* that are naturally part of the ecosystem, and wetland and aquatic habitats. The abundance of coffee trees makes the area economically important both locally and nationally. KBR is recognized by UNESCO and is protected under regional bylaws, but it is not gazetted as a protected area at federal level. Although it hosts about 21% of the country’s rich mammalian diversity and is an important conservation area, it is also threatened by habitat destruction

(Berhan, 2008; IBC, 2009). The forest cover is high but the density of prey is low. Wildlife includes large carnivores like leopards and lions, but it is unclear if they are resident throughout the year and how far they range eastward. The size of the forest has declined notably as a result of human encroachment (Berhan, 2008). From the seven districts in KBR, lions are now regularly observed only in two (Gimbo and Adiyo) and these were selected as the study area (Figure 1). Adiyo is a highland district but Gimbo has highland and lowland; average altitude is 1747 m asl but lions are primarily found at around 2700 m asl.

#### Data collection and analysis

Ethical clearance was obtained from the Human Subjects Research Institutional Review Board of Oklahoma State University. Local research permits were acquired from the Kafa Zone Regional Administration office, and the district and sub-district level administration offices. The Zone and the two districts provided formal letters of introduction. All participants were given a printed descriptive summary of the research (if participants were illiterate the document was read to them). Prior informed consent was obtained orally from all participants. Data was collected from February to April 2014 using household survey with semi-structured questionnaires (quantitative) and FGD (qualitative) approaches. The quantitative survey data provided an estimate for economic impacts of depredation, while the qualitative data from the FGD helped in understanding local attitudes towards lions and leopards. In general; data collection focused on attitudes of local people towards lions and leopards, tolerance for/towards livestock losses, retaliatory actions, conflict mitigation techniques, changes in conflict intensity, and cultural connotation of livestock depredations. Attitude was defined as how a person evaluates a certain object or entity while behaviour is the action performed by the person on that entity (Ajzen & Fishbein, 1977). The household survey was conducted in seven different sub-districts (or *kebeles*; the lowest administrative level in Ethiopia) where 30 household heads were randomly selected from the list of households provided by each sub-district administration office. When a household head was not present, the household head of the right-side neighbour was surveyed instead. We did a total of 210 questionnaires; each took about one hour. The questionnaire was organized into two parts. The first part had 36 open and closed questions, while the second part had 36 statements where feedback was scored on a Likert scale (Albaum, 1997) from 1 to 5 (strongly agree to strongly disagree, respectively). The survey questions assessed five different issues: demographics, general knowledge about lions and leopards, conflicts, attitudes, and behaviours. Questions that assessed demographics were used to distinguish respondents into different social and economic groups. Information collected using these questions included gender of respondents, educational level, occupation, and number of livestock owned. The second set of questions in the questionnaire assessed the general knowledge of respondents about the carnivores. These questions were about the population status of the carnivores in KBR, their diet,

frequency of visual contact with carnivores, knowledge on legal protection for the conservation of the carnivores, and information on hunting of the carnivores in KBR. The third group of questions gathered information on human-carnivore conflicts by asking questions about attacks on humans and livestock, grazing distance, presumed reason of depredation by the carnivores and retaliatory killings. Questions that measured attitude assessed how the respondents feel about the carnivores, how they felt if they had encountered a lion or a leopard, if respondents want the carnivores to be extirpated from their communities, how they feel about compensation payments, if respondents think they have moral obligation to conserve lions and leopards for future generations, and how respondents think about cultural practice in the Kafa context to conserve lions and leopards. The last set of questions assessed the behaviour of respondents by asking about: the behavioural intentions of respondents if their livestock is killed, what their likely behavioural intentions would be for future attacks, depredation preventive techniques, and if respondents respect regulations about conserving carnivores. Before preparing the final version of the questionnaire, we conducted test interviews in Bonga, the Zone capital which is adjacent to the study area, to ensure that all questions were clear.

We have calculated the frequencies of response to the 10 questions pertaining to attitude from the Likert scale questions. Correlation test showed high correlation results for the same questions between lions and leopards, therefore we separated the questions pertaining to lions and to leopards and ran a reliability analysis to test the measure of internal consistency (reliability) using SPSS. We have also calculated the average of the responses and presented them as a composite attitude scale (Table 2). To do this, we have assigned values to each response (Strongly agree = 5 points, Agree = 4 points, Neutral = 3 points, Disagree = 4 points, Strongly disagree). Then we multiplied the number of respondents for each response with its assigned value; and then summed each of these values and divided this sum by the total number of respondents (210). Before calculating the weighted average and running the reliability analysis we reversed the scores of two questions (7 and 8 in Table 2) in order to make them comparable to the other questions. After running the reliability analysis we looked at the Cronbach's alpha value.

Three FGDs were conducted with local elderly leaders, females and young college students. Each FGD had ten participants and was conducted with a traditional coffee ceremony, a social setting preferred by the participants. The local elderly and female FGD participants were selected by inputs from zonal and sub-district administration offices, KBR local project coordinator and KBR rangers that were trained as interviewers and used as translators. The youth college student participants were selected by communicating with the Bonga Teachers' College, which is the only college in Kafa Zone. Names of ten students (who came from the selected sub-districts for the household survey), were forwarded from different departments. Each FGD took about two hours. All three discussions focused on the following themes: comparison of past and current human-carnivore conflicts, experiences of livestock loss to the



carnivores and culturally acceptable retaliatory actions, conflict prevention techniques, local administration support to reducing conflicts, and distribution of the carnivores.

At the outset we asked thirty randomly selected people how they would define rich, medium and poor households; they agreed that the criteria were ownership of livestock, land and houses. Respondents then indicated thresholds for all three criteria to classify wealth categories which were subsequently used in the analysis. Tropical Livestock Unit (TLU) (Njuki et al., 2011) was used to standardize the different types of livestock. Livestock prices for years earlier than 2014 were calculated using mean 2014 prices collected from different markets in Kafa Zone and Consumer Price Index (CPI) obtained from Index Mundi (2014) and Trading Economics (2014). CPI value of a specific year was used to adjust for inflation by taking the ratio of that year's CPI and 2014's CPI. This CPI ratio matches the ratio of livestock price of the respective years, which allowed for computation of past year livestock prices (Appelbaum, 2004).

The quantitative data analysis mainly involved descriptive analysis. We used Spearman's rank correlation to investigate if there was an association between livestock loss to carnivore attacks and how respondents said they will react to future attacks, the latter is a behavioural intention we henceforth refer to as presumed action. We ranked the responses from low (1) to high (3 for leopards and 4 for lions) based on the scale of the severity of the respondents' presumed action; doing nothing because it is a course of nature (1), traditional begging ritual so lions would stop their attacks on livestock (2), reporting to local officials (3), and retaliating by killing the carnivores (4). The leopard correlation analysis had only 1, 3, and 4. We also used Spearman's rank correlation to investigate the association between livestock loss and respondents attitude towards having a 'carnivore-free' place to live. We asked if respondents would want lions and leopards to be extirpated from their environment and ranked responses from strong disagreement (5) to strong agreement (1). Livestock loss was converted to TLU, and it ranged from 0 to 3.23 TLU and 0 to 20.05 TLU per household for leopard and lion attacks, respectively.

To analyse the qualitative data from the FGDs, we used discourse analysis; which is the process of understanding issues by identifying similarities and differences (Jørgensen & Phillips, 2002; Doody et al., 2013). We used participants' languages (how they describe and frame issues together with body language) on knowledge about, attitude and behaviour towards lions and leopards to identify patterns and commonalities within and among the three groups.

## Results

We surveyed 210 households, 13 headed by a woman and 197 headed by men; 67% of respondents were above 35 years old. People who had more than 13 cattle,  $\geq 4$  ha of land, and  $\geq 3$  houses were considered rich in the local settling. Those who had 8 to 12 cattle, 2 to 3.75 ha of land and two houses were medium, and anything below that was considered poor. The average number of livestock per household was 9 (SD =  $\pm 14.9$ ), the locally defined categories thus effectively created categories that were useful as a variable

(see below). Grazing was always done at daytime and in the presence of a herder, distance from home was generally low (< 1km away from their houses for about 93% of our respondents).

#### Knowledge about lions and leopards

Although uncommon, lions used to be present in KBR highlands and lowlands in the past. However, respondents stressed that lions nowadays were progressively restricted to the higher altitudes. FGD participants in highlands claimed that lions were not able to withstand the cold weather and the ants that are common in the forest. Leopards, on the other hand, have been known to exist at all elevations in KBR. All FGD discussions reached consensus that the community did not know where the lions were resident, when they came, which route they used and other related information. The local elderly and the college students FGD participants claimed that attacks escalated at the end of the dry season and the beginning of the rainy season.

#### Overview of attacks and economic losses

About 42% (N=89) of the respondents knew of lion attacks on humans during their lifetime. We recorded a total of 17 attacks on human beings, out of which four were fatal (all before 2006); 12 occurred between 2009 and 2013. Only 1.4% (N=3) of respondents claimed to know of leopard attacks on humans, two of which happened in 1996 and one in 2000. More losses were reported for lions than for leopards (Figure 2). Rich households lost more than medium and poor ones to both lion (48.3%, 29.7%, and 22.0%) and leopard (40.59%, 34.7%, and 24.5%) attacks. Livestock depredation claims from 2009 to 2013 accounted for 80% (N= 350) of lion and 62% (N=62) of leopard reported attacks (Table 1 a & b) on 73 and 20 households, respectively. Of these households, 14 incurred losses due to both carnivores. Lions caused 85% of the total livestock depredation from 2009-2013. In 2012 and 2013, 38 households claimed loss of livestock worth \$11,259, with the lions' damage amounting to \$10,841 (96%). Households that suffered livestock loss in 2012 and 2013, lost an average of \$287 and \$310 per year. If livestock are considered a commodity, and their loss as a direct reduction in household income, these households lost about 70% and 66% of the average Ethiopian GDP per capita (which was \$410 and \$470 in 2012 and 2013 respectively (World Bank, 2013)).

Lion attacks in KBR were not restricted to grazing fields only. There were cases where lions went inside peoples' houses at night, leading to attacks on humans. More than half of the survey respondents, and all FGDs, mentioned an example from 2010 in Adiyo; a lioness broke into a house during the night, ate two goats and attacked the owner who was sleeping in her bed. The woman survived after medical treatment, with big scars on her face and scalp. Two-third (63%) of the lion attacks were reported as happening between 18:00 and 6:00 while about half (55%) of the leopard attacks happened between 12:00 and 18:00. Half of our household survey respondents thought that the main reason for these attacks was the

lack of wild prey due to destruction of the forest. However, 26% of respondents thought that attacks happened because lions are violent in nature and habitual raiders. During FGDs, the consensus was that the community tried to share the burden of losing livestock; typically, neighbours contributed money to buy a calf so as to help victims cope with the loss. In line with this, 76% of respondents who incurred losses informed only their neighbours, whereas only 26.9% reported to the administration.

#### Attitude towards lions and leopards

In general, Table 2 shows that respondents have more or less similar positive attitude towards both carnivores. Out of the ten selected questions, the one that rated the most highly is if conserving lions/leopards is a positive cultural practice in Kafa (with an average weighted score of 4.33 for lions, and 4.32 for leopards). The Cronbach's alpha value 0.64 for lions and 0.63 for leopards; suggesting that 64% and 63% of the variance is reliable for the attitude data collected for lions and leopards, respectively. A majority of respondents and youth FGD participants, and all of the female and local elderly FGD participants did not refer to lions as just lions, they used a special name '*Donno*' which translates to 'King'. When they hear others addressing lions with just the name lion, they cover their ears as a way of saying '*I cannot hear this*'. This deep rooted respect and honour for lions extended to the time of attacks too. During the FGD with the elderly one of the participants explained that "*We do not think lions take our livestock to hurt us. As a result, we do not refer to it as an attack or killing but taking what they needed*". Although leopards do not face retaliatory or preventive killings, they do not get such honour and respect. Most (91.4%) respondents claimed that fear of legal actions is an additional reason for the absence of lion and leopard killings in KBR (86% of our respondents are aware that killing lions is prohibited by law in Ethiopia).

All FGDs explained that losing livestock to lions is considered as a sign of good luck in all of KBR – a sign of upcoming wealth. Three of the females' and four of the local elderly FGD participants explained that the number of their livestock had increased significantly after losing some to lions. One of the female FGD participants explained: "*Before seven years, two of our cattle were 'taken' in one night. In the morning, my husband and I were very happy to see lion footprints, because we believed our livestock were going to be fertile and we were going to be wealthy. And indeed we have been blessed since*".

The Kafa culture considers lions to be a kinder animal than leopards. One of the elderly FGD participants expressed: "*If we encounter a lion while on the road, all we have to do is cut some leaves and put them on our head and beg the lion and bow down. It is guaranteed that it will walk away. Male lions even convince or drag lionesses with them, who otherwise might block the path and lay around for a long time. But a leopard never shows such mercy; it always attacks if confrontation happens accidentally*". The FGDs also revealed that community elders hold a ritual ceremony when lion attacks become frequent, in

which they beat drums and pray to their ancestors that the lions leave them and their livestock alone. The local elderly FGD participants explained that a few years back there has been an incident in which a lion became a problem animal that was 'taking' livestock every night but not eating them; just killing them and walking away. They claim that a local spiritual leader prayed and that specific lion died. An informant told us confidentially that people killed the lion but maintained the narrative, which illustrates on the one hand respect for the lion and the spiritual leader, and on the other hand the resentment of retaliatory killing. The lion carcass was given a ceremonial burial; it was covered in hand-made traditional cloth before being buried in a meadow that remains fenced to this date.

The attitude of local people towards lions and leopards shows that although most of our respondents are afraid to go to the field or into the forest where lions and leopards are believed to live, they also like seeing these carnivores in the wild and do not want them to disappear from KBR (Figure 3).

#### Behaviours or actions

Lions and leopards in KBR elicited very few retaliatory killings. Only 2.9% (N= 6) and 1.9% (N=4) of respondents had witnessed lion and leopard killings, respectively. Three lion killings and one leopard killing occurred in the 2009 - 2013 period. Of the 93 households that suffered livestock losses between 2009 and 2013, only 2.1% (N=2) responded that they wanted to kill the carnivores in retaliation (and they might do so if it happens in the future). However, the majority, N=66 (71%) did not want to retaliate and replied that they would not retaliate in the future either.

#### Correlation of economic losses with attitude and behaviour

Spearman's correlation showed a highly significant association between livestock loss and presumed action to leopard attacks ( $\rho_s = 0.181$ ,  $p < 0.01$ ), but that association was not significant for lion attacks ( $\rho_s = -0.132$ ,  $p = 0.056$ ).

Spearman's correlation between wanting to see carnivores extirpated in their community and livestock loss showed a non-significant association for both leopards ( $\rho_s = 0.015$ ,  $p = 0.83$ ), and lions ( $\rho_s = -0.108$ ,  $p = 0.118$ ).

#### Compensation vs. prevention

A minority of livestock owners who experienced carnivore attacks (N= 60 (17%) for lion and N=15 (24%) for leopard) responded that they would like to be compensated. The rest of the victims believe that depredation was a course of nature and no one is responsible for compensating their loss. All respondents and FGD participants highlighted the importance of preventive techniques. The two most preferred remedies (79% of the respondents) are: introducing better protection schemes for livestock and fencing the reserve to keep the carnivores away from people. The 'better protection techniques' include keeping cattle in houses or in fenced fields during nights, not letting livestock graze in forests. The majority of respondents and all FGD participants suggested that the carnivores' habitat, particularly that of the lions,

should be fenced, at least during the rainy season. FGD participants explained that fire and watch dogs were common for night guarding but their efficiency as a preventive technique has dropped as the carnivores, particularly lions, started to attack livestock even in the presence of fire and dogs. The elderly and youth FGD participants reported five incidents where dogs were killed by lions during attacks.

## Discussion

Depredation had an economic impact on the households studied, but compared to other landscapes with lions damage was on average not high (Gifford-Gonzalez, 2000; Frank et al., 2005). Moreover, the tolerance we reported is striking; tolerance for carnivore attacks varies across Africa but is rather common in India (Karanth et al., 2013; Meena et al., 2014). Effective carnivore conservation is difficult where tolerance is low (Sillero-Zubiri & Laurenson, 2001; Bruskotter & Wilson, 2014); in KBR the habitat and prey availability are sub optimal (extensive deforestation and low density of ungulates reported in Berhan (2008)); and it is probably due to the prevailing culture of tolerance that lions and leopards have survived. By combining the overview provided by quantitative data with insights and details provided by qualitative data we were able to make a more complete analysis. We found that rational choice theory poorly explains human lion conflict; social, political and cultural factors are at least as important as economic rationale (Inskip & Zimmermann, 2009; Bruskotter & Shelby, 2010). Traditionally in Kafa, if individuals lost livestock to lions they would be happy, because it is believed to be a sign that their livestock number is to increase. People's response to carnivore conflicts is culturally contextualized and complex; rational choice theory would predict retaliation, but culture can be a stronger incentive and encourage the conservation of carnivores (Karanth & Chellam, 2009; Kopnina, 2015; Thomas et al., 2015). Rising conflict and external influences may erode tolerance and may lead to different narratives (Ikanda & Packer, 2008; Maclellan et al., 2009), but up to now people in Kafa still proved to be tolerant, with almost no retaliatory killings. Attitude, whether positive or negative, to carnivores will influence behaviour towards carnivores (Thorn et al., 2015). Human-carnivore conflicts are increasing in many areas (Treves & Karanth, 2003). Attacks on people have been reported in Ethiopia (Gebresenbet et al., 2009), but are not a major problem in KBR at present. The suspected increase in human-lion conflicts in the wet season could be a result of seasonal variation in prey availability as suggested by Patterson et al. (2004) and Woodroffe and Frank (2005). Although our reliability analysis suggests a less than the ideal (70%) variance reliability; our qualitative responses and the frequency of responses, suggest a positive attitude in Kafa for lions and leopards. The highest average ratings (Table 2) for the questions if conserving lions/leopards is a positive cultural practice in Kafa (with an average weighted score of 4.33 for lions, and 4.32 for leopards) also support this claim. Additionally, the correlation between wanting to see carnivores extirpated in their community and livestock loss

showed a non-significant association for both lions and leopards, supporting the claim that there is a positive attitude towards both carnivores.

Lions are more problematic than leopards in KBR, which makes it even more striking that there is a more tolerance towards lions than leopards. The correlation between livestock loss and respondents' presumed actions to lion attacks in KBR was not significant, supporting the claim that there is a culture of tolerance towards lions. However, attitudes to leopards were less positive and the significant correlation between livestock loss and respondents' presumed actions to leopard attacks reveals that as households lose more livestock to leopards, their behavioural intention to retaliate becomes stronger. KBR appears to be exceptional in this regard; leopards generally coexist more easily with people, their diet adaptability and secretive behaviour often allow them to persist close to people without significantly affecting them (Hayward et al., 2006; Odden et al., 2014; Athreya et al., 2016).

Wildlife and people are integrated across Ethiopia, the biosphere reserve model fits the de facto management of protected areas in Ethiopia that are practically all open access systems (Gebresenbet et al., 2013). Coexistence is important across the country, and in the context of widespread extreme poverty depredation must be addressed. Our results show that policy will be more effective and efficient if it looks beyond economic impacts and considers the depth and complexity of communities' relationships with large carnivores. Integrated damage mitigation (Bauer et al., 2010) may be more appropriate than segregation (e.g. fences, Packer et al. 2013) or compensation (Naughton-Treves et al., 2003; Dickman et al., 2011; Bauer et al., 2015b). There are plans for a pilot consolation scheme in KBR (Schütze, 2014); it will not compensate directly for losses, but provide a more general subsidy for coexistence. This fits with global trends in conservation to focus on ecosystem services, monetary values and tradeoffs (Goldman et al., 2010; Anyango-Van Zwieten et al., 2015). While this may improve attitudes and lead to better conservation outcomes, other factors are equally important (Heberlein, 2012). For example, Marchini & Macdonald (2012) found that fear, personal and social motivations and internal and external barriers to retaliatory killing (e.g. lack of skills and force of law, respectively) influence jaguar killing. We add that communal coping mechanisms, beliefs in long term positive wealth impacts and a culture of tolerance are important. The relative importance of these factors varies in space and over time, adding to the complexity of conservation.

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544 abundance and community tolerance of depredation in human-dominated landscapes in Northern Ethiopia. *Mammalian*  
545 *Biology*, **79**, 325-330.

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547 Biographical sketches

548 Fikirte Gebresenbet is a PhD candidate at Oklahoma State University. She works on large carnivore and herptile conservation in  
549 Ethiopia. Brhane Baraki worked on human carnivore conflict in Kafa. Gidey Yirga is based in Mekelle University and has done  
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551 on carnivores and human–wildlife conflict and is the Chair of the IUCN SSC Canid Specialist Group. Hans Bauer is based in  
552 Ethiopia, working on lion conservation in West, Central and the Horn of Africa.

553

For Peer Review

Table 1 (a &amp; b): Amount and type of livestock lost 2009 - 2013 by lions (a) and leopards (b).

a.

Year	Cattle	Sheep	Goats	Horses	Mule	Donkey
2009	7	58	12	15	0	1
2010	13	17	3	20	0	0
2011	13	20	6	19	4	0
2012	15	63	4	20	3	1
2013	6	16	10	2	1	1

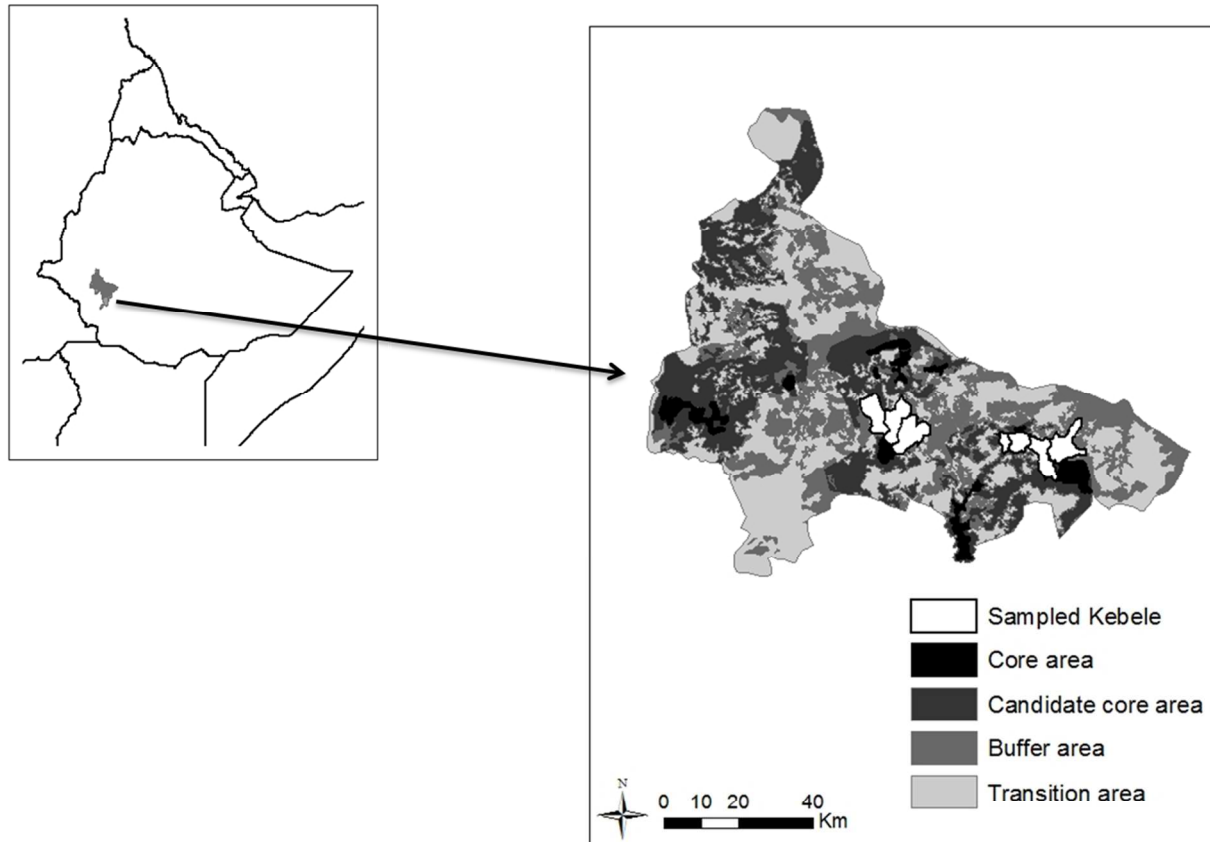
b.

Year	Cattle	Sheep	Goats	Horses
2009	0	2	5	1
2010	1	11	9	0
2011	0	17	0	0
2012	0	0	8	0
2013	1	5	2	0

Table 2: Percentage of responses to ten Likert scale questions pertaining to attitude, and their average responses as a composite attitude scale.

No.	Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Average
1	I like seeing lions in the wild	53.81	22.38	11.9	10.48	1.43	4.17
2	I like to see leopards in the wild	50.95	20.48	14.29	13.81	0.48	4.08
3	Conserving lions is culturally a positive practice in Kafa	51.9	34.76	8.57	4.29	0.48	4.33
4	Conserving leopards is culturally a positive practice in Kafa	50.48	36.67	8.57	3.33	0.95	4.32
5	People should relocate from areas of lions' habitat	30.95	24.76	4.76	29.05	10.48	3.37
6	People should relocate from areas of leopards' habitat	31.43	22.38	6.67	29.05	10.48	3.35
7	I would like lions to disappear from my community	6.19	6.67	10	70	7.14	3.65
8	I would like leopards to disappear from my community	6.19	5.71	10	70.95	7.14	3.67
9	The presence of a lion is a sign of a healthy environment	48.1	30	8.1	9.52	4.29	4.08
10	The presence of a leopard is a sign of a healthy environment	47.62	29.05	8.57	10	4.76	4.05

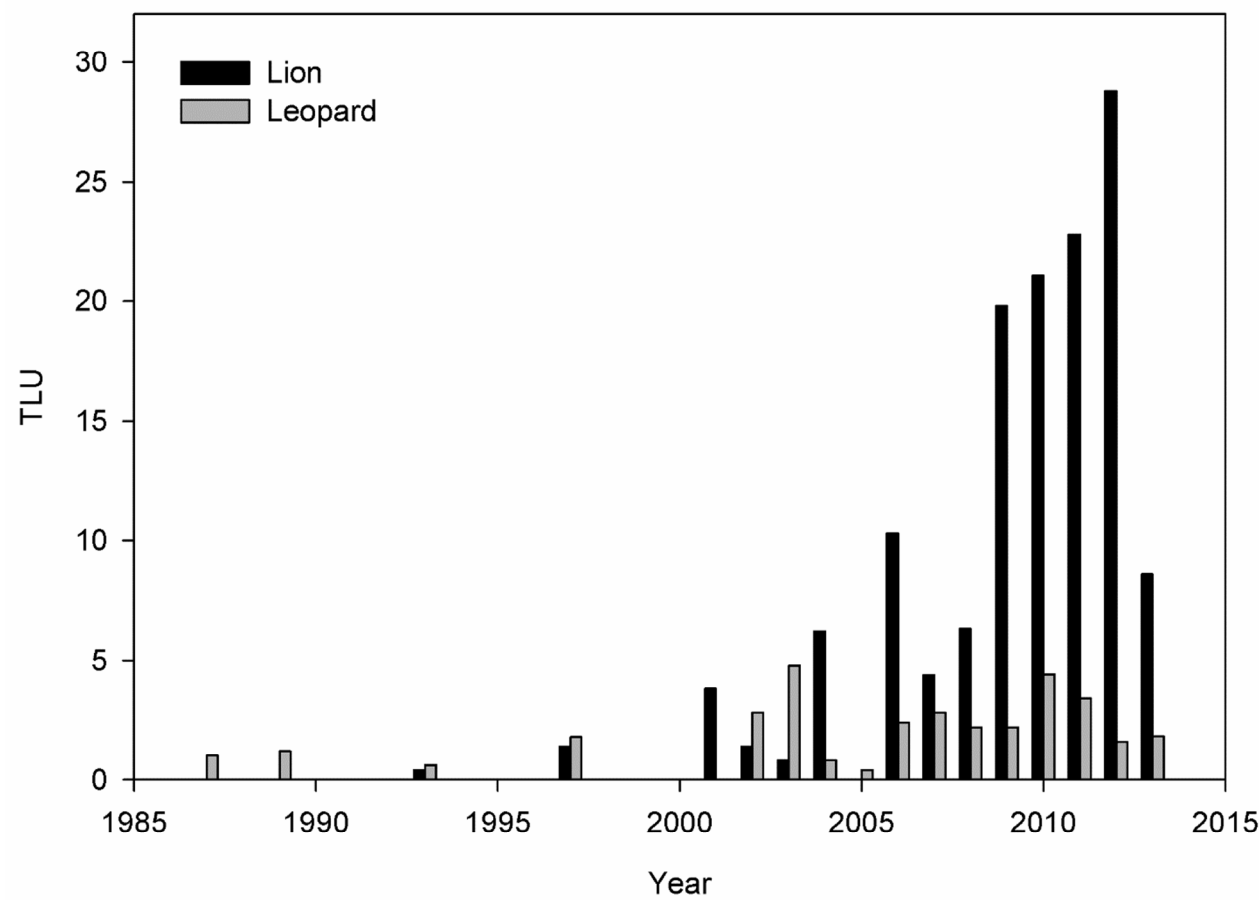
563 Figure 1: Sampled sub-districts displayed on Kafa Biosphere Reserve, South West Ethiopia



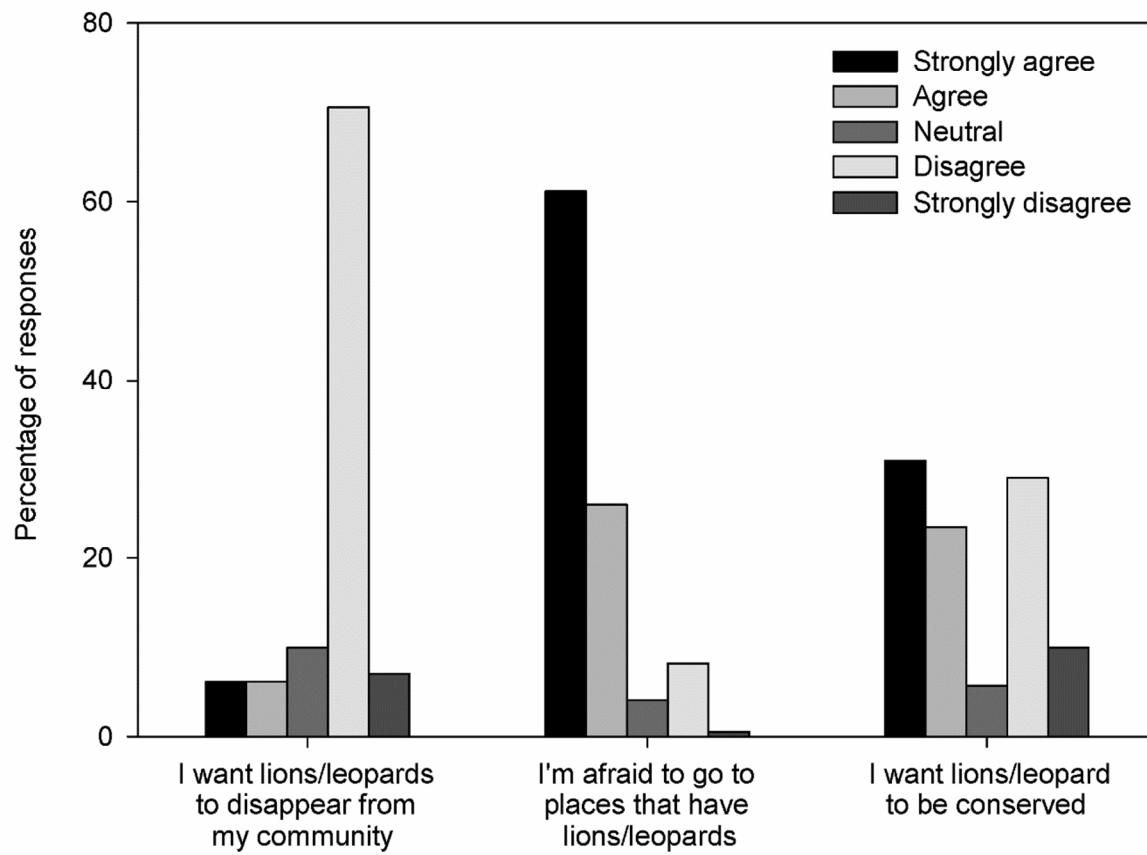
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Figure 2: Recorded TLUs lost as a result of lion and leopard attacks per year



570 Figure 3: Averaged (for lion and leopard) percentage of attitude responses towards the carnivores and their conservation



575 **Authors contributions:**

576 FG: processed ethical clearance, co-prepared survey questions, trained translators, collected part of the  
577 data and wrote the manuscript

578 BB: co-prepared survey questions and collected part of the data

579 GY: gave comments on the manuscript

580 CS: gave comments on the manuscript

581 HB: assisted in project design and data collection, and wrote the manuscript

For Peer Review



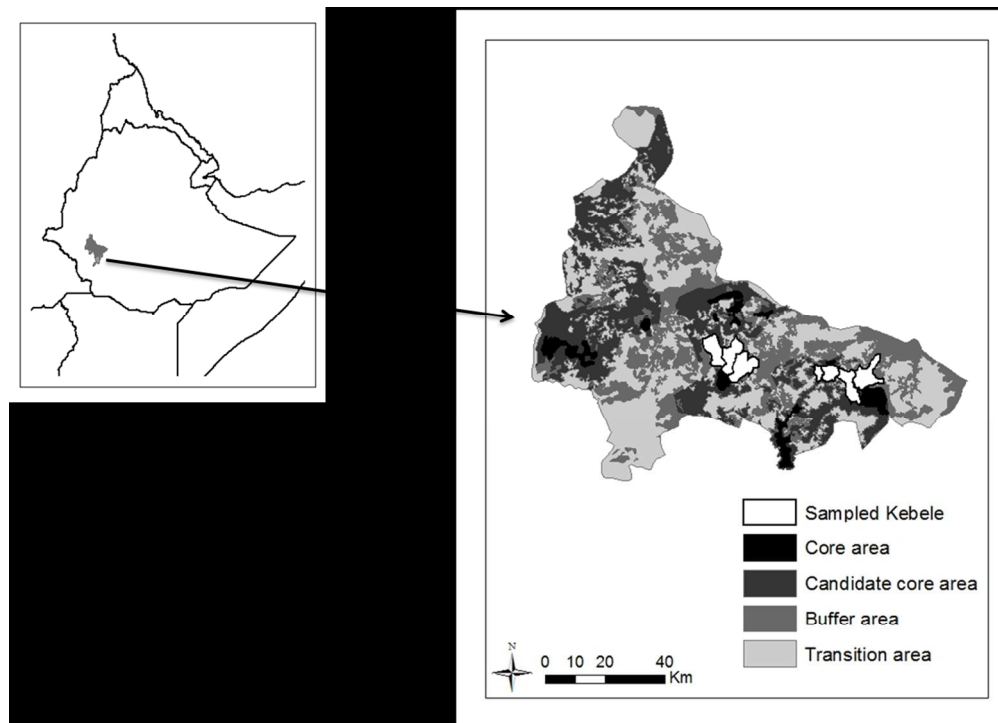


Figure 1: Sampled sub-districts displayed on Kafa Biosphere Reserve, South West Ethiopia

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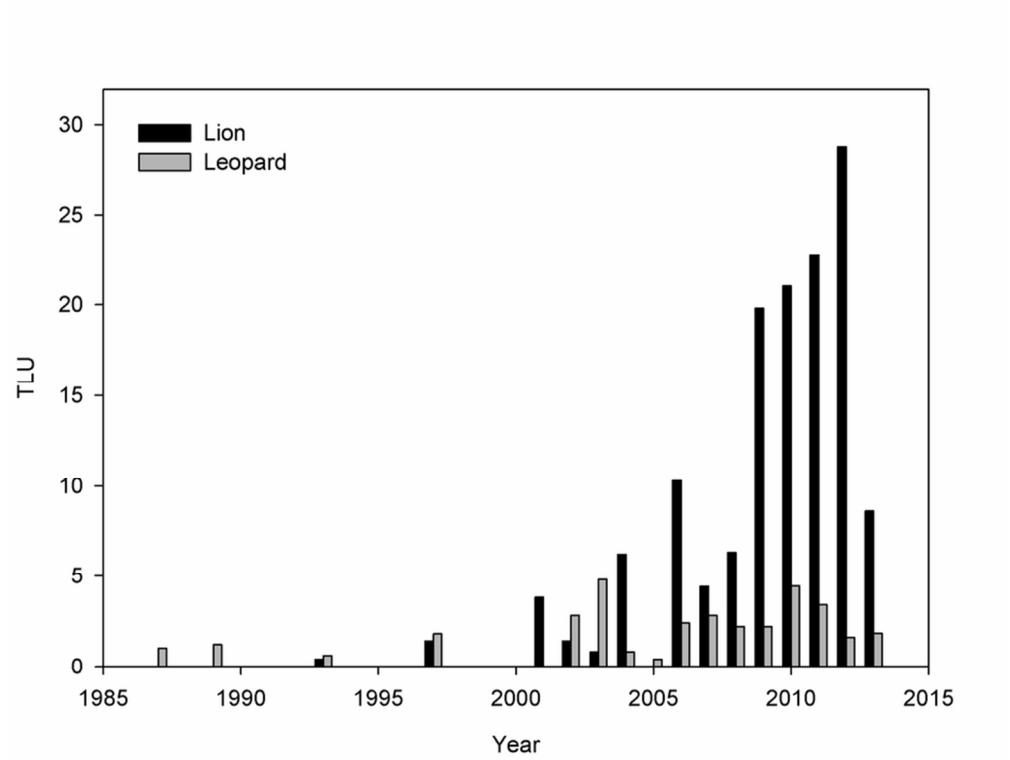


Figure 2: Recorded TLUs lost as a result of lion and leopard attacks per year  
78x60mm (300 x 300 DPI)

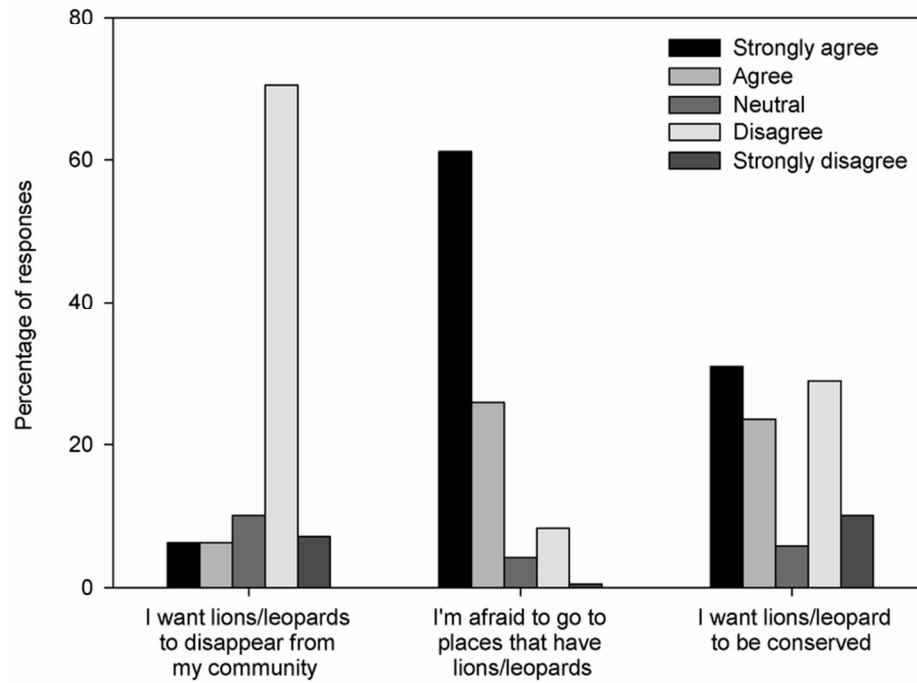


Figure 3: Averaged (for lion and leopard) percentage of attitude responses towards the carnivores and their conservation

78x59mm (300 x 300 DPI)