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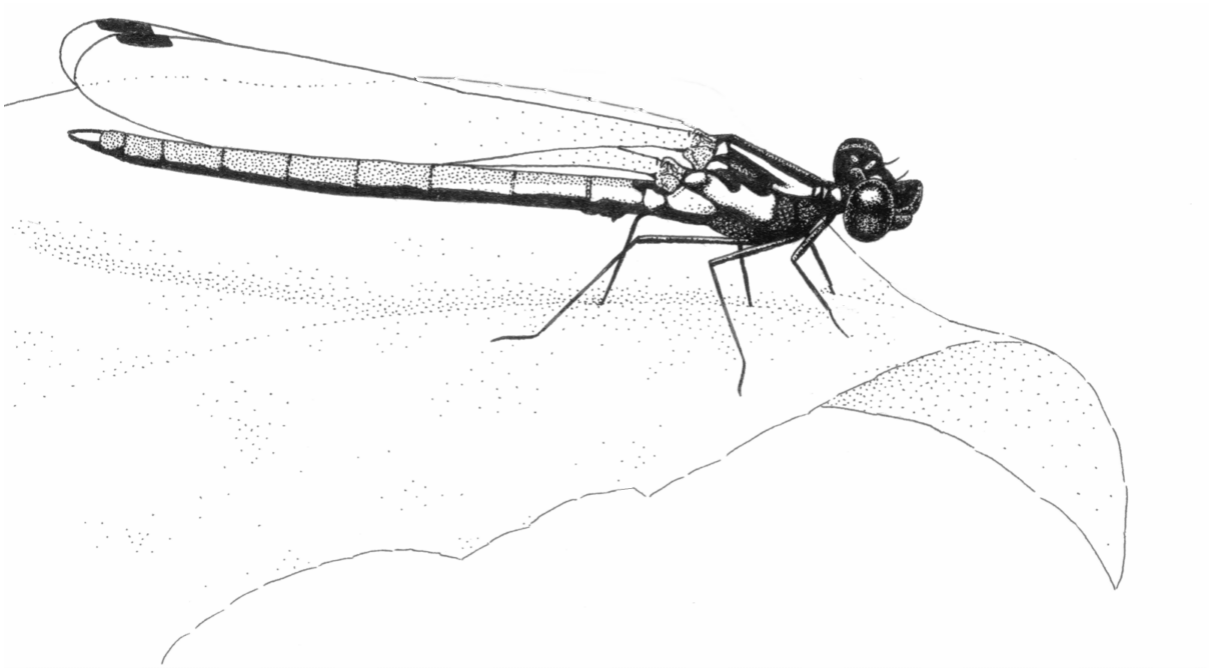

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Front cover: Chlorocypha tenuis*, a species of damselfly found in Kakamega Forest. Drawing by K.-D. B. Dijkstra.*

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PEOPLE, PREDATORS, PRACTICES AND PERCEPTIONS: SOCIO-ECONOMIC IMPLICATIONS OF LIVESTOCK PREDATION BY AFRICAN LARGE CARNIVORES IN SAMBURU COUNTY, NORTHERN KENYA

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ABSTRACT

We conducted an attitudinal study on the socio-economic implications of human-carnivore conflict in an East African pastoralist landscape through a semi-structured questionnaire survey complemented by a locally organised community carnivore conservation workshop. We compared actual livestock predation rates by the large carnivores from a nine-year livestock predation dataset for Samburu County to perceived predation rates from our respondents. Our study revealed that perceived rates of livestock predation vis-à-vis actual rates of livestock predation by large carnivores in a modern pastoralist community setting are dissimilar. Even though community goodwill to embrace coexistence with wildlife persists, the perceived lack of equitable sharing of benefits from wildlife earnings nationally with local communities inadvertently reinforces negative views towards wildlife in general and carnivores specifically. Therefore, an increased participatory community approach in the management

and conservation of wildlife needs to be addressed appropriately by policy makers for the benefit of the communities and wildlife.

Keywords: Human-carnivore conflict, community participation, coexistence

INTRODUCTION

The study and mitigation of human-wildlife conflict has focused on the negative aspects of the interactions between humans and wildlife. More specifically, it has given attention to the patterns and predictors of damage caused by wildlife; the description of the damage to human life and property, with emphasis on livestock predation and crop-raiding; the monetary costs associated with damage; the implications of the situation for wildlife conservation; and the prevention of damage and mitigation of monetary losses (Woodroffe *et al.,* 2005; Boitani & Powell, 2012). Several studies have looked into the factors which could reduce livestock predation by wild carnivores (*e.g.* Kruuk, 1972a; Ogada *et al.*, 2003; Treves & Karanth, 2003; Patterson *et al.*, 2004; Dickman, 2005; Ikanda & Packer, 2008; Kissui, 2008a; Hazzah *et al.*, 2009; Cotterill, 2013; Boast, 2014; Western *et al.*, 2015; Miller *et al.*, 2016). These studies indicate that livestock predation by large carnivores is to some extent preventable and that key factors characterising the conflict landscape such as livestock husbandry practices, herding patterns and retaliation to livestock predation, are directly linked to human behaviours and therefore have the potential to be managed. Samburu County in northern Kenya is unique in the sense that it hosts populations of the six large carnivore species found in Eastern Africa, namely; African lion *Panthera leo* (Linnaeus, 1758), leopard *Panthera pardus* (Linnaeus, 1758), striped hyaena *Hyaena hyaena* (Linnaeus, 1758), cheetah *Acinonyx jubatus* (Schreber, 1775), spotted hyaena *Crocuta crocuta* (Erxleben, 1777) and African wild dog *Lycaon pictus* (Temminck, 1820). It therefore forms an ideal candidate for implementation of community wildlife awareness and conservation strategies towards mitigation of human-wildlife conflict through creation and promotion of wildlife management areas and better husbandry practices to deal with livestock predation.

Evidence gathered from past research on human-carnivore conflict (*e.g.* Weber & Rabinowitz, 1996; Kruuk, 2002; Woodroffe *et al.*, 2007; Sangay & Vernes, 2008; Inskip & Zimmerman, 2009; Dickman, 2010; Suryawanshi *et al.*, 2013; Gervasi *et al.*, 2014; Johansson *et al.*, 2015; Blackburn *et al.*, 2016; Ghoddousi *et al.*, 2016; Adhola, 2019) indicates that in a landscape where humans and wild carnivores live side by side, livestock predation can never be totally eradicated, at best it can only be reduced to a tolerable minimum. While perceived impacts of large carnivores on livelihoods drive negative attitudes, positive attitudes towards predators may potentially deteriorate over time if conflicts are not addressed, which could undermine the conservation efforts being implemented in an area (Boitani & Powell, 2012; Kingdon & Hoffmann, 2013). We formulated three study hypotheses on the socio-economic implications of demographic (gender, age group, socioeconomic class and duration of residence at a locality) and attitudinal variables (community attitudes and perceptions) on management of human-carnivore conflict in Samburu County, northern Kenya.

Hypothesis 1: We evaluated the impact of attitudinal variables on management of human-carnivore conflict using a null hypothesis that perceived and actual rates of livestock predation by large carnivores in Samburu County are similar.

Hypothesis 2: We evaluated the impact of demographic variables on management of human-carnivore conflict using a null hypothesis that demographic variables do not influence community attitudes and perceptions on human-carnivore conflict in Samburu County, Kenya.

Hypothesis 3: We evaluated the socioeconomic implications of human-carnivore conflict using a null hypothesis that economic losses due to livestock predation by large carnivores do not influence community attitudes and perceptions on human-carnivore conflict in Samburu County, Kenya.

MATERIALS AND METHODS

Study area

Samburu County (1°07'–0°57'N, 36°40'–37°55'E) is found in northern Kenya (figure 1) and covers approximately 21 000 km^2. It is a vast semi-arid landscape with a mean annual rainfall between 600-800 mm. Major ecosystems in the area include savannah mosaics, *Acacia* grasslands, *Acacia* scrublands, and dryland forests (Barkham & Rainy, 1976; De Leeuw *et al.*, 2001; Adhola, 2019).

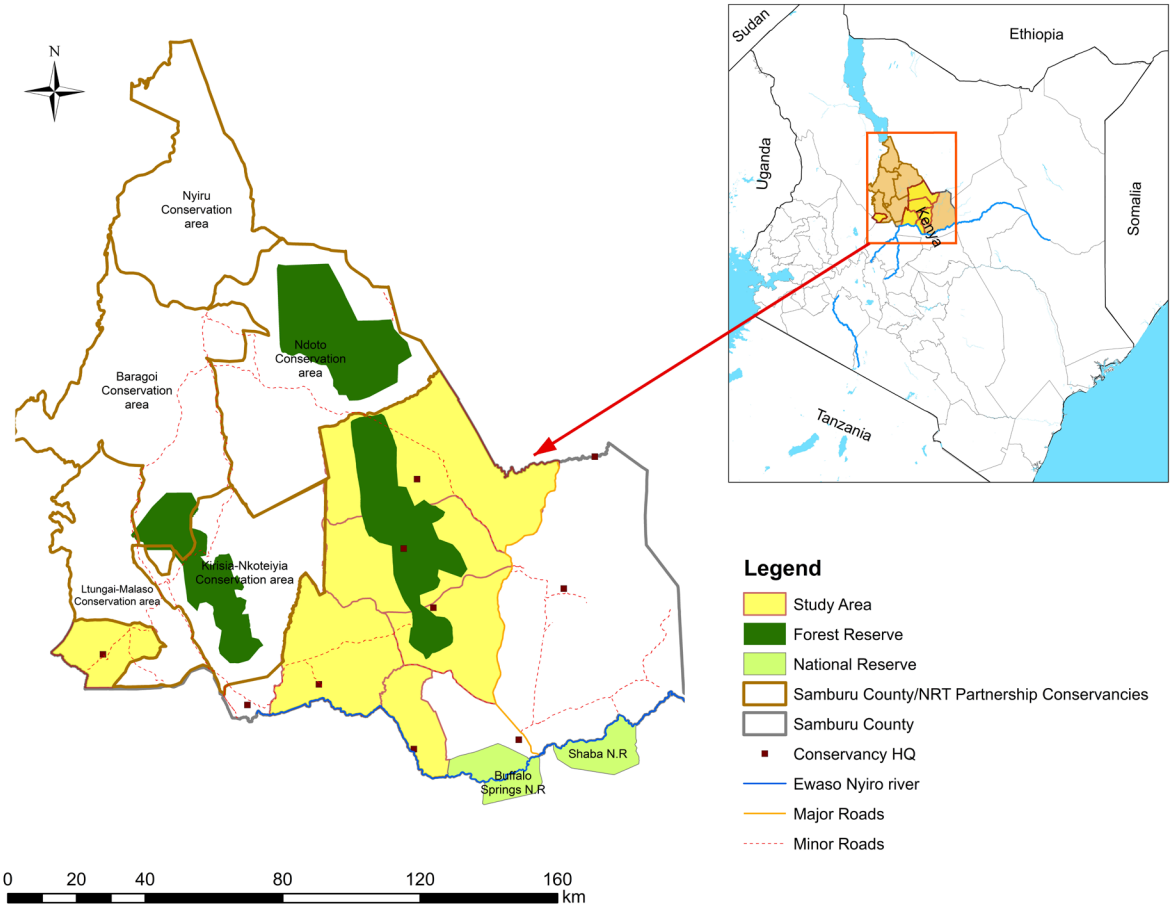


Figure 1. Map showing location of Samburu in Kenya; and project study area highlighted within the Samburu County map.

Methods and data analyses

Demographic (gender, age group, socioeconomic class and duration of residence in the area) and attitudinal (community attitudes and perceptions) information was gathered to understand the dynamic relationship between the Samburu pastoralists, and large carnivores in the county (lion, leopard, cheetah, spotted hyaena, striped hyaena and African wild dog). A semi-structured questionnaire survey design (appendix 1) modified from Kuriyan (2002), Mwebi (2007), Romañach *et al.* (2007) and Dickman (2008) was used to survey pastoralist households in the Meibae Community Wildlife Conservancy in Samburu County using a randomised approach of sampling every third household along a randomly chosen transect within strata (conservancy blocks). Our three-month survey in 2018 tested attitudes towards wildlife in general, as well as snapshot attitudes at one period of time towards the large carnivore species. The survey was initially pre-tested on local community members of varying ages, sexes and backgrounds by conducting mock interviews to ensure clarity before use. Due to budgetary and logistical challenges, the semi-structured questionnaire survey could only be conducted in one Community Wildlife Conservancy (Meibae) to represent the Samburu ethnic community in all the wildlife conservancies in Samburu County.

All randomly selected interviewees representing 75 households consented to the interviews. Qualitative outputs of key responses given to our open ended questions during the interviews were graphed (figures 2 to 5).

Demographic variables such as gender, age group, socio-economic status (upper, middle and lower classes) and duration of residence in the area, were treated as explanatory variables and tested against response variables such as: ability to coexist with large carnivores, perceived benefits of large carnivores, attitudes (positive *vs.* negative) towards large carnivores and tolerance towards large carnivore presence in the landscape. Following the recommendation by Bilder & Loughin (2015), and Agresti (2019), our quantitative analyses were conducted using R software version 3.6.0 (R Core Team, 2019) using a binomial regression analysis (general linear model—GLM), followed by an analysis of variance (ANOVA) with a chi-square statistic. Significant outputs were subsequently presented (table 1; figure 6).

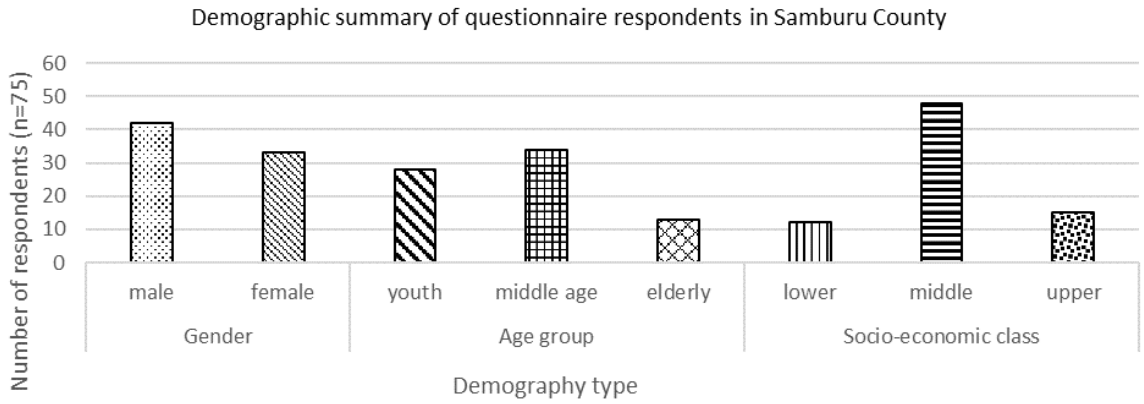
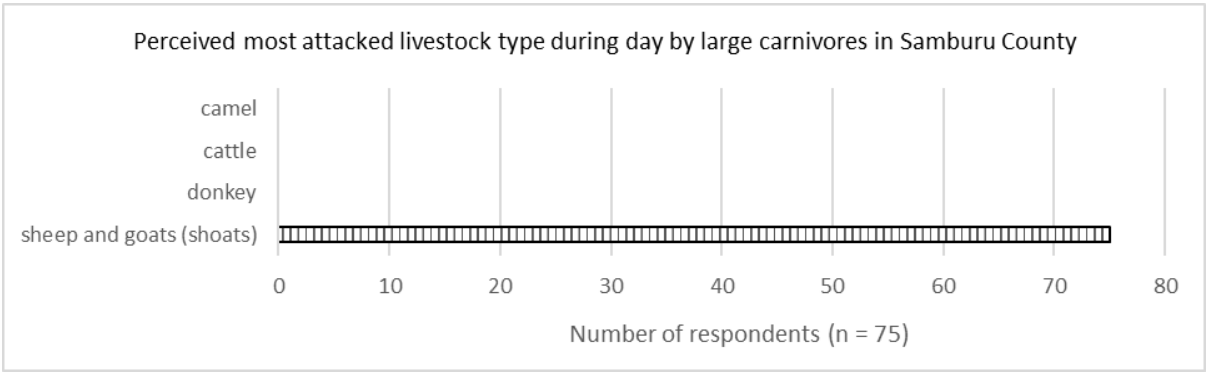


Figure 2. Demographic constitution of respondents in the semi-structured questionnaire survey in Samburu County, northern Kenya.



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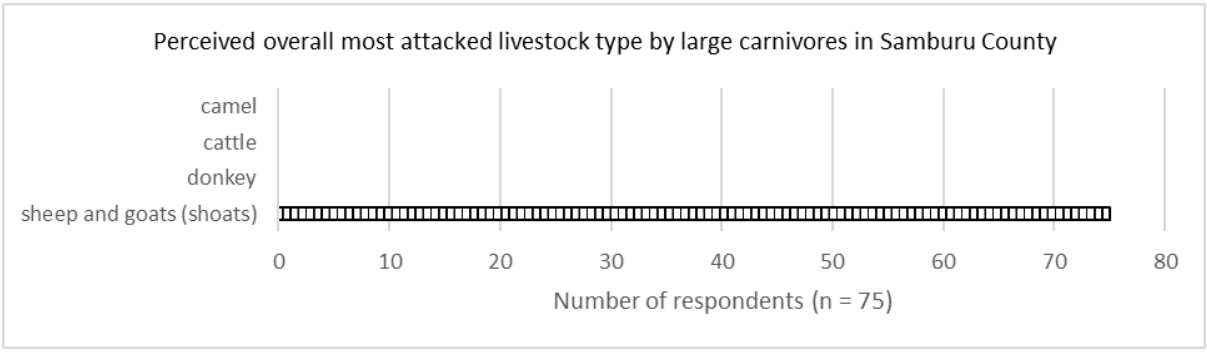

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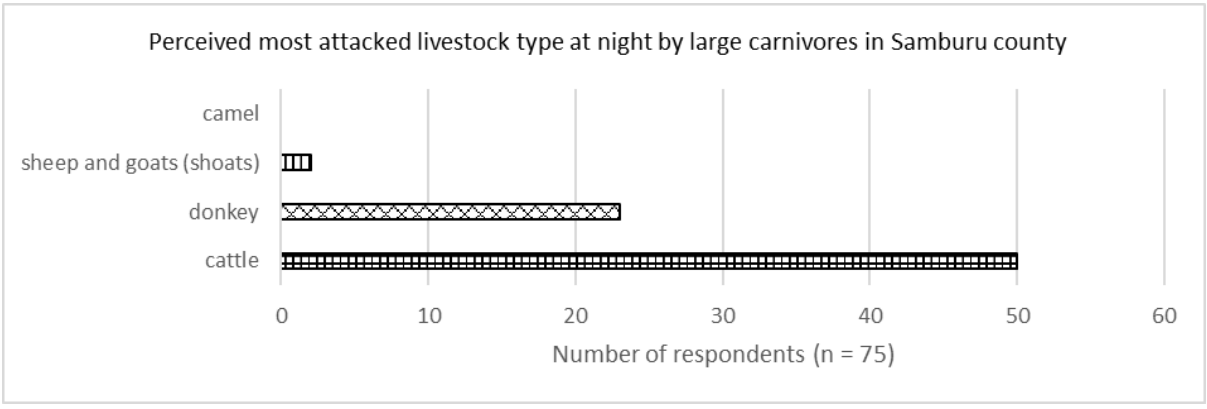

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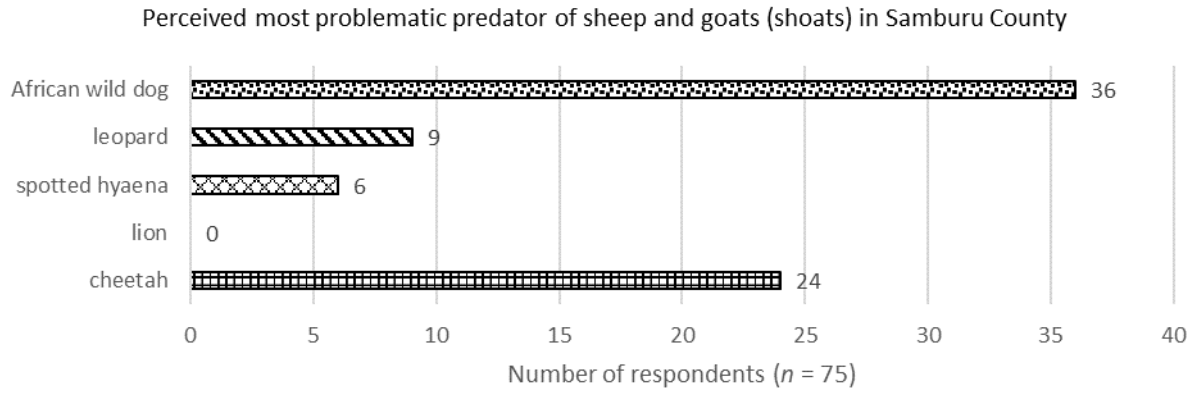
Figure 3 (a, b, c). Perceived large carnivore predation rates per livestock type in Samburu County.



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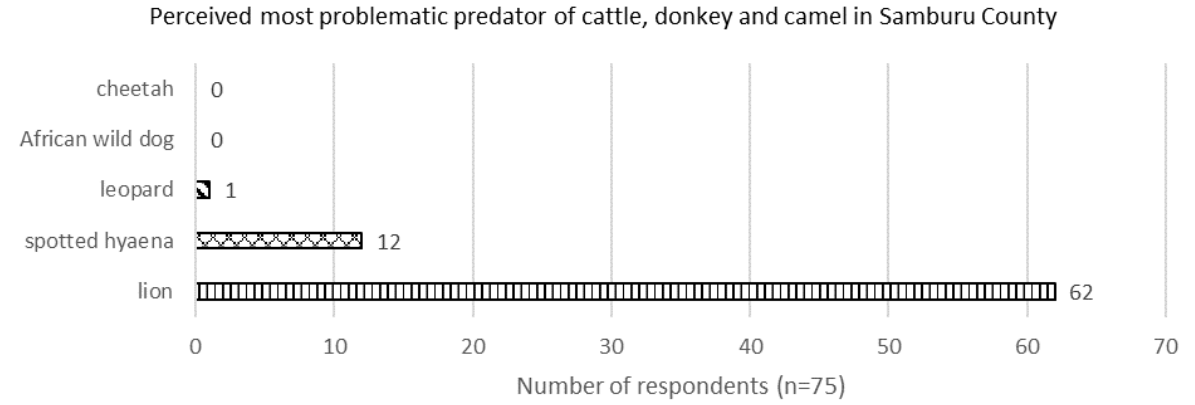

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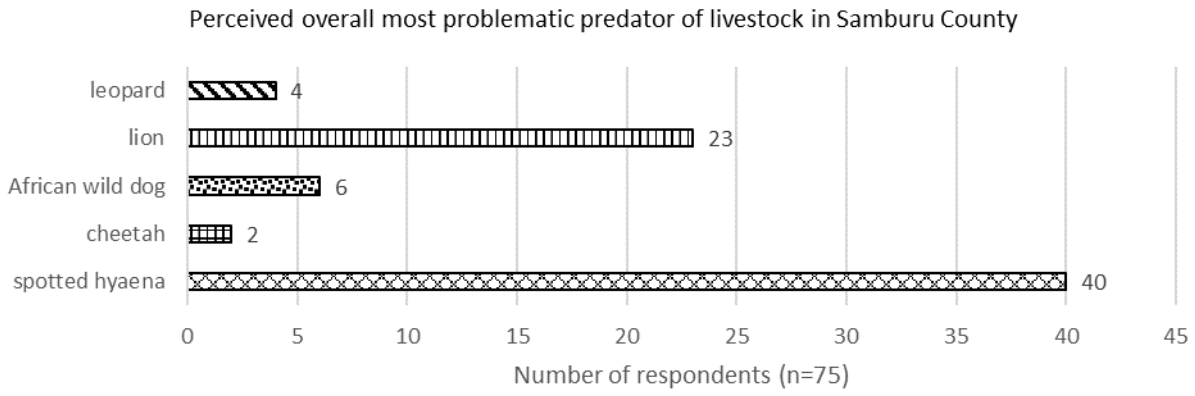

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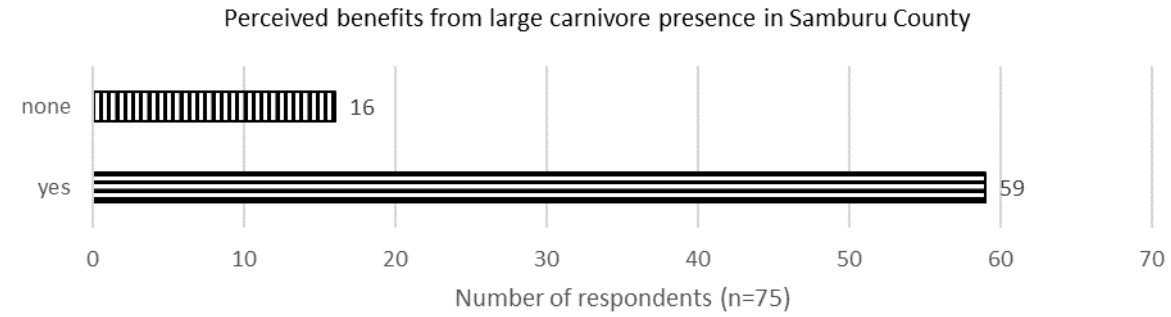
Figure 4 (a, b, c). Perceived most problematic predator of livestock in Samburu County, northern Kenya.

Aerial mammal (livestock and wild herbivores) census data collected in the years 2010, 2013 and 2015 by the Directorate of Resource Surveys and Remote Sensing (DRSRS) for Samburu County were incorporated into this study to get an overview of the average livestock and wild herbivore populations within any given year between 2010 to 2018 (figure 7). The data were collected through systematic aerial sample survey methods modified from Norton-Griffiths (1978) and Sinclair and Norton-Griffiths (1979) which have been widely applied to census wildlife and livestock in African savannahs for many decades. Aerial sample surveys of Samburu County were carried out using one or two high-wing, twin-engine Partenavia P68s, each with a crew of four, consisting of the pilot, a front seat observer (FSO), and two rear seat observers (RSO). Flying at about 190 km/h and at a height above the ground of 122 m (using a radar altimeter), the pilot navigated transects oriented north– south using GPS. Observers counted animals that fell within narrow strips of known width (150 m) on either side of the aircraft, defined by rods attached to the wing struts. Both wild and



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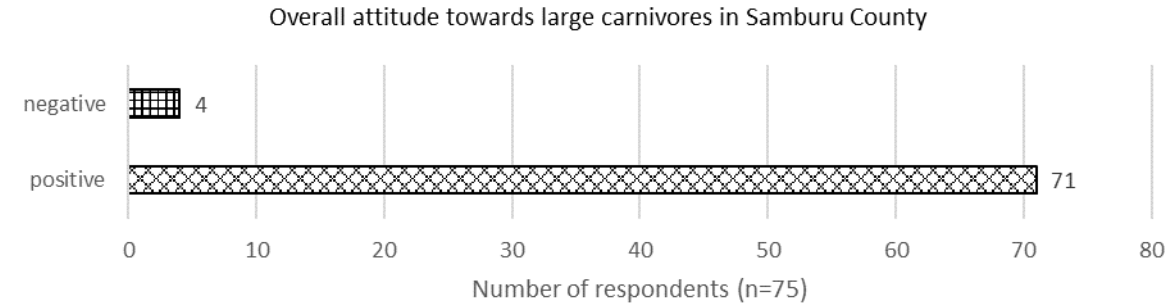

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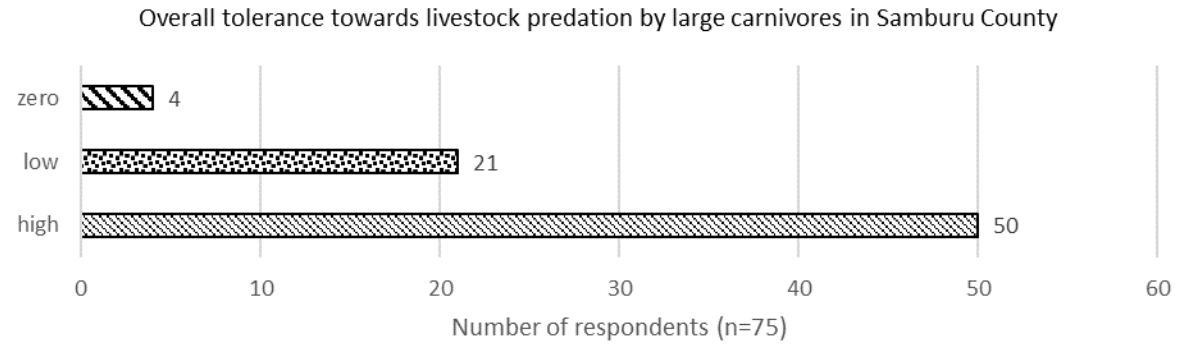

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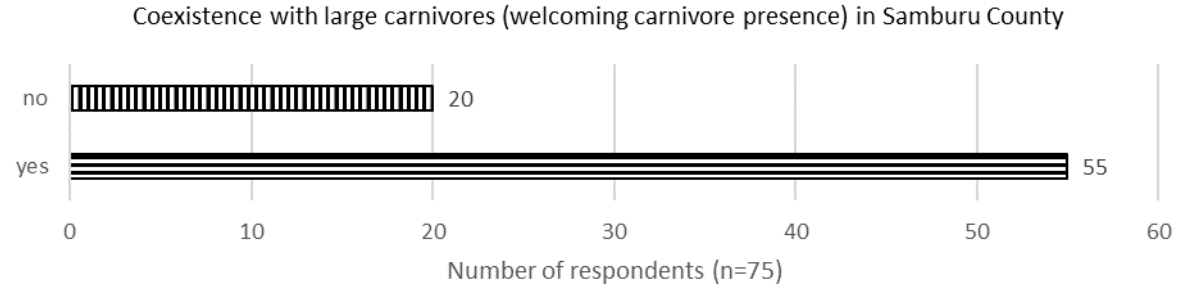

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Figure 5 (a, b, c, d). Perceptions, attitudes, tolerance and coexistence with large carnivores in Samburu County.

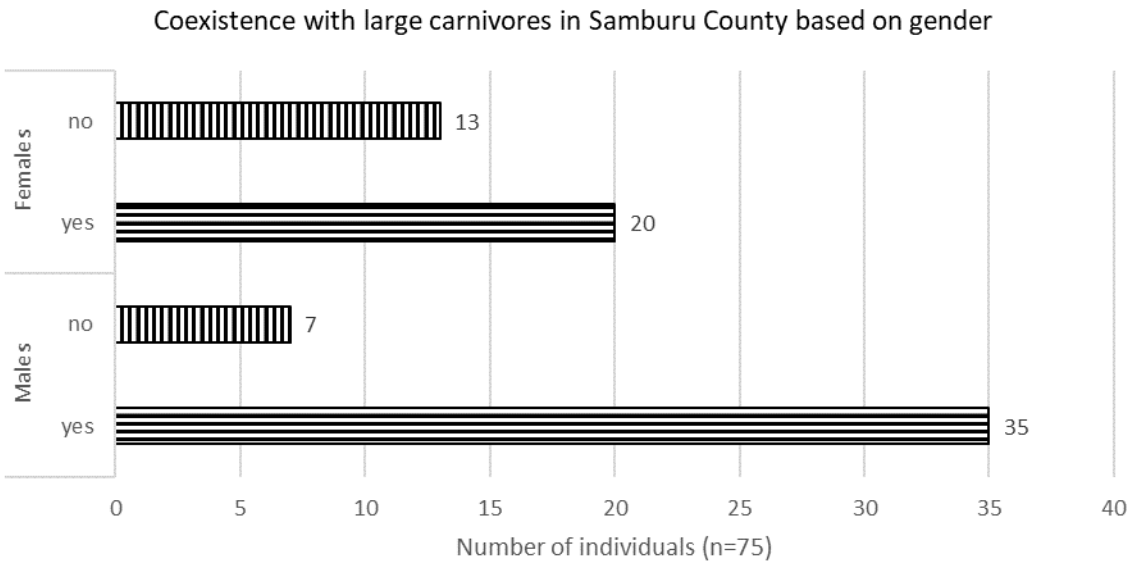


Figure 6. Responses by gender on the prospect of coexistence with large carnivores in the Samburu landscape in northern Kenya.

Table 1. A general linear model output followed by one-way analysis of variance with a chi-square test statistic from R software (version 3.6.0) showing the effect of demographic variables on the inherent ability of a Samburu local to coexist with large carnivores in Samburu County, northern Kenya (n = 75).

Step 1. Binomial regression analysis (general linear model)				
coefficients	estimate	standard error	Z value	Pr (>|z|)
(intercept)	0.7202	1.0096	0.713	0.4756
gender: male	1.6522	0.6552	2.521	0.0117 *
age group: elderly	11.5679	1455.3981	0.008	0.9937
age group: middle age	-0.5557	0.9693	-0.573	0.5665
age group: youth	-1.9563	1.0396	-1.882	0.0599 .
socio-economic class: middle	1.2304	0.8051	1.528	0.1264
socio-economic class: upper	2.0144	1.0826	1.861	0.0628 .
residence at locality in years	-0.1295	0.0818	-1.583	0.1134
significant codes: 0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' ' 1
Dispersion parameter for binomial family taken to be 1; null deviance: 86.987 on 74 degrees of freedom; residual deviance: 72.288 on 67 degrees of freedom; AIC: 88.288; number of fisher scoring iterations: 14				

Step 2. Analysis of variance incorporating a chi-square test					
	df	deviance	residual df	residual deviance	Pr(>chi)
null			74	86.987	
gender	1	4.8886	73	82.099	0.02703 *
age group	3	3.8731	70	78.226	0.27550
socio-economic class	2	3.3975	68	74.828	0.18291
residence at locality in years	1	2.5399	67	72.288	0.18291
significant codes: 0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' ' 1	

domestic herbivore species were counted, including cattle, donkeys, camels, and sheep and goats, the latter two treated as a single "species" because they cannot be distinguished from the air. Herds of 10 or fewer animals were counted directly. Herds exceeding 10 animals were estimated and obliquely photographed using 35 mm digital cameras for subsequent counting (Georgiadis, 2011). To determine the economic losses due to livestock predation

by large carnivores, we first determined the relative frequencies of prey (livestock vs. wild herbivores) being killed by any species of carnivore (figure 8). The population (*N*) for possible carnivore prey was derived by averaging the census output for each prey category; sheep and goats (hereafter referred to as 'shoats'), cattle, camel, donkey and wild herbivores. Determining number for livestock present in Samburu County in any given year from 2010 to 2018 was derived by multiplying the relative frequency for livestock by *N*. Since the focus of this study was mainly on livestock predation by the large carnivores, we discarded the wild herbivore component (table 2).

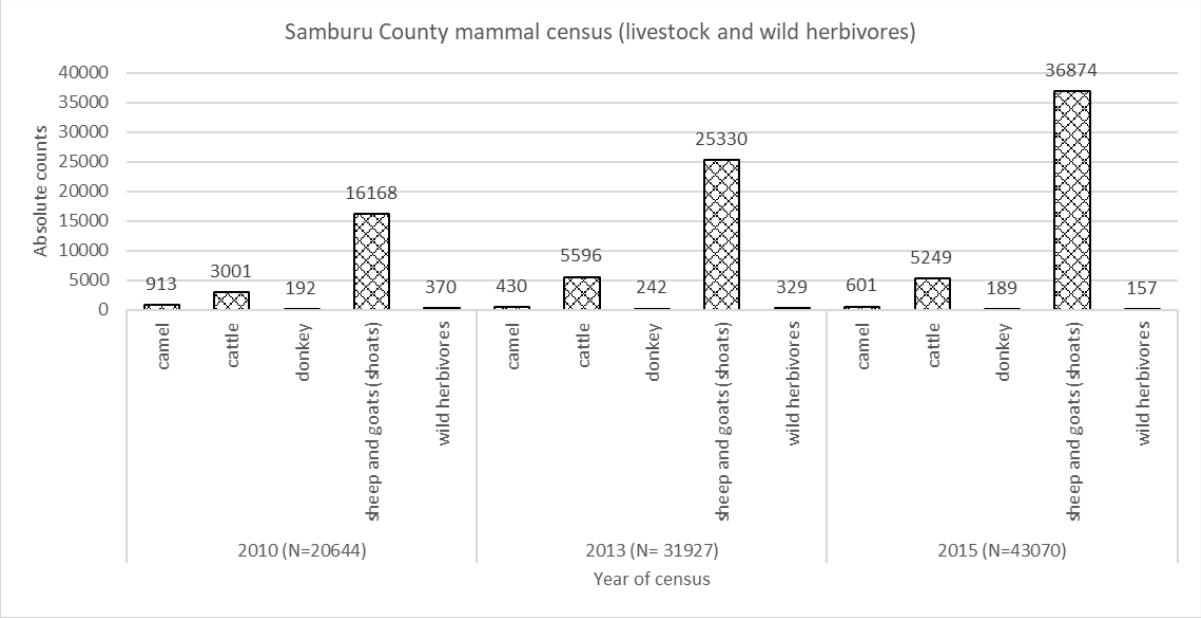


Figure 7. Directorate of Resource Surveys and Remote Sensing aerial mammal (domestic and wild herbivores) censuses for Samburu County.

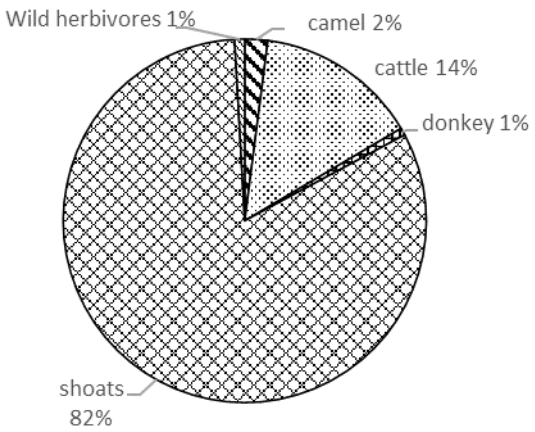


Figure 8. Relative frequencies of domestic and wild herbivores in Samburu County from 2010, 2013 and 2015 (N = 31880).

Table 2. Relative frequencies of livestock type based on an average of three animal census counts for the years 2010, 2013 and 2015 when the wild herbivores are excluded.

stock type	relative frequency
sheep and goats (shoats)	0.83
cattle	0.14
camel	0.02
donkey	0.01

To standardise data in terms of consistency of collection of human-carnivore conflict data from the years 2010 to 2018, only four Community Wildlife Conservancies (Meibae, Westgate, Ltungai and Namunyak) were selected to derive the livestock to wild herbivore ratio. The four study sites span across the major ecosystems within Samburu County; covering approximately 30% of the entire Samburu landscape (figure 1). To compute the ratio of each livestock type from the livestock populations per year, wild herbivore populations were excluded from the new analysis and relative frequencies derived from the averaged population totals per stock type as follows; shoats, cattle, camel and donkey. The cumulative totals for each stock type killed per large carnivore species (with the exception of striped hyaena which was excluded from our analysis due to missing data) for Samburu County were computed through extrapolation of the cumulative totals for each stock type killed in our study sites between the years 2010 to 2018 by factor *x* (where factor *x* = total area of Samburu County divided by the combined area of our study sites). Therefore, factor *x* (2 100 000 ha/561 204 ha) = 3.7. The postulated probability of livestock attacked by large carnivores was then used to compute the average numbers of each livestock type killed per annum by large carnivores in Samburu County from January 2010 to December 2018 (table 3).

Table 3. Average number of livestock type killed annually per large carnivore species in Samburu County in northern Kenya from January 2010 to December 2018.

livestock type	spotted hyaena			leopard			lion			African wild dog			cheetah			carnivores combined		
	day kills	night kills	day and night kills	day kills	night kills	day and night kills	day kills	night kills	day and night kills	day kills	night kills	day and night kills	day kills	night kills	day and night kills	day kills	night kills	day and night kills
sheep and goats (shoats)	124	308	432	203	209	412	60	89	149	190	0	190	51	0	51	628	606	1234
cattle	21	52	73	34	35	69	10	15	25	32	0	32	9	0	9	106	102	208
camel	3	7	10	5	5	10	1	2	4	5	0	5	1	0	1	15	15	30
donkey	1	4	5	2	3	5	1	1	2	2	0	2	1	0	1	7	8	15

Diurnal and nocturnal livestock predation incidences were investigated from January 2010 to December 2018 to determine actual carnivore species responsible; and, to monitor diurnal and nocturnal rates of livestock predation by lions, leopards, cheetahs, African wild dogs and spotted hyaenas per study location relative to livestock type. Woodroffe *et al.* (2005), Romañach *et al.* (2007) and Dickman, (2008); recommend the need, to check the validity of such long-term monitoring data on human-carnivore conflict through subsequent interviews. To address the above raised concern the Northern Rangelands Trust (NRT), a conservation NGO based in Isiolo County (https://www.nrt-kenya.org/), collects all human-wildlife conflict data through the Wildlife Conservancy Management Monitoring System (WCoMMS) which is a devolved standardized ranger based monitoring system for monitoring wildlife threats and keeping track of the abundance and distribution of key wildlife species in each community wildlife conservancy (NRT, 2013). For the purposes of this study, only data specific to human-carnivore conflict from January 2010 to December 2018 were extracted from the WCoMMS database collected and validated by NRT-trained community wildlife conservancy rangers using methods modified from Ogada *et al.* (2003) and Woodroffe *et al.* (2005). The economic losses incurred due to livestock predation by the large carnivores in Samburu County in terms of United States dollars (USD) were computed per carnivore species, carnivores as one cumulative group, and per stock type. Market rates for each livestock killed were computed based on comparative data from annual reports from the livestock market information system (LMIS) at the Ministry of Agriculture, Livestock and Fisheries in 2018

An average market rate was then computed for each livestock type (table 4). The perceived rates of livestock predation by the large carnivores (figures 3, 4) were then compared with the actual rates of livestock predation by the large carnivores (figures 9, 10) in Samburu County.

Finally, we facilitated the first ever locally organised one-day community carnivore conservation workshop in Samburu County, aptly themed; "*To conserve our carnivores is to conserve our environment and*

our pasturelands". The workshop took place on the 15th March 2018 at the Kalama Community Wildlife Conservancy in Samburu County with presentations on the management and conservation of wildlife in the area by researchers and community members (appendix 2). The aim of the workshop was to deliberate and discuss which practices would work best for a participatory community approach, that leads to an improved human-carnivore coexistence in Samburu County, northern Kenya.

Table 4. Average market rates in United States of America dollars (USD) for each livestock type in Samburu County within the context of January 2010 to December 2018 using comparative data from annual reports from the Ministry of Agriculture, Livestock and Fisheries.

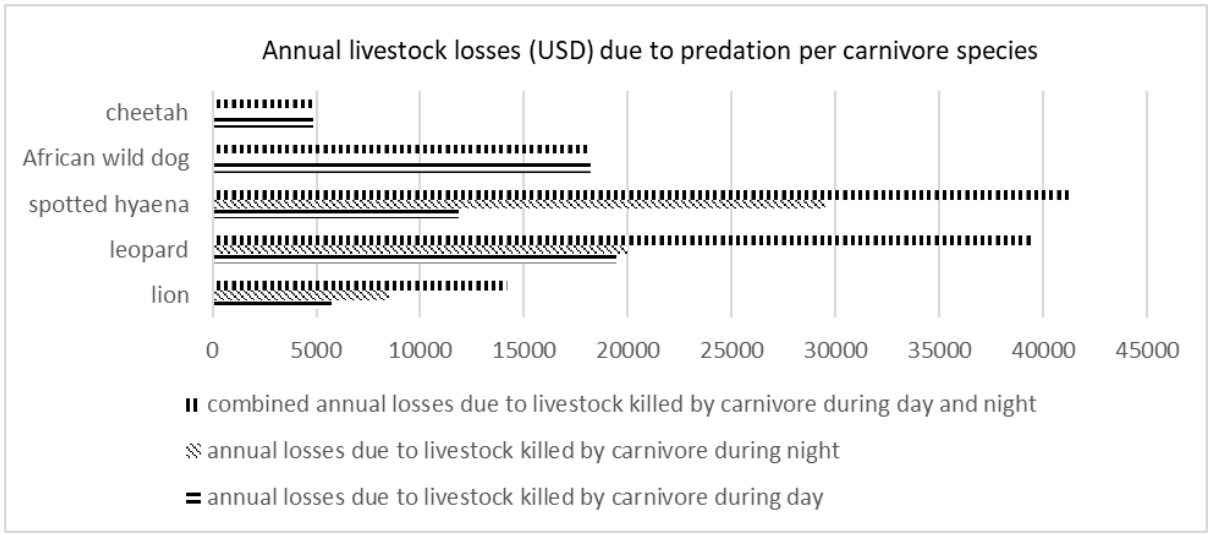
livestock type	high season rates (USD)	low season rates (USD)	average market rates (USD)
camel	550	350	450
cattle	450	130	290
donkey	120	40	80
sheep and goats (shoats)	50	20	35

RESULTS

Among the demographic variables assessed (gender, age, duration of residence, socio-economic status of each respondent representing a household), only gender was identified to significantly influence the capability of an individual to coexist with large carnivores in the landscape (table 1; figure 6).

Key highlights from respondents during the open-ended interview discussions included: shoats being the most preferred stock to rear due to their low maintenance costs, and high fecundity rates making them ideal for subsistence, and profitable through quick sales. When asked about their thoughts on local solutions to human-carnivore conflict the following talking points featured prominently; government compensation should be given for livestock killed, but regardless of compensation or lack of it, there should be no retaliatory killings of predators. The locals observed that conflicts with wildlife are inevitable therefore good husbandry practices such as close and/or vigilant herding during the day in addition to use of guard dogs and secure cattle sheds to protect livestock from night predatory attacks should be consistently utilised. The locals also expressed interest in being actively consulted and involved in local community wildlife education and awareness programmes. Shoats were uniformly perceived by all respondents (100%) as the most attacked livestock during the day and most attacked livestock over time by the large carnivores (figure 3a,b). Cattle were perceived by 67% of respondents as the most attacked livestock during night attacks by the large carnivores (figure 3c). The African wild dog was perceived by 48% of respondents as the most problematic predator of shoats. However, 32% of respondents believed the cheetah was the most problematic predator of shoats (figure 4a). The lion was perceived by 83% of respondents as the most problematic predator of large stock (cattle, donkey and camel) (figure 4b). The spotted hyaena was perceived by 53% of respondents as the overall most problematic predator of all livestock types. However, 31% of the respondents believed the lion was the overall most problematic predator of all livestock types (figure 4c).

In the structured section of the questionnaires, 79% of respondents were in favour of large carnivore presence in Samburu County due to an assortment of perceived benefits such as tourism and tourism related benefits such as employment to locals as tour guides and sale of local artefacts sold as souvenirs (figure 5a). 95% of respondents had an overall positive attitude towards large carnivores in Samburu County (figure 5b). 67% of respondents had a high overall tolerance towards livestock predation by large carnivores in Samburu County (figure 5c). 73% of respondents supported the concept of coexistence with large carnivores (welcoming carnivore presence) in Samburu County (figure 5d).



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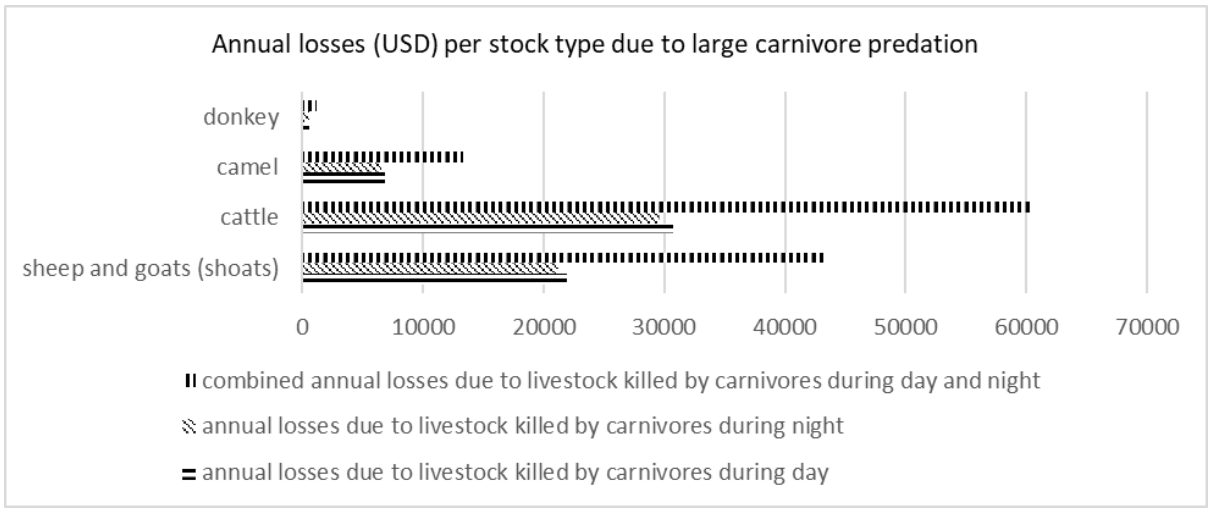

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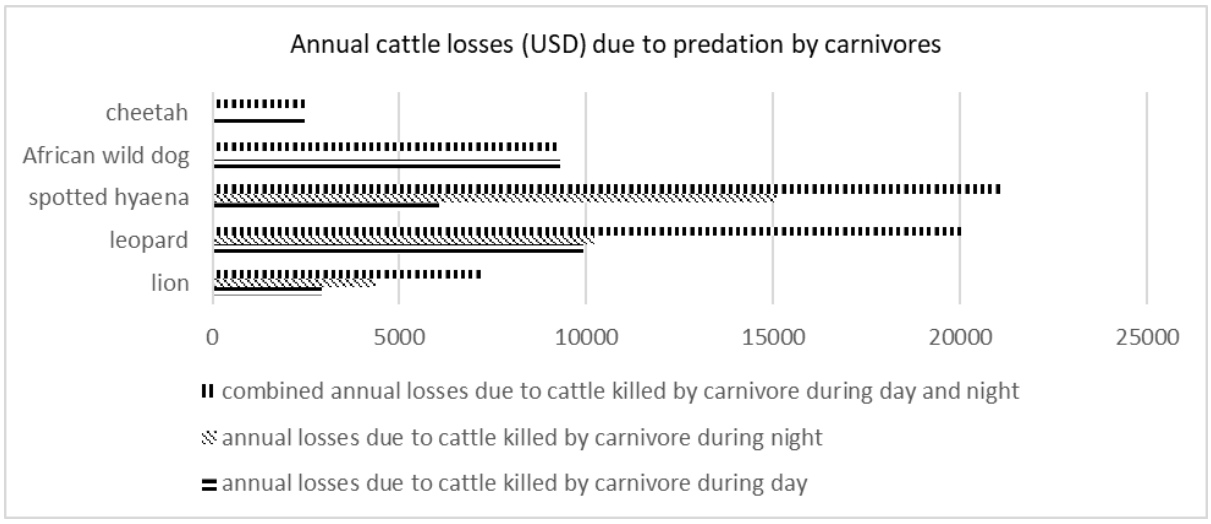
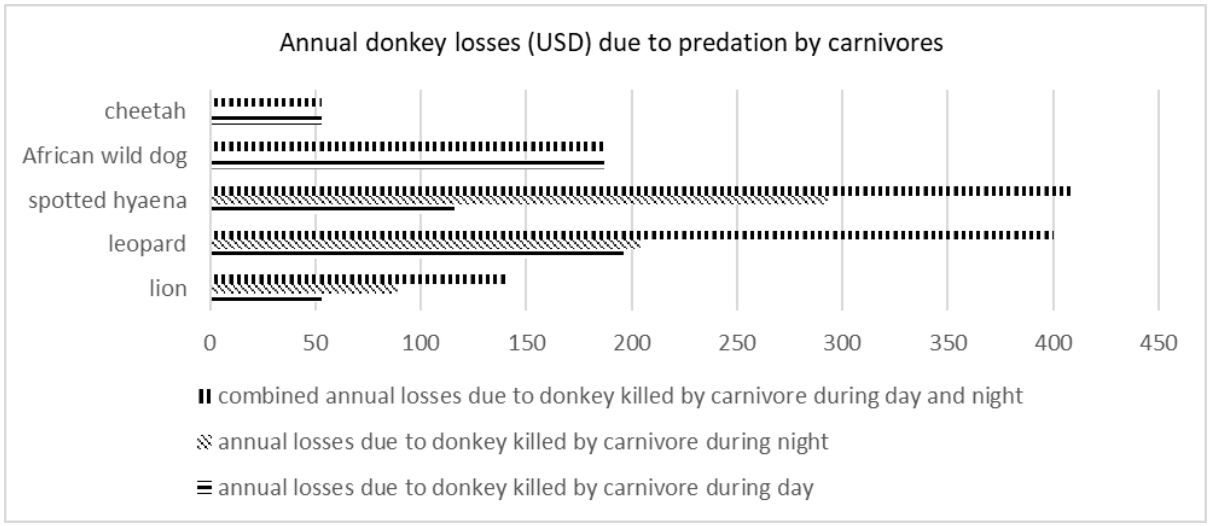
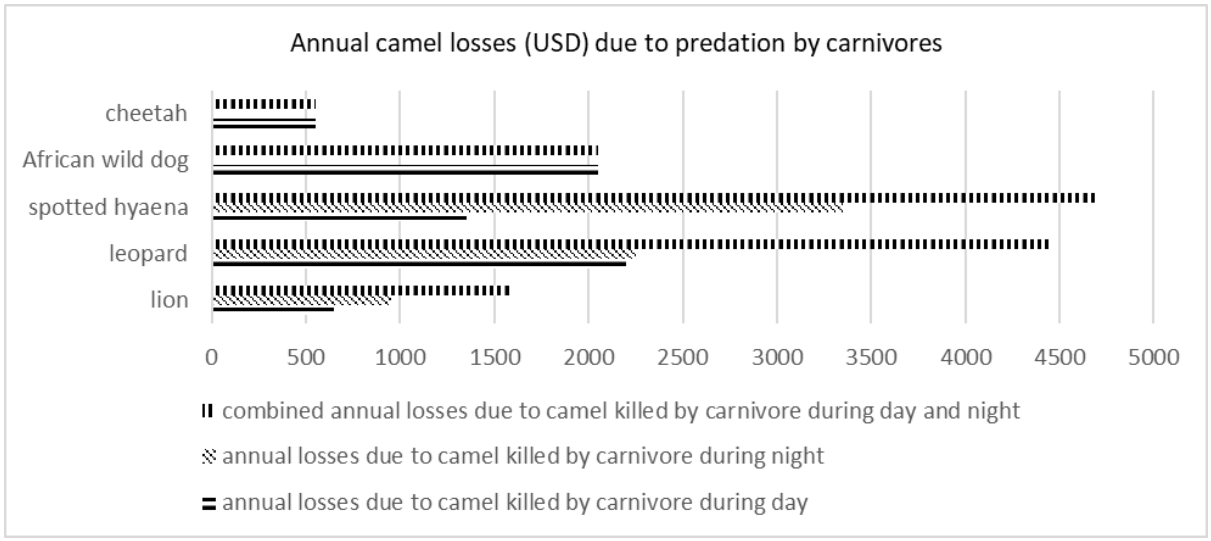


c.

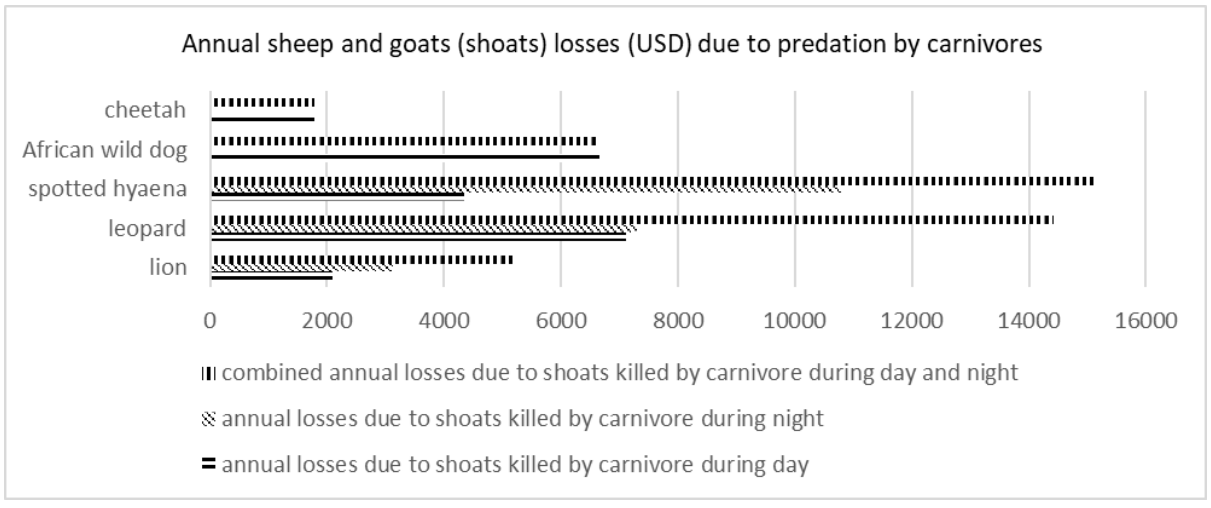
Figure 9 (a, b, c). Annual livestock losses, losses per stock type and cattle losses in United States of America dollars (USD) due to predation by large carnivores from January 2010 to December 2018 in Samburu County, northern Kenya.



a.



b



c.

Figure 10. Annual donkey (a), camel (b) and shoats (c) losses in United States of America dollars (USD) due to predation by large carnivores from January 2010 to December 2018 in Samburu County, northern Kenya.

According to the DRSRS aerial census data, shoats were the most abundant (82%) followed by cattle (14%) irrespective of the census year (figure 7). The relative frequencies of livestock and wild herbivore

populations that made up *N* (31 880 herbivores) were shoats (0.82): cattle (0.14): camel (0.02): donkey (0.01): wild herbivores (0.01) (figure 8). Numbers of individual wildlife herbivore species collectively combined to form one super group called 'wild herbivores' were extremely low relative to those of domestic herbivores. The average numbers of each livestock type killed by large carnivores per annum in Samburu County from January 2010 to December 2018 were consequently computed (Table 3). The annual economic costs of livestock predation in USD were then computed per carnivore species, carnivores as one cumulative group, and per stock type (figures 9, 10). Even though some proportions of domestic herbivores killed may have been immature livestock, we did not have the means to verify such vital information since it had not been collected in our NRT data set. We recommend that this type of data be collected for a future analysis on the impact of immature-adult livestock ratios on human-carnivore conflict. We therefore computed the market rates for adult livestock types only (Table 4). Other related information such as livestock losses due to disease, drought or theft during the study period was not available and/or accessible to our conservation project team, and therefore excluded from our analyses and discussions.

Amongst the large carnivores, the spotted hyaena was responsible for the highest economic losses due to livestock predation per stock type and livestock predation in general followed closely by the leopard (figures 9a, c; 10a, b, c). The cheetah was responsible for the least economic losses due to livestock predation (figure 9a). The highest economic losses were incurred when large carnivores preyed on cattle and least economic losses were incurred when large carnivores preyed on donkeys (figure 9b).

Two key policy issues emerged during the one-day community carnivore conservation workshop in Samburu County composed of 46 participants, majority being representatives of the Samburu pastoralist community; (1) the perceived lack of equitable sharing of benefits from wildlife earnings nationally with local communities inadvertently reinforces negative views towards wildlife in general and carnivores specifically; (2) community goodwill to provide space for wildlife persists. Future workshops will address other pertinent issues such as association between livestock predation and illegal killings of large carnivores.

DISCUSSION

When the actual predation rates on livestock by the large carnivores were compared to the perceived rates of livestock predation by the same, the respondents correctly identified the spotted hyaena as the most problematic predator overall. However, the lion was incorrectly identified as the most problematic predator for large stock (cattle, donkey, and camel), instead of the spotted hyaena. The locals also incorrectly identified the African wild dog as the most problematic predator of shoats instead of the spotted hyaena. This has an implication on the ecology and conservation efforts for the African wild dog in the Samburu pastoralist landscape in northern Kenya. The African wild dog could erroneously be persecuted in the Samburu pastoralist landscape on the false assumption that it is the most problematic predator of shoats. Therefore, community wildlife education efforts in Samburu County are necessary to prevent its extirpation from the Samburu pastoralist landscape. The African wild dog is currently listed as Endangered in the International Union for Conservation of Nature (IUCN) Red List (https://www.iucnredlist.org/species/12436/166502262). The locals correctly identified shoats as the most attacked livestock overall by the large carnivores. Generally, even though the number of cattle killed paled in comparison to those of shoats killed, the greatest economic losses were incurred due to predatory attacks on cattle by the large carnivores in Samburu. This was due to the financial worth of one head of cattle being worth several head of shoats. During our semi-structured questionnaire survey in 2018, locals persistently expressed their dislike for the spotted hyaena due to its notoriety in livestock predation. This is contrary to findings by Yirga *et al.* (2014) who studied community tolerance to livestock predation by the spotted hyaena in human-dominated landscapes in northern Ethiopia. Hyaenas are particularly detested by the general citizenry and have always been negatively depicted in popular literature and/or folklore according to Kruuk (1972b), Mills & Hofer (1998), Maude & Mills (2005), and Romañach *et al.* (2007).

Our research findings mirror a similar pattern to the study by Mkonyi *et al.* (2017) in the Tarangire ecosystem in northern Tanzania, in terms of order of prowess in cattle predations by large carnivores. In their study, the spotted hyaena was foremost, followed in descending order by leopard, African wild dog, lion and cheetah. Our research findings that attribute most livestock predatory attacks by the spotted hyaena occurring at night, mirror findings by Kruuk (1972b), Mills (1990), Ogada *et al.* (2003), Kissui (2008b), Maclennan *et al.* (2009), and Yirga & Bauer (2010) who indicate that spotted hyaena attacks livestock that stray but may also break into poorly constructed enclosures at night. Our research findings indicate that gender significantly influences the capability of an individual to coexist with large carnivores in the Samburu pastoralist landscape of northern Kenya. This is an interesting aspect that requires further assessment in a future study to look at

ways of harnessing any prospective conservation benefits to mitigating future conflicts between local communities and large carnivores.

Our DRSRS aerial census data indicate that livestock numbers exceed wild herbivores in Samburu County by a ratio of 9:1. According to Woodroffe & Frank (2005) and Bagchi & Mishra (2006), predators have been found to kill livestock in areas with livestock abundances that greatly exceed wild prey contrary to Maclennan *et al.* (2009). In effect, reducing livestock densities not only reduces the likelihood of predator attacks but it also has the potential to increase the sustainability of livestock production, improve the quality of livestock, and increase the carrying capacity for wild prey resulting in a robust ecosystem (Pimentel & Kounang, 1998). However, livestock keeping in numbers has been a historical strategy for pastoralists in Africa. To that end, advocating for reduced stocking densities to mitigate conflict is a delicate conservation strategy that requires a balanced mixture of tactful environmental policies and political correctness (Dregne, 1983; Prins *et al.*, 2000; Adhola, 2019).

In conclusion, even though human-wildlife conflict is inevitable, it can be mitigated. According to our study, it is apparent that perceived rates of livestock predation vis-à-vis actual rates of livestock predation by large carnivores in a modern pastoralist community setting are dissimilar. Perceptions are often linked to attitudes, and both are influenced positively or negatively by conservation knowledge or lack of it. Even though community goodwill to provide space for wildlife persists, the perceived lack of equitable sharing of benefits from wildlife earnings nationally with local communities inadvertently reinforces negative views towards wildlife in general and carnivores specifically. Therefore, an increased participatory community approach in the management and conservation of wildlife needs to be addressed appropriately by policy makers for the benefit of the communities and wildlife.

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APPENDIX 1. SAMPLE OF SEMI-STRUCTURED QUESTIONNAIRE USED TO COLLECT ETHNOGRAPHIC DATA IN SAMBURU COUNTY.

Household questionnaire
Household code (location/boma n°).....Date.....
Interview location.....
GPS co-ordinates.....Survey no.....
County..... Division.....
Interviewer's name .....
Language used to conduct interview.....

Questionnaire: Community perceptions towards African large carnivores in Samburu.
This questionnaire is for research purposes only, conducted in selected households within community conservancies in Samburu County. Any information you share will be kept confidential. Your answers will not affect government policies, such as taxes or compensation.

Interviewee's details

1. Property/community name where you live.....
2. Property type: Group ranch/conservancy..... Squatter ..... other (specify).....
3. Mother tongue/ ethnic language.....
4. Male..... Female.....
5. Age (specify interviewee relationship to the entire household).....
6. How long have you lived here.....
   Where were you living before moving to this place (if moved in recently)
7. Highest level of education.....
8. How many family members: men...., women...., young men....., young women....., boys..... and girls..... live in this household?
9. Do you or any member of family own livestock yes..... no.....
   If yes which of the following types: camel..... cow.....donkey.... sheep....goat
   If no move to question #20
10. How are the livestock kept at night? In a shelter..... in the open..... other.....
    Do you keep all your livestock together in one place at night?
    yes..... no.....
    If yes, where are they
    kept?.....
    If no, how are they
    kept?.....
11. Do you herd all the animals together as one group during the day? Yes..... No.....
    If no, how are they taken to pastures each day? .....
12. Who herds the livestock during the day?
    family member..... professional/hired herder(s)..... free ranging.....other.....
    If yes for family member, which family member(s)?
    If yes for professional/hired herder, age and gender: e.g., young men only, boys *etc*
13. Do you own any dogs? yes..... no.....
    If yes, how many..... and for what purpose(s)?.....
14. How do you graze livestock with young
    ones?.....
15. In which areas do you prefer to graze your cattle?.....
16. Which is the most common livestock type kept by this household (donkey, cow, camel, sheep & goats)?.....
    Do you have any reason(s) for this preference?.....
17. Which of the following categories best suits the general number of livestock in your household: a few ..... moderate..... a lot/many.....

18. What main challenges do you (or your family) face(s) when rearing your livestock from day to day?
    .....
    .....

19. Which type(s) of livestock (donkey, cow, camel, sheep and goats) in your household are the most prone to attack by wild carnivores in general and where (in bomas at night or while grazing during day) or other (specify).....list in order of decreasing frequency, starting with most frequently taken e.g., goats/sheep, cows etc..
.....
.....

20. What do you think about the wild animals living in the area around this household?
.....
.....

Community Practices and Attitudes towards predators

21. Given a choice, would you prefer to have the following predators on your property? Any reason(s) why? (pictures of the carnivores listed to be shown to respondent)

predator	yes	no	don't know	reason(s)
cheetah				
lion				
spotted hyaena				
leopard				
African wild dog				
striped hyaena				

22. In your opinion, what is the best way to deal with large carnivores that stray into villages and kill livestock? (*choose only one option*)
    a) They should be killed before they attack livestock
    b) They should be captured by the Kenya Wildlife Service and returned to the park and prevented from ever coming back to community land
    c) People should be taught how to avoid them, and how to prevent their cattle from being attacked, but the carnivores should not be killed in retaliation
    d) There ought to be compensation for the livestock lost to carnivores, but even without compensation, I don't think the carnivores should be killed in retaliation

23. Please rank the following predators in terms of their effect upon cattle in the district (1=highest impact, 6= lowest impact), and then rank them in terms of effect on sheep and goats (1= highest impact, 6= lowest impact). (Interviewer: write n/a if interviewee does not think the predator attacks livestock.)

predator	cattle	sheep and goats (shoats)
leopard		
African wild dog		
lion		
spotted hyaena		
striped hyaena		
cheetah		

Comments

24. What do you think are the most effective ways of protecting livestock from predators?
.....
.....
.....

25. Do you use these methods? If not, why not?
.....
.....
.....
26. Are there any solutions you would suggest to promote the co-existence of people and predators?
.....
.....
.....

THANK YOU FOR PARTICIPATING IN THIS SURVEY!

Interviewer's comments (to be filled by interviewer AFTER interview is complete):

APPENDIX 2. CARNIVORE CONSERVATION WORKSHOP'S LANDSCAPE AND PORTRAIT BANNERS.