

Full Length Research Paper

## Livestock depredation by wild carnivores in the Eastern Serengeti Ecosystem, Tanzania

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**Livestock losses caused by wild carnivores foster negative attitudes and promote retaliatory killings, threatening the future of carnivore populations. Measures to bring about coexistence between humans and carnivores are of great importance to carnivore conservation. The study questionnaire survey involved 180 respondents from Eastern Serengeti tribes (Maasai and Sonjo), all of which owned livestock. Reported livestock depredation in 2016 by the Maasai tribe (pastoralists) was higher than that by the Sonjo tribe (agropastoralists) because the Maasai own many livestock and live closer to the Serengeti National Park boundary. Most livestock depredation occurred during the day when livestock were out feeding and during the dry season. Spotted hyenas (*Crocuta crocuta*) were the most commonly reported carnivore responsible for livestock depredation. Livestock depredation caused by lions (*Panthera leo*) and cheetahs (*Acinonyx jubatus*) was only reported by the Maasai tribe. Leopards (*Panthera pardus*), jackals (*Canis spp.*), and African wild dogs (*Lycaon pictus*) were responsible for more livestock depredation of the Maasai livestock. A similar study was performed six years earlier, in 2010. Therefore, this study brings insight to the temporal changes of livestock depredation patterns and changes of carnivorous species causing livestock depredation in the Eastern Serengeti ecosystem. The Maasai and Sonjo are the main tribes living in the Eastern Serengeti ecosystem. The Maasai preferably use knives and/or spears, whereas the Sonjo use bows and poisoned arrows to protect their livestock against depredation by wild carnivores, and both tribes prefer the use of multiple techniques to increase the efficiency of livestock protection.**

**Key words:** Boma, herding, Maasai, preferences, Sonjo, tribe, weapons.

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### INTRODUCTION

Human-wildlife conflict presents an increasing challenge to conservation biology worldwide, and developing novel

solutions for the coexistence between humans and different species, particularly carnivores, has been a

research focus (Dickman, 2010; Gehring et al., 2010; Woodroffe et al., 2005).

Conflicts escalate when carnivores attack livestock, thereby hampering carnivore conservation (Gehring et al., 2010; Megaze et al., 2017; Treves & Karanth, 2003; Woodroffe et al., 2005). Livestock depredation by large carnivores negatively impacts coexistence between humans and such species (Holmern et al., 2007; Karlsson and Johansson, 2010; Mwakatobe et al., 2013). Livestock represents a source of income to pastoralist communities (Mwakatobe et al., 2013). Hence, if depredation incidences increase, household livelihood quality tends to be compromised (Ogada et al., 2003). Additionally, as the human population grows, particularly in third world countries, human-carnivore conflict increases (Pirie et al., 2017) which hampers the future of large carnivores.

In rural areas, especially those close to protected areas, land for livestock husbandry is open access, which attracts pastoralists to such places. Most people in Africa live in rural areas and there are many trade-offs encountered by people living adjacent to protected areas. The livelihoods of such societies have been compromised due to the costs associated with wildlife interactions (Adams and Hutton, 2007; Nana and Tchamadeu, 2014; Vedeld et al., 2012). Thus, people living adjacent to protected areas tend to have negative attitudes towards wildlife as they impact their livelihoods negatively (Dickman et al., 2014; Romanach et al., 2007; Røskaft et al., 2007). For instance, some communities tend to respond to attacks on their livestock by killing carnivores (Kissui, 2008; Lindsey et al., 2013; Mwakatobe et al., 2013).

Living close to protected areas may have enormous costs, and the human-carnivore conflict in such communities is high (Carter et al., 2012; Holt, 2001; Lindsey et al., 2017). To reduce livestock depredation, local people may employ various traditional husbandry techniques to kill problematic carnivores, with certain techniques being more effective than others (Ed and John, 2001; Lyamuya et al., 2016b; Mwakatobe et al., 2013). Most of these techniques are temporary and inefficient, therefore a long-term solution is needed (Dickman, 2010).

Measures to curb livestock depredation by wild carnivores includes different approaches depending on the culture and livestock keepers (Dickman, 2010). Countries with no consolation schemes for livestock losses from predators use herders, who have developed different guarding techniques. Guarding livestock against depredation has been a successful tool in countries

where labour is cheap (Lyamuya et al., 2016b). In the modern world, however, as in Norway, livestock are allowed to roam freely without shepherds because labour costs are high (Widman et al., 2017).

Livestock guarding elsewhere, for instance in the Maasai and Sonjo communities in Tanzania, is a family obligation and is mostly performed by boys and girls who are denied access to school by their parents (Ikanda and Packer, 2008). Thus, they might be less motivated to perform their duties effectively due to lack of incentives (Maclennan et al., 2009). Additionally, the Maasai and Sonjo communities own large flocks of livestock, and herding a large flock might reduce protection from predation. It is easier for carnivores, such as African wild dogs, which normally move in packs, to sneak in and attack large herds of livestock (Lyamuya et al., 2016b).

Many studies in Africa have focused on quantification of reported livestock depredation by wild carnivores in relation to the distance from protected areas. Such studies have been conducted in low human density areas adjacent to protected areas (Holmern et al., 2007; Kissui, 2008; Mwakatobe et al., 2013; Patterson et al., 2004; Rasmussen, 1999). Few studies have evaluated how tribe, age and education may affect how people report numbers of depredated livestock. Each tribe has its own way of living which may influence how people report livestock depredation by wild carnivores. Age can be a predictor of wealth associated with livestock in pastoralist tribes, while education will elucidate whether educated people have more efficient methods of protecting their livestock against depredation. We performed a comparison study between the two tribes (Maasai and Sonjo) to quantify reported livestock depredation by wild carnivores and assess the techniques preferred by both communities in protecting their livestock against depredation.

The presence of large carnivores in any ecosystem is important due to their vital ecological and economical roles (Durant et al., 2011). Monitoring livestock depredation (Spira, 2014) and assessing the preferred techniques used by local communities to safeguard their livestock is therefore relevant to develop good, solid coexistence measures that will enhance the future of all existing carnivore species in the face of human populations. In this study, we addressed three objectives:

- (1) To assess if tribe (Maasai and Sonjo), age and education have an effect on the number of livestock reported depredated in a questionnaire;
- (2) To determine wild carnivore species responsible for livestock depredation and;

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(3) To assess the preferred techniques of protecting livestock from carnivores within the two ethnic groups.

## MATERIALS AND METHODS

### Study area

The study was conducted in the Eastern Serengeti ecosystem, in the Loliondo Game Controlled Area (LGCA; Figure 1). The LGCA lies between 1°40'S and 2°50'S and 35°10'E and 35°55'E, covering a total area of about 4,500 km<sup>2</sup> in the Maasai land (Lyamuya et al., 2014a). On the northern side, it borders Narok County (Kenya), on the western side it borders Serengeti National Park (SNP), and on the southern side it borders the Ngorongoro Conservation Area (NCA). The area includes diverse vegetation types, ranging from forests, woodlands, wooded grasslands, shrub lands, and grasslands (Lyamuya et al., 2016a). Administratively, the area is under control of the District Council, and the District Game Officer (DGO) manages tourism hunting in the LGCA. Hunting without a licensed permit is illegal (MNRT, 2013), and hunting concessions are under the Ortello Business Company of Saudi Arabia. LGCA is the home to the Maasai and Sonjo tribes, the former tribe being dominant. The Maasai people are pastoralists, whereas the Sonjo people are agro-pastoralists (Lyamuya et al., 2014a; Maddox, 2003), where both tribes keep cattle, sheep and goats. An increase in the human population has reduced the available grazing space and resulted in the increasing livestock population grazing on a smaller piece of land results in land and environmental degradation (Lyamuya et al., 2014a). The Maasai people live close to the park boundary, while the Sonjo people live slightly further away (Lyamuya et al., 2016b). Thus, carnivore abundance is higher in the Maasai land compared to the Sonjo land (Maddox, 2003).

### Data collection

Data collection was performed from September to November 2016. A sample size above 100 respondents tends to give a broader idea about the information given by respondents, and reduces the biasness of the data (Delice, 2010). We collected data from six villages, in each of which we randomly selected 30 respondents to acquire better details and to ease the data collection work. To be objective we employed a random sampling technique which reduces bias and allows us to cover most of the villages.

A total of 180 respondents were interviewed from six villages, including three villages from the Maasai tribe (Ololosokwan, Oloipiri, and Soitsambu) and three from the Sonjo tribe (Yasimdito, Samunge, and Sale). From each village, 30 respondents were randomly selected. Only one respondent was interviewed from each household. We used local people to introduce us to all interviewed households to acquire confidence and readiness to speak openly. After arriving at a household, we introduced the project and asked if they were ready to answer the questions regarding livestock depredation by wild carnivores. All interviewed persons agreed to give the requested information and we assured them to use their information only for the purpose of our research and as advice to the government. Additionally, we assured their anonymity by hiding their identities. More males were interviewed than females because in the Maasai and Sonjo tribes, men speak on behalf of the household. Females are never allowed to speak openly in the presence of their husband.

Therefore, the sample included more male ( $n = 144$ ) than female ( $n = 36$ ) respondents, as females were interviewed only in the absence of their husband. The survey was conducted through a

semi-structured questionnaire employing face-to-face interviews, and questions were in both closed-ended and open-ended. The language of the interview was Swahili for those respondents who spoke it well, and sometimes, a mix of Maasai and Sonjo languages were used by local translators for those respondents who did not understand Swahili clearly.

The information gathered from the respondents was: tribe, gender, age, education level, whether their livestock had been attacked by large carnivores over the last twelve months in the boma or in the pasture (yes, no), when was the last livestock depredation (year), what was the time of depredation, where did the depredation occur, what type of livestock were depredated (cattle, sheep, and goats), what was the number of livestock depredated, what was the carnivore species responsible for the depredation, and what were their herding equipment preferences (Figure 1).

### Data analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 21 (IBM, 2012). The significance level was set to be below 0.05 ( $p < 0.05$ ). Binary logistic regression analysis (enter method) was performed to determine the probabilities of perceived number of carnivore-induced depredations. Independent variables in the model were (tribe, age and education).

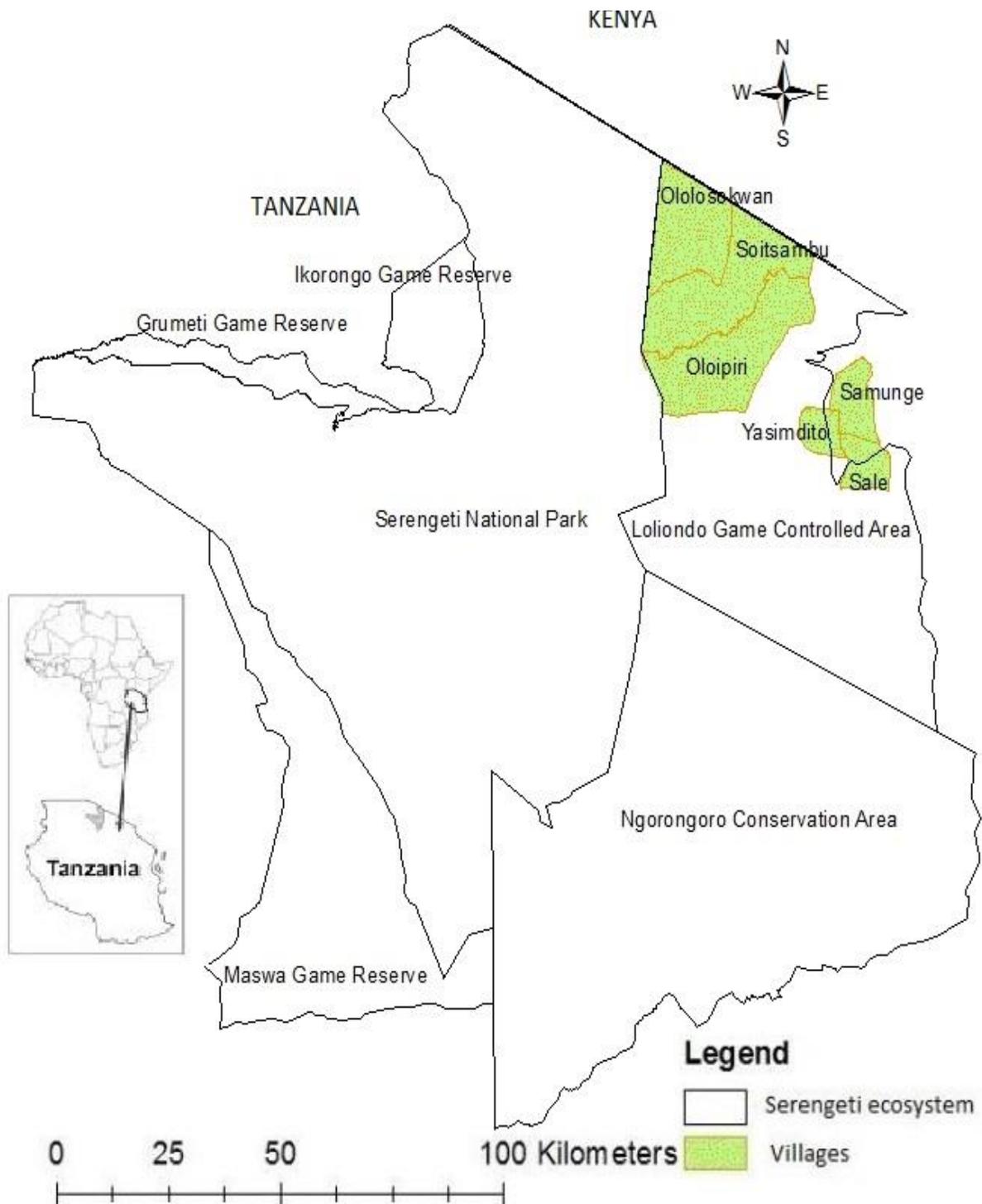
One-way analysis of variance (ANOVA) tests were carried out on the perceived number of livestock depredation and depredation rate between the Maasai and the Sonjo tribes. Chi-square tests determined the differences between the two ethnic groups on the following variables: year of livestock depredation, time (day/night) of depredation, where (boma/pasture) depredation occurred, season (dry/wet) of depredation, type of livestock that was depredated, number of livestock that were depredated, identity of the carnivore responsible for the depredation and herding equipment preferences.

## RESULTS

### Demographic variables

The sampled population was from two ethnic groups (Maasai and Sonjo), and respondents were above 18 years old. Age categories were youth (18 to 35 years; Maasai;  $n = 45$ , Sonjo;  $n = 37$ ), adult (36-49 years; Maasai;  $n = 21$ , Sonjo;  $n = 37$ ) and elder (>50 years; Maasai:  $n = 24$ , Sonjo;  $n = 16$ ). Educational level for the respondents ranged from no education (Maasai;  $n = 32$ , Sonjo;  $n = 12$ ), primary education (Maasai;  $n = 48$ , Sonjo;  $n = 72$ ) and secondary education (Maasai;  $n = 10$ , Sonjo;  $n = 6$ ).

We interviewed 180 household members (90 respondents from each tribe), of which 135 (75.0 %) had experienced livestock depredation and 45 (25.0 %) had not experienced livestock depredation over the previous 12 months. A total of 662 livestock (cattle = 105, goats = 310, and sheep = 247) were depredated by wild carnivores ( $\bar{x} = 13.2 \pm 23.9$ ,  $n = 135$  per household, excluding zeros).

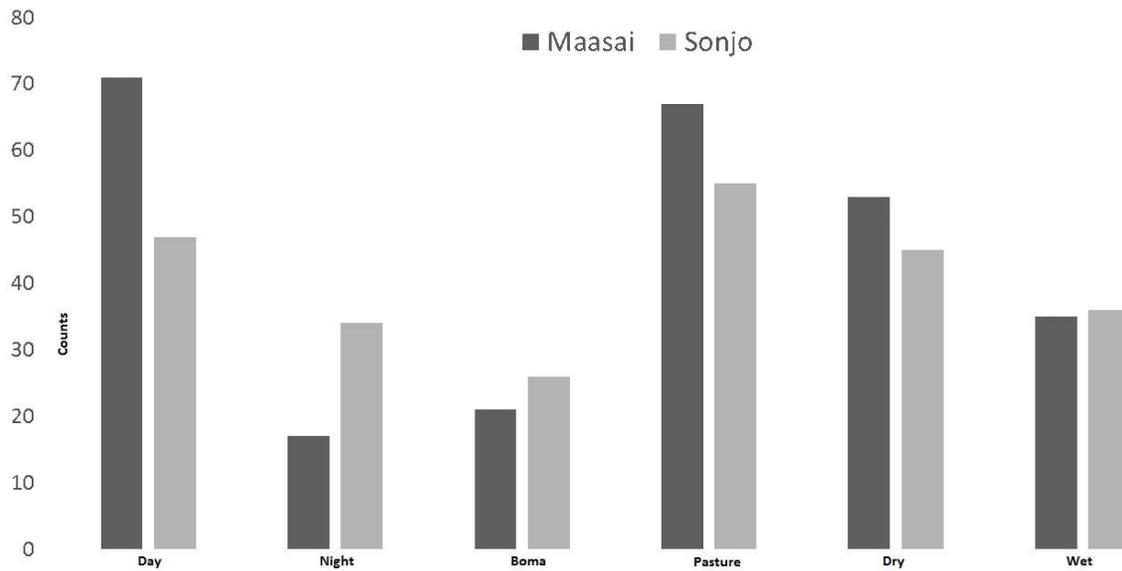


**Figure 1.** Map showing the study villages (Ololosokwan, Soitsambu, Oloipiri, Samunge, Sale, and Yasimdito) in the Eastern Serengeti ecosystem.

**Tribe**

Different tests (excluding zeros) were carried out with

reported livestock depredation number versus age, education and tribe. Tribe was the only predictor variable that significantly explained the number of livestock



**Figure 2.** Livestock depredation depending on the time of depredation, where it occurred and in what season it occurred.

**Table 1.** Carnivore species reported for livestock depredation.

Tribe	Spotted hyena	Leopard	Jackal	Lion	African wild dog	Cheetah	Total depredation
Maasai N	51	33	34	38	14	11	181
%	28.2	18.2	18.8	20.9	7.7	6	100
Sonjo N	32	16	6	0	10	0	64
%	50	25	9.4	0	15.6	0	100

\*Some respondents had more than one attack.

depredations (t-test;  $t = 6.696$ ;  $df = 133$ ,  $p < 0.0001$ ). The other two variables were insignificant (age;  $\rho = -0.014$ ,  $p = 0.869$ ; education;  $F = 1.379$ ,  $df = 2$  and  $132$ ,  $p = 0.255$ ). The reported rate of depredated livestock (yes, no) was significantly different between the two tribes (yes: Maasai=60%, Sonjo=40%; and no: Maasai=20%, Sonjo=80%) ( $\chi^2 = 23.1$ ,  $df = 1$ ,  $p < 0.0001$ ). The Maasai tribe ( $\bar{x} = 19.1 \pm 29.2$ ,  $n = 81$ ) experienced much higher livestock depredation than the Sonjo tribe ( $\bar{x} = 4.3 \pm 4.0$ ,  $n = 54$ ) ( $F = 13.6$ ,  $df = 1$  and  $133$ ,  $p < 0.0001$ ). The Maasai own more livestock ( $\bar{x} = 295 \pm 306.5$ ,  $n = 90$ ) than the Sonjo ( $\bar{x} = 72.2 \pm 55.4$ ,  $n = 90$ ). Additionally, the livestock depredation rate per 1000 livestock was significantly higher in the Maasai ( $\bar{x} = 6.9 \pm 10.8$ ,  $n = 78$ ) than in the Sonjo ( $\bar{x} = 0.4 \pm 0.5$ ,  $n = 54$ ) ( $F = 19.8$ ,  $df = 1$ ,  $p < 0.0001$ ). More incidences of depredation occurred during 2016 (75%), compared to previous years (25%) ( $\chi^2 = 32.3$ ,  $df = 1$ ,  $p < 0.0001$ ). Depredation occurred most frequently during the day in both tribes; however, it was significantly more common during the night in the Sonjo

tribe ( $\chi^2 = 10.3$ ,  $df = 1$ , and  $p = 0.001$ ) (Figure 2). In addition, livestock depredation occurred more frequently in the pasture land than in the boma ( $\chi^2 = 6.2$ ,  $df = 1$ ,  $p = 0.046$ ; Figure 2). Finally, livestock depredation occurred more frequently during the dry season (Figure 2).

### Carnivore species responsible

A significant difference was found in the frequency of attacks by different carnivore species (that is, lion, cheetah, leopard, spotted hyena, African wild dog, and jackal) between the two tribes ( $\chi^2 = 27.7$ ,  $df = 5$ ,  $p = 0.002$ ; Table 1). In both ethnic groups, spotted hyena was the most common predator (Table 1). Lions and cheetahs were only found to cause livestock depredation in the Maasai land (Table 1), while leopards and jackals caused more livestock depredation in the Maasai tribe than the Sonjo tribe (Table 1). Similarly, livestock depredation by African wild dogs was higher in the Maasai tribe than the

**Table 2.** Herding equipment preferences with the responses (yes or no) regarding whether the household had experienced livestock depredation.

Livestock depredation	Tribe	Spear and/or knives and club	Combination	Bow and poisoned arrows	Use of domestic dogs	No equipment	Total
-	Maasai N	25	49	0	14	2	90
	%	27.8	54.4	0	15.6	2.2	100
-	Sonjo N	0	41	33	15	1	90
	%	0	45.6	36.7	16.7	1.1	100
Yes	-	23	70	20	21	1	-
%	-	92	77.8	60.6	72.4	33.3	-
No	-	2	20	13	8	2	-
%	-	8	22.2	39.4	27.6	66.7	-

Sonjo tribe, though the difference was not statistically significant ( $\chi^2 = 0.8$ ,  $df = 1$ ,  $p = 0.38$ ; Table 1).

### Preferences of herding equipment

The study results revealed a difference in the preferences of herding equipment between Maasai and Sonjo herders ( $\chi^2 = 69.9$ ,  $df = 5$ ,  $p < 0.0001$ ; Table 2). Only three herders did not use any weapon (Table 2). Maasai herders ( $n = 25$ ) used more spears and/or knives and clubs (Table 2), whereas Sonjo herders ( $n = 33$ ) preferred to use bows and poisoned arrows (Table 2). Both tribes rarely used domestic dogs, which would alert them to the incoming carnivores during the night or while in the pastures (Table 2). There was a statistically significant difference in the use of herding equipment and the livestock depredation frequencies (yes, no) ( $\chi^2 = 10.7$ ,  $df = 4$ ,  $p = 0.03$ ; Table 2).

### DISCUSSION

A study similar to the present study was performed in 2010 by Lyamuya et al. (2016b) who studied livestock and herding efficiencies in relation to the livestock loss caused by wild carnivores. This study adds value in assessing the temporal change six years after the last study and providing insight into predation patterns. African wild dogs at that time were the main predator causing livestock losses in the Sonjo land; however, our results found a different pattern. Spotted hyenas were the most common predator among both tribes due to their higher density in the Serengeti ecosystem and ability to commute in both protected and unprotected areas (Goymann et al., 2001). The frequency of livestock depredation by hyenas was higher than that of any other predator (i.e. lion, cheetah, leopard, African wild dog and jackal), as also found in the western Serengeti by Holmern et al. (2007) and Mwakatobe et al. (2013).

Maasai herders used knives and/or spears whereas Sonjo used bows and poisoned arrows to protect their livestock against depredation by wild carnivores. Both tribes preferred the use of multiple, rather than single, techniques to increase the efficiency of livestock protection.

### Tribe

The study results revealed that more attacks were found to occur in the Maasai tribe lands than in the Sonjo tribe lands because the Maasai own more livestock and live closer to the Serengeti National Park boundary, where there are higher influxes of different wild carnivores (Lyamuya et al., 2016b; Lyamuya et al., 2014b). The frequency of livestock depredation was higher during daytime while herding, with increased rates during the dry season. During the dry season, herders normally take livestock far from home in search of green pastures, which is a predisposing factor for livestock depredation.

Compared to Lyamuya et al. (2016b), this study recorded a higher rate of livestock depredation. Lindsey et al. (2013) found that human tolerance towards carnivores was higher in areas with high wildlife densities. With wild prey numbers declining in the area, carnivores will switch to the available prey (that is, livestock) (Patterson et al., 2004; Souza et al., 2017). Areas with low numbers of wild prey tend to experience increased livestock depredation compared to areas with large numbers of wild prey (Woodroffe et al., 2005). Prey diversity and abundance enhance choices and where different carnivore species will find their favourite wild prey (Per et al., 2009).

Furthermore, prey diversity enhances carnivore-human coexistence due to low livestock depredation incidences (Carter et al., 2012). In some instances, areas with low diversities of wild prey may experience skewed livestock predation (sheep and/or goat) (Woodroffe et al., 2005). Prey preferences of some carnivores, such as hyenas

and jackals, which are common in the Maasai and Sonjo areas, are biased towards goats and sheep because of their higher numbers than cattle; thus, the chance of depredation is density dependent (Okello et al., 2014).

Previous studies have found that the absence of compensation and/or consolation schemes worsens the relationship between these communities and carnivores (Dickman et al., 2014; Wanga and Macdonald, 2006). Areas with livestock husbandry see carnivores as a threat to their livelihood (Musiani and Paquet, 2004) and not as tourist benefits, as perceived by the government and investors. In the Maasai and Sonjo communities, there has been a long-standing consolation claim over livestock depredation to the authorities with no rewards, and currently, these communities have developed reporting fatigue to such attacks due to ongoing disappointments.

### Responsible carnivore species

Livestock depredation is higher in the Maasai land than the Sonjo land, which correlates with greater numbers of livestock and higher carnivore densities. Similar findings were found in villages around Jigme Singye Wangchuck National Park in Bhutan, where high carnivore densities correlated with increased livestock depredation (Wanga and Macdonald, 2006). Livestock depredation occurred more frequently in pastures than in bomas and during the daytime. Livestock depredation was mainly caused by spotted hyenas, followed by leopards. Livestock depredation by leopards increased during the dry season (Lyamuya et al., 2014a), and this might be due to the fact that livestock are taken into thick bushes and forested areas while searching for green pastures at this time of the year, which are preferred habitats for leopards. The frequency of livestock depredation by African wild dog was minimal and different from previous findings, in which the Sonjo experienced more livestock depredation (Lyamuya et al., 2016b). Livestock depredation by lions was skewed to cattle in the Maasai land, which is similar to the findings of Lyamuya et al. (2016b) in 2010. Livestock depredation by lions and/or cheetahs did not occur in the Sonjo land due to habitat degradation, which has displaced their home ranges. With regard to the livestock numbers, as noted before, the Maasai have greater numbers of livestock than the Sonjo (Lyamuya et al., 2016b). Thus, even a small loss among the Sonjo will have a large impact on household livelihood. This means that the livestock depredation costs are much higher in the Sonjo.

### Preferences in herding equipment

Mitigation measures to foster coexistence with carnivores and to tolerate livestock losses should be in place to

cultivate positive attitudes towards carnivore conservation (Dickman, 2010; Jacobs and Main, 2015). The use of multiple livestock guarding techniques was rated as the best method to reduce livestock depredation, which agrees with other findings (Lyamuya et al., 2016b). Different communities have different techniques to keep their livestock safe from carnivores (Patterson et al., 2004; Wanga and Macdonald, 2006). Hence, non-lethal techniques to inhibit livestock depredation need to be thoroughly investigated to minimize dwindling carnivore population trends (Ed and John, 2001). For instance, the use of sticks by the Maasai and Sonjo is only for herding livestock, while carrying defensive weapons helps to scare predators away and can sometimes be used to kill them. However, carnivore killing is very challenging because they silently sneak into groups of livestock that are out in the pasture or inside a boma at night. Although the herding equipment preferences differ between the Maasai and Sonjo communities, the use of weapons is biased to men because they are the ones who take on livestock protection responsibilities. While herding livestock, the Maasai people use spears and/or knives, whereas the Sonjo prefer the use of bows and poisoned arrows. The use of domestic dogs can help to deter predators from attacking livestock (Gehring et al., 2010; Spira, 2014). However, in pastoral communities in Eastern Serengeti, dogs are inadequate at performing this task (Lyamuya et al., 2014a), probably because most of them are in poor condition from starvation and lack of health care. The use of a single method to guard livestock is not effective compared to the use of multiple techniques (Ed and John, 2001). Therefore, implementing livestock surveillance and monitoring practices will help to predict depredation patterns and to develop management measures over time (Patterson et al., 2004; Spira, 2014).

### Conclusion

This study concludes that there are significant differences in the livestock depredation rates and patterns between the Maasai and Sonjo areas. Livestock depredation was more common among the Maasai tribe, which correlated with higher carnivore densities. Understanding livestock depredation patterns and contributing factors will help pastoralists to adopt the best coexistence measures. Protecting livestock against depredation requires further research, which will unravel the long history of human-carnivore conflict. For protection, it is recommended that both tribes use multiple techniques to herd their livestock.

### CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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