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Original Research Article

Do carnivore surveys match reports of carnivore presence by pastoralists? A case of the eastern Serengeti ecosystem

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ABSTRACT

Human-carnivore encounters are common where humans and wild carnivores share the same landscape. The frequency of such encounters gives insight regarding carnivore density and might correlate with human-carnivore conflict incidences. We interviewed livestock owners in the eastern Serengeti ecosystem and recorded reported carnivore presence and relative abundance. We simultaneously conducted a carnivore survey to assess the potential variability of reported carnivore presence that was recorded during the surveys. The playback surveys attracted 9 lions (*Panthera leo*), 88 spotted hyenas (*Crocuta crocuta*) and 47 black-backed jackals (*Canis mesomelas schmidti*) to 12 call-in stations which were resurveyed three times (36 playbacks in total). Reported encounters with lions, leopards (*Panthera pardus*), cheetahs (*Acinonyx jubatus*), spotted hyenas, African wild dogs (*Lycaon pictus*) and jackals were higher closer to the Serengeti National Park (SNP). Data from carnivore surveys were positively correlated with what people reported in questionnaires. These results indicate that local reports of encounters with wild carnivores may act as an important indicator of carnivore presence. Combining observational data through surveys with data reported by local people in areas where humans and wild carnivores coexist may improve existing data on carnivore abundance and distribution in such areas.

1. Introduction

Human-carnivore encounters in African savannas are a common phenomenon (Lagendijk and Gusset, 2008; Lindsey et al., 2013; Lyamuya et al., 2014b; Spira, 2014; Laverty et al., 2019). Local people living with wild carnivores can interact with these species on a daily basis (Frank et al., 2019), and the frequency of encounters is often a function of the distance to adjacent protected areas (Lagendijk and Gusset, 2008; Carter et al., 2012; Dolrenry et al., 2016; Lindsey et al., 2017). However, it has been argued that local people's perception of carnivore encounters might differ from the actual presence of the species due to biases in observability, lack of knowledge or socio-cultural prejudice towards certain species (Purchase et al., 2007;

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Rodriguez, 2007; Karanth et al., 2011; Anand and Radhakrishna, 2017). If data on carnivore encounters are collected by questionnaire surveys, this might provide a cost-efficient first step toward estimating encounters without having to implement often costly and time-consuming monitoring (Dröge et al., 2020; Madsen et al., 2020). Carnivore encounters in this study refers to actual observation of animals in the field which is unexpectedly but the person was able to identify them.

Habitat loss and depletion of prey availability for wild carnivores increases the chances of human-carnivore encounters (Mbau, 2013; Yirga et al., 2013; Ronnenberg et al., 2017). On Maasai land, coexistence with carnivores is likely due to seasonal shifts of the people's settlements and grazing areas (Mbise et al., 2018). In southern Kenya, lions were found in more secluded habitats when humans were nearby (Schuette et al., 2013). Mapping the habitats preferred by carnivores will be a good measure for reducing human-carnivore encounters (Abade et al., 2014). Informing local people where and when carnivore encounters might occur may help reduce encounter frequency, which will improve coexistence between humans and wild carnivores (Campbell et al., 2014). Zoning could also be a promising option to reduce the frequency of human-carnivore encounters (Breitenmoser, 1998; Packer et al., 2013). Additionally, assessment of the spatial separation between carnivores' habitats and human activities may contribute to solid measures on how to reduce existing human-carnivore conflicts due to livestock depredation and attacks on humans (Shivik, 2006; Mbau, 2013; Packer et al., 2013).

Historically, the Maasai tribe, in northern Tanzania, were purely pastoralists, but they are increasingly switching to agropastoralism to provide food for sustenance (Lyamuya et al., 2014b; Masao et al., 2015) in a similar way to the neighbouring Sonjo tribe. Due to the present human population increase in Africa, land for livestock pasture is declining, which might cause conflicts with other stakeholders such as farmers, conservationists and pastoralists (Mbau, 2013; Pooley et al., 2017). Land ownership is one of the factors that affects local people's tolerance towards wild carnivores (Romañach et al., 2007), and balancing resource demands between wildlife and people is challenging (Peterson et al., 2010). Anthropogenic activities near the boundaries of protected areas threaten conservation of carnivores (Shivik, 2006).

Wild carnivore encounter rates can guide management plans for effective measures that will promote coexistence (Smith, 2005; Lagendijk and Gusset, 2008; Dorresteijn et al., 2014; Frank et al., 2019). Carnivore encounters might be positively correlated with conflict intensity, although the phenomenon is not always true due to other factors such as terrain, habitat, and prey abundance (Carter et al., 2012). For instance, due to a decline in wild prey abundance, carnivores present in Loliondo Game Controlled Area (LGCA) (Mbise et al., 2018), are more likely to prey on livestock (Maddox, 2003; Karlsson and Johansson, 2010; Yirga et al., 2014). Thus, different approaches are needed to inculcate sense of tolerance on human-carnivore coexistence in LGCA. This study is among few studies that have compared observations of carnivores with what local people report. We predicted that, carnivore reports by local people would be correlated with call-back observations.

2. Methods

2.1. Study area

The Maasai and Sonjo tribes live in the eastern part of the Serengeti ecosystem in the designated reserve called the Loliondo Game Controlled Area (LGCA). The study area lies between 2°5′00″−2°2′60″S and 35°61′67″−35°37′00″E (Masenga, 2011) (Fig. 1). The Maasai are pastoralists, whereas the Sonjo are agro-pastoralists (Lyamuya et al., 2014a; Mbise et al., 2018). The human population has been increasing at a rate of >3% annually and is presently most populated in the small town of Wasso due to cross-border business with Kenya (Masenga and Mentzel, 2005; Lyamuya et al., 2016b). This human population increase has also led to major land use changes in the areas of both tribes through farming expansion and settlements (Lyamuya et al., 2014a). However, the area is still rich in both ungulates and wild carnivores (Maddox, 2003; Holdo et al., 2010), although there are signs that the wild carnivore population in particular is declining in this area (Lyamuya et al. 2016a, 2016b; Mbise et al., 2018).

2.2. Data collection

Audio playback surveys are frequently used but rarely validated for estimating the density of large carnivores in African savanna ecosystems (Ogutu and Dublin, 1998; Mills et al., 2001; Ferreira and Funston, 2010; Dacier et al., 2011; Cozzi et al., 2013; Omoya et al., 2013; Benson-Amram et al., 2018). Playback techniques give reasonable estimates of carnivore species found around the call-in stations when stations are well-calibrated (Ogutu and Dublin, 1998; Benson-Amram et al., 2018; Dröge et al., 2020). Our study aimed to test the inference of what local people report about the presence of carnivore species in their areas. Therefore, we performed a correlation analysis between what we observed versus encounters that local people reported. Our playbacks followed protocols developed by Maddox (2003), however, the duration of each playback was 30 min to avoid disturbing the villagers. We tested our instruments before starting our playbacks. Call-ins started from 6:00 to 9:00 and our equipment had similar level of broadcast as Maddox (2003). Furthermore, we had two broadcasts every day and driving further away on the difficult terrain, we did not wait more than 30 min after broadcasting. This can be a drawback for our approach as some carnivores may show up 1 h later after broadcasting. The 12 call-in stations were resurveyed during three sessions: two during the dry season in November 2016 and February 2017 and one during the wet season in July 2017.

Distance between the two call-in stations within one village land ranged from 7.8 to 11.4 km. The distance covered by the broadcast was 2.5−3.0 km away as calibrated by Maddox (2003). The volume of the playbacks reached a peak of 114 db. Playbacks were only conducted when there was little wind (<3.7 m per seconds) to minimize the effects on the detection of

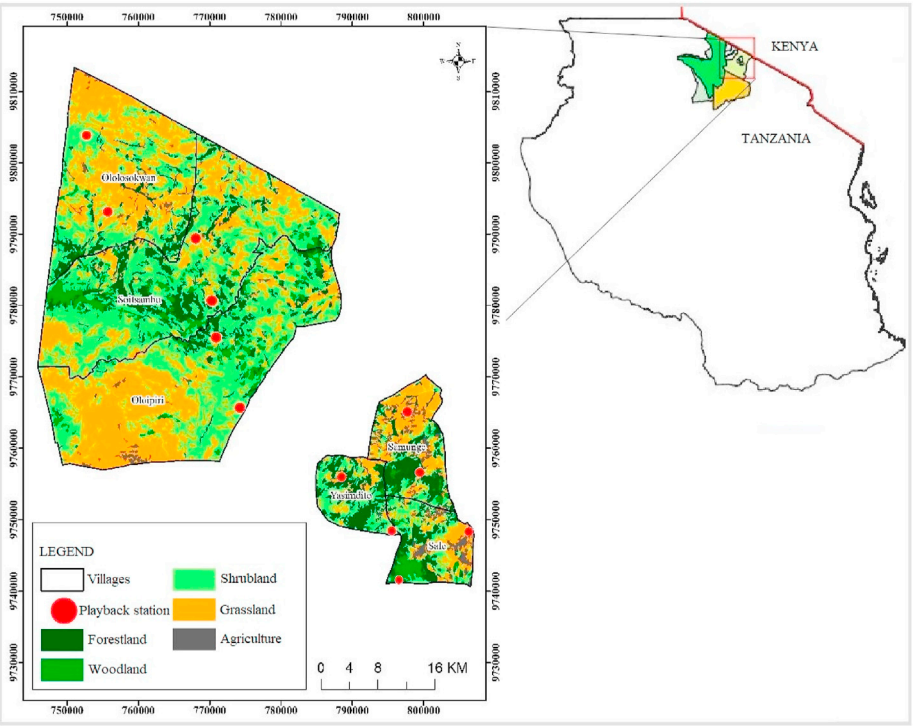

Fig. 1. Map showing playback stations (red dots) and study villages in the eastern Serengeti ecosystem. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

the sound by carnivores. We used two speakers (130 db max SPL), a Pioneer GM-D8604 amplifier, mp3 player, sound metre (model SL 328), wind speed metre (model WS 9500), binoculars (Olympus 10 × 25 WP II BLK), GPS (eTrex® Vista HCX), and range finder (Nikon Laser 350 G). Our instruments were different from those used by Maddox (2003) but had the same capacity when calibrated. Therefore, the difference in the protocol used is only time spent and the way we selected our points compared to Maddox (2003).

Playbacks were performed in grassland, shrub land, wooded grassland and woodland habitats and were broadcasted using two speakers, pointed in opposite directions, and placed on the roof of a Land Cruiser. After 15 min, the speakers' direction was rotated 90°, allowing us to cover all directions equally. The audio lasted for 15 min; the first 3 min broadcasted a wildebeest calf distress call followed by 12 min of hyenas and a lion squabbling over a kill. We counted all carnivores that arrived within 100 m of the speakers during a period of 30 min. Our analysis included only three species of interest (lions, spotted hyenas, and jackals). Correlation analysis was done for the latter two species because they were common around all twelve call-in stations and were commonly attracted to playbacks (Maddox, 2003). Altogether, 36 call-in surveys were conducted, three in each of the twelve call-in stations. All playbacks were carried out between 6:00 a.m. and 9:00 a.m. Distance from village centres to playback stations varied between 5 and 10 km depending on village size.

To compare the observed numbers of the two carnivore species at the call-in stations with statements from interviewed villagers, we conducted a questionnaire survey about the chances of observing spotted hyenas and jackals and other carnivore species such as lions, leopards, cheetahs, and African wild dogs on a daily, weekly, and monthly basis or rarely in relation to the respondent's gender, age and village distance from the SNP (Table 1). The questions were closed-ended: "How often do you see the following carnivore species (lions, leopards, cheetahs, spotted hyenas, African wild dogs, and jackals) around your area?" Respondents had the following choices: daily, weekly, monthly, or rarely. In the model, we excluded education and tribe because these variables were not statistically significant in explaining the variation in observing these carnivore species. We interviewed only one respondent from each household using random sampling. We interviewed 15 respondents who were as close as possible to each call-in station, thus in each village we divided the 30 respondents in two groups according to their closeness to each of the two call-in stations. A total of 180 respondents were interviewed for the twelve call-in stations, including six call-in stations from the Maasai tribe and six call-in stations from the Sonjo tribe. During the survey, we interviewed local people who were given permission by the village chairperson. Whether in the Maasai tribe or the Sonjo tribe, we mixed languages (Swahili, Maasai, and Sonjo) depending on the respondent's fluency. Before interviewing, we introduced the purpose of our survey and the content of our questions and promised all the respondents that their identities would remain anonymous.

Table 1
Demographic variables of the respondents.

		N	%
Gender	Male	144	80.8
	Female	36	19.2
Age	Youth (18–26)	82	45.6
	Adult (27–45)	58	32.2
	Elder (<46)	40	22.2
Education	Informal	44	24.4
	Primary graduate	120	66.7
	Secondary graduate	16	8.9
Tribe	Maasai	90	50.0
	Sonjo	90	50.0
Village	Ololosokwan	30	16.7
	Oloipiri	30	16.7
	Soitsambu	30	16.7
	Yasimdito	30	16.7
	Samunge	30	16.7
	Sale	30	16.7

2.3. Data analysis

Chi-squared test and multinomial logistic regression tests were used to examine differences in the reported encounters with spotted hyenas and jackals. Thereafter, we used generalized linear models with quasi-Poisson error distribution to examine whether the number of observed hyenas and jackals at a call-in station was associated to the distance gradient from the SNP border. Additionally, we used Spearman's rank correlation to evaluate how the trend in reported encounters with hyenas and jackals corresponded to distance from the SNP.

Correlation analysis between the number of observed (12 call-in stations) and reported encounters with these carnivore species was based on maximum counts and median scores of reported encounters. Additionally, correlation was performed in relation to maximum counts observed for each carnivore species at each call-in station relative to the median scores of what people encountered in their areas (daily, weekly, monthly, or rarely). Chi-square tests were used to assess the reported encounters with lions, leopards, cheetahs, spotted hyenas, African wild dogs, and jackals by the interviewed persons in relation to their distance to the SNP border. In some analyses for those species that were not attracted by playbacks we pooled distances in two groups (<35 km and >35 km). Multinomial logistic regression tests were used to determine the predictor variable that explained most of the variation in the reported encounters with lions, leopards, cheetahs, spotted hyenas, African wild dogs, and jackals.

3. Results

3.1. Reported encounters with spotted hyenas and jackals

Reported encounters with spotted hyenas and jackals by the persons interviewed along the distance gradient from the SNP border (daily, weekly, monthly and rarely) as a dependent variable were tested with three independent variables (gender, age and village distance from the SNP) using a multinomial logistic regression analysis (spotted hyenas; Pearson $\chi^2 = 142.6$, df = 12, $p < 0.0001$, Nagelkerke $r^2 = 0.59$; jackals; Pearson $\chi^2 = 253.3$, df = 12, $p < 0.0001$, Nagelkerke $r^2 = 0.83$). However, distance from the SNP was the only predictor variable that significantly explained the reported encounters with hyenas and jackals along the distance gradient from the SNP border (spotted hyenas; Pearson $\chi^2 = 128.4$, df = 3, $p < 0.0001$; jackals; Pearson $\chi^2 = 240.4$, df = 3, $p < 0.0001$; Figs. 2 and 3). The other two variables were not significant; Gender (spotted hyenas; $p = 0.12$; jackals; $p = 0.33$) and Age (spotted hyenas; $p = 0.91$; jackals; $p = 0.96$).

3.2. Reported encounters with other carnivores

The reported encounters with lions, leopards, and cheetahs from the SNP were all significantly higher closer to the SNP border compared to further away (lions; Pearson $\chi^2 = 30.4$, df = 1, $p < 0.0001$; leopards; Pearson $\chi^2 = 8.6$, df = 1, $p = 0.003$; cheetahs; Pearson $\chi^2 = 22.5$, df = 1, $p < 0.0001$). However, the reported encounters with African wild dogs was not statistically significant (Pearson $\chi^2 = 0.7$, df = 1, $p = 0.39$).

3.3. Observations of spotted hyenas and jackals

In total, 9 lions, 88 hyenas and 47 jackals were attracted at call-in stations during the three repetitions of playbacks at the twelve selected call-in stations. There was a statistically significant negative correlation between number of observed spotted hyenas at a call-in station and the distance from the SNP border (Estimate −0.05, SE = 0.013, t = −3.811 $p < 0.001$: Fig. 4).

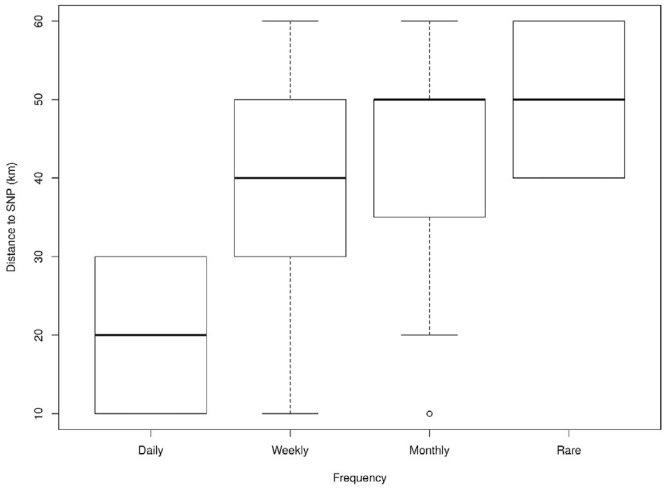

Fig. 2. Reported encounters with spotted hyenas along the distance gradient from the SNP.

However, habitat and season did not explain any of the variation in hyena numbers relative to distance from the SNP border (Poisson model: $p = 0.24$; and $p = 0.87$ respectively). Similarly, there was a statistically significant negative correlation between number of jackals at call-in stations and distance from the SNP border (Estimate $= -0.07$, SE $= 0.014$, $t = -5.246$, $p < 0.001$: Fig. 5). Habitat and season were not statistically significant in explaining the variation in jackal numbers relative to distance from the SNP border (Poisson model: $p = 0.95$; and $p = 0.89$ respectively).

3.4. Correlation between field observations and reported encounters with spotted hyenas and jackals

There was a statistically significant positive correlation between number of observed spotted hyenas at call-in stations and reported encounters with these species relative to distance from the SNP border (Spearman's rho $= 0.73$, $n = 12$, $p = 0.007$) (Fig. 6). Furthermore, there was a statistically significant positive correlation between number of observed jackals at call-in stations and reported encounters with these species relative to distance from the SNP border (Spearman's rho $= 0.96$, $n = 12$, $p < 0.0001$) (Fig. 6).

4. Discussion

Hyena and jackal observations at call-in stations matched what people reported on their encounters for the same areas. We can therefore conclude that people were reporting encounters with other carnivore species such as lions, leopards, cheetahs, and African wild dogs accurately. The chances of encountering African wild dogs were similar in both areas (<35 km and >35 km). The reported encounters with lions, leopards, cheetahs, hyenas, and jackals from the SNP were highest closer to the SNP. However, one village at 30 km from the park boundary showed a deviating trend as the reported encounter rates with lions, leopards, cheetahs, and African wild dogs were much higher than those reported closer to the park. Although this observation needs further research, one possible explanation might be that this village has a favourable habitat for carnivores. Additionally, since the people living in the three closer villages are pastoralists, most of their time is spent on the non-agricultural habitats. Therefore, further research is needed to consider different factors explaining lower and/or higher chances of encountering carnivores.

At call-in stations, we observed a significant negative correlation between spotted hyena and jackal numbers and distance from the SNP. On average, the closer to the park, the higher the observed numbers of these carnivore species. However, habitat and seasonal variables were not important indicators in explaining variation in hyena and jackal observations along the distance gradient from the SNP. A study by Cozzi et al. (2013) in northern Botswana found that hyenas were evenly distributed independent of habitat and season. However, Ogutu and Dublin (1998) in the Maasai Mara National Reserve, Kenya, found that carnivore response tends to vary seasonally with the presence/absence of migratory prey. Additionally, village distance from the SNP was the only predictor variable that significantly explained the reported encounters with hyenas and jackals along the distance gradient from the SNP border.

While some people might be biased or answer inaccurately during interviews, with a sufficient sample size (Francis et al., 2010; Sophat et al., 2019), it would be rare for all to be biased or untruthful; hence, such a bias is highly controlled by increasing respondents' sample size. In the case of this study, sample size was satisfactory for minimizing bias and we were able to correlate information with field observations for two of the carnivore species. The reported encounters with hyenas and jackals were significantly correlated with field observations along the distance gradient from the SNP boarder. Lions, leopards, cheetahs, and African wild dogs can be encountered in the area, although we focused on comparing the two species

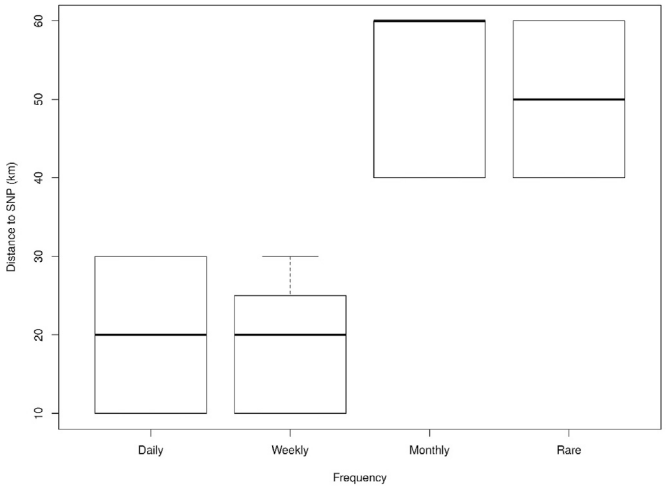

Fig. 3. Reported encounters with jackals along the distance gradient from the SNP.

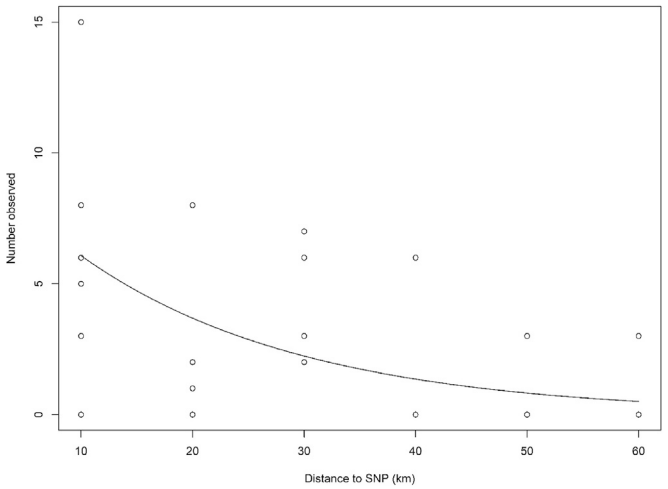

Fig. 4. Spotted hyena numbers at call-in stations along the distance gradient (in kilometres) from the SNP.

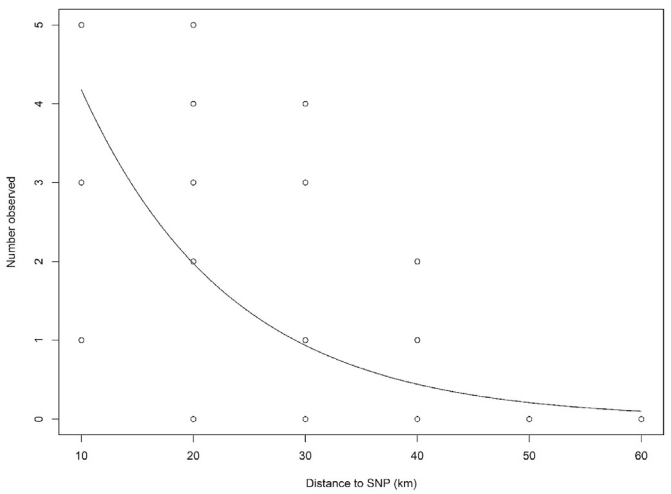

Fig. 5. Jackal numbers at call-in stations along the distance gradient (in kilometres) from the SNP.

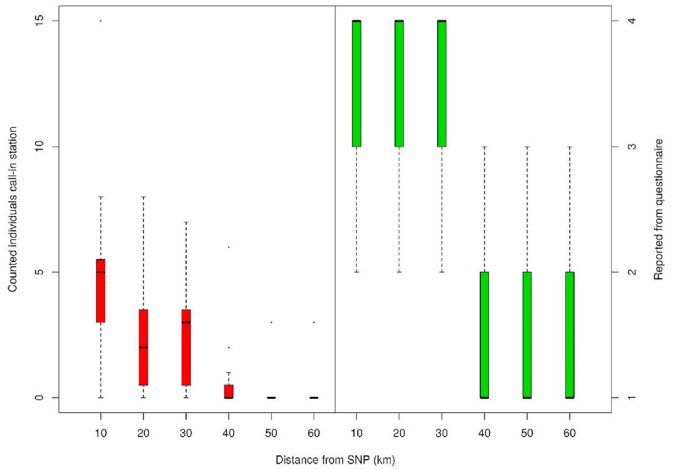

Fig. 6. Field observations (red bars) and the reported encounters (green bars) for the two species (spotted hyenas and jackals). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

that were attracted by playbacks with the respondents' reported encounters with these species in their area. Nine lions were attracted only once at Ololosokwan village (10 km), which was the closest village to the SNP.

Anthropogenic activities adjacent to protected areas negatively affect wildlife populations in their intact habitats (Shivik, 2006; Markovchick-Nicholls et al., 2008; Veldhuis et al., 2019). A study from Taveta district adjacent to Tsavo National Park in Kenya found that due to human population increase, land use and land cover changes are largely caused by agricultural expansion (Mbau, 2013). Similarly, the Maasai and Sonjo tribal lands are now in high demand for farming activities because the Maasai are switching to agropastoralism and the population increase of the Sonjo tribe requires more farming area to be cleared at the expense of forests and wild carnivores' pristine habitats (Mbise et al., 2020; Unpublished). Major threats to wild carnivore populations are conflicts with people living adjacent to protected areas (Woodroffe and Ginsberg, 1998). People's hostility toward carnivores in areas outside the SNP that are not well protected is increasing, which threatens the conservation of these species. The areas outside SNP are becoming a sink for wild carnivore populations due to hunting and retaliatory killings (mostly by poisoning) (Masenga et al., 2013). For instance, in Queen Elizabeth Conservation Area (QECA), Uganda, Omoya and Plumptre (2011) found that most retaliatory killings of hyenas and other carnivore species were caused by poison (*carbofuran and other agro-vet chemicals*). Similarly, currently in Tanzania most retaliatory killings of carnivores species is mainly caused by poison in areas outside protected areas (Masenga et al., 2013; RCP, 2018).

Call-ins surveys for carnivores' are time consuming, expensive and difficult to conduct depending on the geographical area, terrain and availability of the study species (Benson-Amram et al., 2018). Combining different approaches that are more relevant to people on the ground and managers is useful for monitoring and enhancing conservation of carnivores (Benson-Amram et al., 2018; Braczkowski et al., 2020; Elliot et al., 2020), especially in the context of Tanzania and other regions in Africa (Madsen et al., 2020). Wild carnivores play an important role in ecosystem dynamics, ecosystem health and economics through tourism for local people living with these keystone species (Durant et al., 2011; Koziarski et al., 2016). As hypothesized, the reported encounters with spotted hyenas and jackals by local people matched the numbers observed at call-in stations near twelve selected calling stations along the distance gradient from the SNP border. We conclude that if what people report is taken seriously and verified by employing interdisciplinary techniques, this verification will help managers develop plausible conservation strategies for carnivores, especially in human-dominated landscapes.

Declaration of competing interest

The authors declare no conflict of interest.

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