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Abstract

Context. Livestock depredation is a major medium and large carnivore conservation challenge around the globe, causing a substantial economic loss to small-scale agricultural communities in the Wolaita Highlands, Southern Ethiopia, and often leading to retaliatory killing. In the Wolaita Highlands, Southern Ethiopia, livestock depredation rates are increasing due to conversion of wild habitats into grazing lands. Various studies have examined the interactions between humans and carnivores in time and space and the prey preference of carnivores with regard to livestock type. **Aim.** This study aimed to assess livestock depredation by large carnivores in time, space, season and prey preference by carnivores and economic losses by farmers with regard to livestock depredation in the Highlands of Wolaita, Southern Ethiopia. **Methods.** In total, 384 herders who are heads households were interviewed and an information-theoretic approach was used to analyze the factors influencing self-reported livestock losses to spotted hyena, leopards and jackal. **Key results.** The economic loss associated with livestock depredation by spotted hyena, leopard and jackal amounted to an average loss of US$ 33.3 per herder and year. We found that spotted hyena had a preference for sheep, goat and donkey; leopard for goat and sheep; and jackal for goat and poultry. Livestock depredations by the three carnivores were mainly during the night time and more severe during the dry season. **Conclusion.** The number of livestock owned by a household, night time, dry seasons and the availability and preferences of the type of livestock by carnivores had the strongest influence on livestock losses. **Implications.** To mitigate wild carnivore conflicts in the Highlands of Wolaita, Southern Ethiopia, we make recommendations that the farmers should be trained and equipped in order to build a better wild carnivore management strategies and to scale up their mitigating strategies.

keywords: depredation, economic impact, jackal, leopard, livestock, management strategies, spotted hyena

Introduction

Background of the study

Human-wildlife conflict is becoming a bigger issue in conservation biology around the world, and finding solutions for cohabitation between humans and diverse animals, especially wild carnivores, is becoming more difficult (Dickman 2010; Gehring et al. 2010; Woodroffe et al. 2005). The Sodo Zuriya and Damot Gale Community Protected Area was established in January 2006 as collaboration between the Sodo community and World Vision Ethiopia to restore and safeguard the montane high-forest on the slopes of Mt Damota in the Highlands of Southern Ethiopia. The area is owned by five Sodo Zuriya and Damot Gale Communities, who have secured the site and the Ethiopian Government issued land user-rights certificates in 2006. In addition, the Ethiopian Government has supported the ownership of carbon rights trade, and therefore revenues derived from carbon offsets, are earned by the community. Co-operatives societies were established to manage the protected areas, such as Gurumu Woyde, Kokate Marachere, Kunasa Pulasa, Damot Waja, and Dalbo Wogene. Several larger carnivores are found in this area: golden jackals (*Canis aureus*), black-backed jackals (*Canis mesomelas*), leopards (*Panthera pardus*), spotted hyenas (*Crocuta crocuta*), and servals (*Leptailurus serval*), African civet (*Civettictis civetta*) (World vision report 2010).

Livestock depredation is a major large carnivore conservation challenge around Sodo Zuriya and Damot Gale, causing substantial economic losses and often leading to retaliatory killing (World vision report 2010). Studies in African countries show that human-predator conflicts have resulted in significant economic losses (Mishra 1997; Patterson et al. 2004; Van Bommel et al. 2007) and retaliatory killings of predators (Ogada et al. 2003; Holmernet al 2007). Studies of the economic value of livestock losses to large carnivores in Ethiopia are very limited (Yirga et al. 2012). However, those that exist indicate that the costs are significant compared to the living standards of the farmers (Abay et al. 2011). Livestock depredation can cause considerable monetary losses (Bauer et al. 2010). The percentage of the household income that is lost to livestock depredation was 37.7%, 13%, 12 % and 7% in india (Mishra 1997), Kenya (Koskey 2021), Zimbabwe (Butler 2000) and North Ethiopia (Yirga et al. 2012), respectively. Deforestation and livestock overgrazing have worsened frequent human and livestock encounters with large carnivores. The wild prey species in the area are highly depleted, and thus hyenas, leopards, and jackals are presumably highly dependent on anthropogenic food sources. The high human density and wild prey depletion are perhaps the most critical causes for livestock depredation in the area (World vision report 2010). Human population growth is one of the leading factors to increase human-carnivore conflicts (Graham, Beckerman & Thirgood 2005), which coincided with declines in carnivore population levels and their geographic ranges (Woodroffe & Frank 2005). Conflict resolution and conservation management solutions

require a thorough understanding of the ecology of human-carnivore coexistence (Bagchi & Mishra 2006). There is a need for interdisciplinary applied research (Hotte & Bereznuck 2001; Nyhus et al. 2003; Ogada et al. 2003) to develop appropriate conflict management strategies (Treves & Karanth 2003). We thus aimed to investigate the type of livestock depredation in relation to economic losses by large carnivores in the Highlands of Southern Ethiopia.

Materials and methods

Study area

The study was conducted in Sodo Zuriya and Damot Gale district situated at approximately 6°54°N 37°45°E through to 6.9°N 37.75°E in the highlands of Southern Ethiopia. The study sites include the Gurumu Woyde, Kokate Marachere, Kunasa Pulasa, Damot Waja and Dalbo Wogene sub-districts**.** (Fig 1). The study area covers 380 km^2 and is mainly extended over the top of the Mt Damota . During the dry (January to March) and wet seasons (April to August), the area receives 1450-1800 mm of rain during wet season (World vision report 2010). The area receives its maximum rain between June and September, while the short rains fall between March and April (World vision report 2010). The rainfall data for the dry and rainy seasons were collected by Addis Ababa Station of the Ethiopian Meteorological Agency.Temperature ranges from 16^0c to 24^0c between wet and dry seasons. The Yichia, Etana, Kaleta, and Beshir rivers and their tributaries are found in the area. The study site is in the immediate watershed of Lake Abaya, the second largest of the Rift Valley lakes in Ethiopia (World vision report 2010). The site is also characterized by rugged topography, diversified agro ecology, fauna, and flora. The dominant plant species in this area are Woodland waterberry (*Syzygium guineesnse*), African Juniper (*Juniperous procera),* broad leaved croton (*croton macrostachyus*), briar root (*Erica arborea*), common olive (*Olea europea*), Shittim wood (*Acacia hockii*) (World vision report 2010). The area also hosts a variety of large and medium-sized mammals, such as olive baboons (*Papio anubis*), grivet monkey (*Cercopithecus aethiops*), duikers (*Sylvicapra grimmia*), Common bushbuck (*Tragelaphus scriptus*), Guenther's dikdik (*Madoqua guentheri*), Porcupine (*Hystrix cristata*), and predators include predators include golden jackals, black-backed jackals, leopards, Servals, African civet, spotted hyenas (World vision report 2010). It sustains the lives of 16,342 (CSA 2015) of the local people in an agricultural community that has built a livelihood on the natural resources of the area. Subsistence farming is the main source of income for the local population, with potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), false banana (*Ensete ventricosum*), taro (*Colocasia esculenta*), banana (Musa sp.), maize (Zea mays), and common bean (*Phaseolus vulgaris*; World vision report 2010).

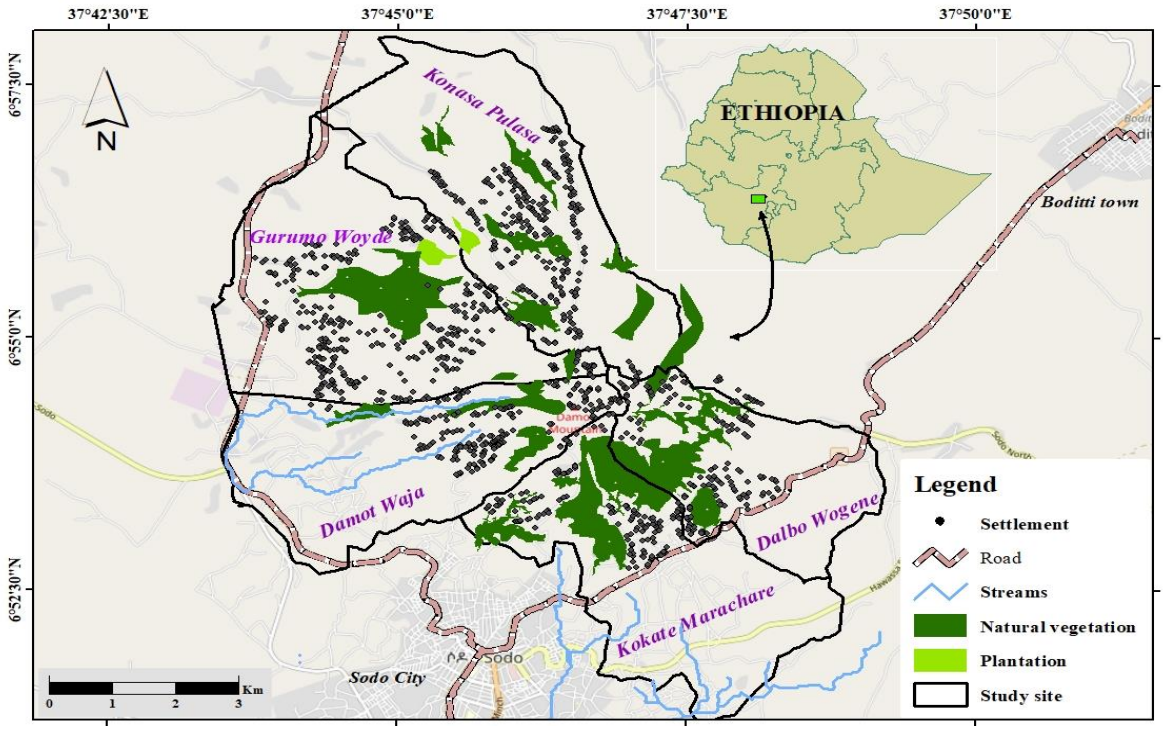

Fig 1. Location of households Interviewed in Sodo Zuriya and Damot Gale district of the South Ethiopia, Wolaita (n=384)

Methodology

The study area extends to the summit of Mount Damota. Habitats are characterized by forests, woodlands, grasslands, farmlands and human settlements. A questionnaire- based survey was carried out within the two targeted communities, Sodo Zuriya and Damot Gale, to assess self-reported livestock depredation by wild carnivores over the last five years (2016-2020). The community is agriculturalist herders who keep cattle, sheep, goats, horses, donkeys, and poultry. At night, livestock are kept inside the house with people and inside house with roof (roof made of thatch and with wooden branch enclosures). The livestock are also kept enclosures with both the iron sheet and the walls. The kraals were 3 meters tall. During the day time between 11:00- 12:00 am, the livestock are kept in enclosures with stick and ropes. The herders mainly use dogs and scarecrows to guard livestock. Animals left on pasture too long and especially sheep and cattle will eat the grass down to the roots and destroy the pasture and so are herded to a different location to protect the land for one hour with 2.5km^2 spaces. The animals are grouped independently and with different sorts of animals together.

We conducted interviews in Wolaitigna, a native language. All data were collected in accordance with institutional ethics requirements, established ethical guidelines for social and carnivore research, and with the consent and support of zone and district administrators, village

124 councils, and participating farmers. For the interview, we randomly selected 384 herders from 319
125 households in Sodo Zuriya and 65 households in Damot Gale district in southern Ethiopia. We
126 interviewed farmers who have their own farms in various places. Interviews were conducted with an
127 adult member (age >18 years) who self-identified as a household herder. All interviews were taken
128 50 minute to complete. Before the start of the survey, the questionnaire was tested among 10
129 herders in a separate area and subsequently modified as necessary to ensure the respondents'
130 comprehension of each question. The questionnaire was divided into four sections that provided
131 information on the following aspects: (1) basic demographic and socio-economic information of the
132 herders interviewed (2) the type of predators, Predation events and the economic costs are
133 estimated. (3) the location of livestock depredation events (grazing field, or enclosures) (4) the
134 season or month when livestock depredation events occurred (Dry season, Wet season). Systematic
135 random sampling was made by numbering the households and drawing the numbers from a random
136 starting point but with a fixed, periodic interval. Respondents provided information on predation
137 losses of cattle, goats, sheep, poultry, donkey and horse caused by leopard, spotted hyena and jackal
138 between 2016 and 2020. Using a theoretical approach, we analyzed self-reported livestock losses for
139 leopards, spotted hyenas, and jackals. The average market prices of different category of livestock
140 species by age and sex were obtained from traders. Prices are converted to US dollars at the
141 exchange rate at the time of the survey.

142 We tried to avoid under or overestimation during data collection by explaining the study's
143 objectives to informants to report the actual losses. In addition, there have not been any incentives
144 (monetary compensation for livestock depredated) in the study area for livestock farmers that would
145 lead to exaggerated depredation claims. Farmers were able to identify which carnivores were
146 responsible for the livestock depredation based on sighting, foot prints, and call. They were able to
147 differentiate spotted hyenas, leopards, and jackal spoor in pictures. The data obtained from
148 interviews were used to measure reported depredations, and used as the measure of prey selection.
149 A total of 11, 101 livestock population size and 29.21 livestock abundance per km^2 were obtained
150 from the report of herder communities of Sodo Zuriya and Damot Gale districts, South Ethiopia.

151 Jacobs' index was calculated to determine the preference of each species compared with availability.

152 $$\mathbf{D=}\frac{r-p}{r+p-2rp}$$

153 Where r is the proportion of the total kills at a site made by a species, and p is the proportional
154 availability of the prey species, the resulting value ranges from +1 to -1, where +1 indicates
155 maximum preference and -1 indicates maximum avoidance (Jacobs 1974). We used the Chi-square

test to test the observed frequency of predation on different types of livestock and contexts of livestock attack events by the three carnivores. The differences in livestock predation between spotted hyenas, leopards and jackals were calculated according to the number of livestock killed. All statistical tests were performed using SPSS Version 20 Software (see http: //www. oracle.com/technetwork/java/javase/jaf-136260.html).

Result

Herding practices

Among the 384 herders respondents, 337 (87.7%) were men and 47 (12.3%) were women. Children are involved in herding and watering of livestock; women are responsible for collecting water, milking, milk processing, selling milk products, cleaning the barn or animal shed and men are mainly responsible for feeding the livestock with hay and crop residues. Animals mainly graze in open grazing fields during the Wet season. In the dry season, grass is replaced with the green leaves of a range of trees, barley and wheat straws. The grasses grown on open common grazing fields are very poor, and short. In this case, livestock enjoy free movement but do not get a nutritious diet. Livestock herders cut and carry good quality grasses for evening feeds. The average size of the livestock holding (goat, sheep, donkey, horse and cattle combined) was 5.8 heads per family of herder communities in Sodo Zuriya and Damot Gale districts.

Depredation of livestock

A total of 3210 livestock were reported depredated by spotted hyena, leopard, and jackal over the past five years: (n = 1906) were by spotted hyenas, (n =708) by leopards, and (n = 596) by jackals. Of the 530 attack events on poultry, 100% were by jackals and none by spotted hyenas and leopards (Table 1). Spotted hyena was responsible for 76.7% of the 499 attack events on the donkey, 23.3% were by leopards, and none by jackals. The three carnivore species showed a significant difference (χ^2 =884, d.f. =2, P < 0.000, n = 3210) in the number of attack events on each type of livestock. Each year, almost 5.8 percent of the economic value of animals valued US$13248 was lost. The average livestock loss among respondents was 8.4 head of animals per home out of 3210 livestock population loss during five years when divided into 384 heads of households. By dividing 8.4 livestock losses across five years, the average yearly livestock loss per household was 1.7 head of stock (2016-2020). There was a significant increase in livestock depredation by hyena, jackal, and leopard over the last five years (χ^2 =961.5, d.f. =2, P < 0.000, n = 3210) (Fig 2).

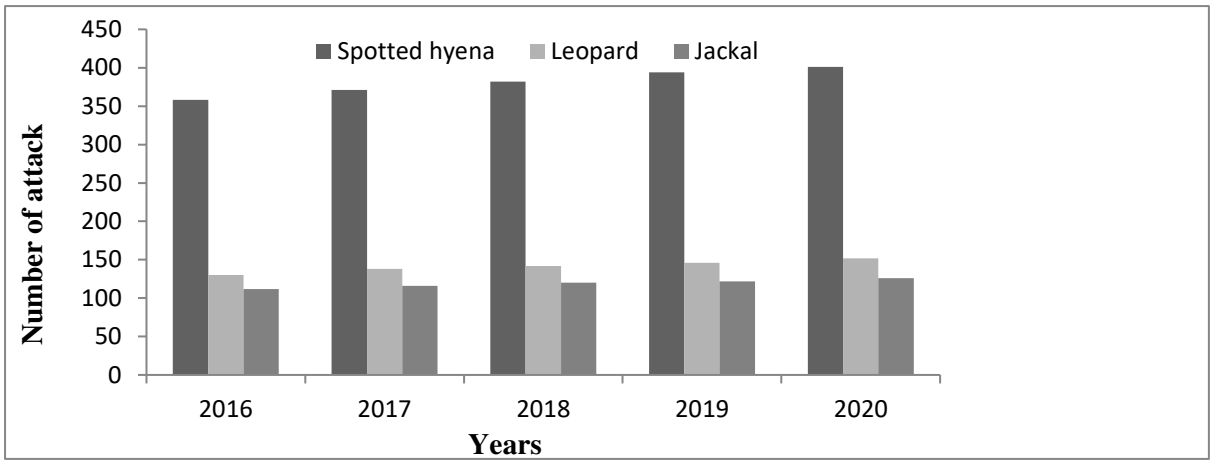

Fig 2. Trends of livestock losses by spotted hyena, leopard, and jackal during 2016 - 2020 in the Highlands of Southern Ethiopia, based on interviews (n =384)

Economic valuation of loss

The total estimated economic loss corresponding to the 3210 predated livestock was the US $63,908. Spotted hyena, jackal, and leopard contributed to about 59.3%, 22.1%, and 18.6% of the livestock kills, respectively. The annual mean economic loss per household was estimated to be the US$ 20.5 and 12.8 during the dry and wet season, respectively. There was a significant difference in terms of economic valuation of losses of livestock species by the three carnivores ($\chi^2 = 5393$, d.f. = 5, $P < 0.000$, n = 3210) (Table 1).

Table 1. Stock numbers and economic valuation of livestock depredated by large carnivores during 2016-2000 in the Highlands of Southern Ethiopia, based on interviews (n = 384)

		Number of depredation events				Economic valuation in US $ (losses in price)			
Species	Stock	Hyena	Leopard	Jackal	Total	Hyena	Leopard	Jackal	Total
Sheep (*Ovis aries*)	5288	1422	652	56	2130	26333	12074	1037	39444
Donkey (*Equus africanus*)	807	383	0	0	383	14185	0	0	14185
Goat (*Capra hircus*)	150	71	37	10	118	3155	1644	444	5243
Cattle (Bos spp.)	2000	10	14	0	24	740	1037	0	1777
Horse (*Equus caballus*)	556	20	5	0	25	1037	259	0	1296
Poultry (Various avian spp.)	2300	0	0	530	530	0	0	1963	1963
Totals	11,101	1906	708	596	3210	45,450	15,014	3,444	63,908

Prey preference among livestock

Jacobs' index scores were derived from kills of six prey species of livestock recorded as prey of the spotted hyenas, leopard, and jackal (Table 2). Livestock category preferred by spotted hyenas was goat, sheep, and donkey but they avoided mostly cattle and horses. Leopard prefers sheep and goat but avoids the rest other category. Similarly, jackal prefers poultry and goat.

Table 2. Prey preference of spotted hyena, leopard, and jackal based on analysis of 3210 depredated livestock in the highlands of Southern Ethiopia

	Prey preference index		
Species	Hyena	Leopard	Jackal
Sheep (*Ovis aries*)	0.53	0.9	-0.8
Donkey (*Equus africanus*)	0.52	-1	-1
Cattle (Bos spp.)	-1	- 0.8	-1
Goat (*Capra hircus*)	0.47	0.6	0.1
Horse (*Equus caballus*)	-0.7	-0.8	-1
Poultry (Various avian spp.)	-1	-1	0.92

Time and location of depredation incidents

Overall, livestock predation occurred during the night (81%) and daytime (19%). Comparing attack events during the day versus those during the night, spotted hyenas (96.5%, n = 1841) and leopards (90%, n = 638) were more likely to attack livestock during the night, while jackals attacked livestock during the day (100%, n = 596) (Fig 3).

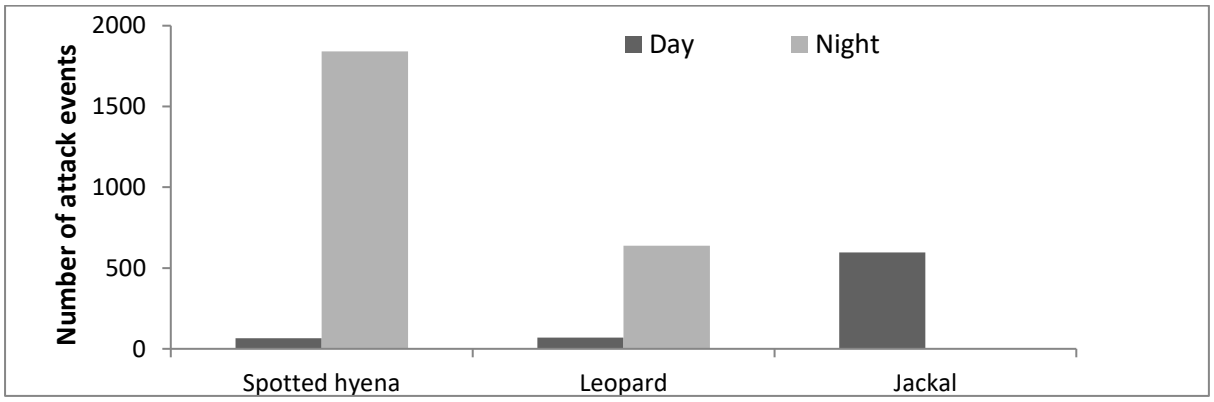

Fig 3. Time of livestock depredation by spotted hyena, leopard and jackal during 2016-2000 in the Highlands of Southern Ethiopia, based on interviews (n =384)

The three carnivore species showed a significant difference (χ^2 =2304, d.f. =2, P < 0.000, n = 3210) in the number of attack events during the day versus night. Livestock predation occurred in the grazing field (81%, n = 2589) and inside traditional kraals (enclosures) (19%, n = 621). Spotted hyenas can break through kraals, while leopards can jump over the kraals. Figure 4 comparing attacks in the grazing field versus enclosure, jackals and spotted hyenas (to some extent) were more likely to attack grazing livestock during the day, while leopards mostly attacked livestock during the night (Fig 4).

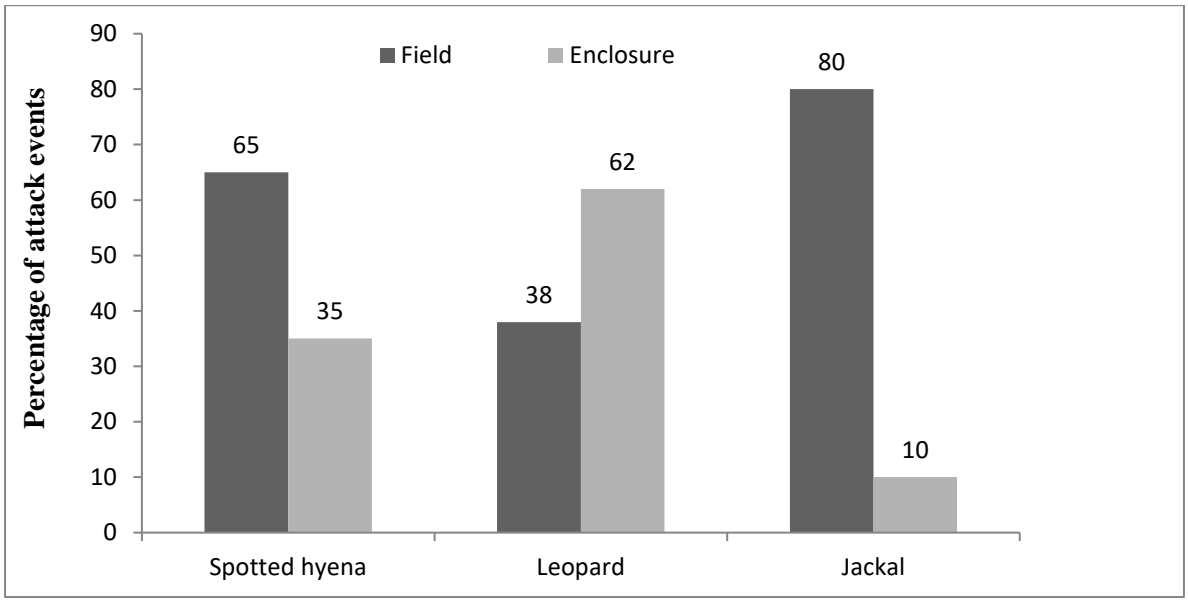

Fig 4. Total number of livestock depredated by carnivores either during the day in the grazing field or during the night inside the kraal during 2016-2020 in the Highlands of Southern Ethiopia based on interviews (n=384)

Season of depredation incidents

Overall, livestock predation mainly occurred during the dry season (63%, n=2018), and livestock predation (37%, n=1192) occurred during the wet season. In the comparison of the dry season from the wet season of livestock predation, in total 2018 (64%) livestock was lost during September to February, and 1192 (36%) livestock was lost during March to August (Fig 5 and 6). The three carnivore species showed a significant difference (χ^2 =985, d.f. =2, P < 0.000, n = 3210) in the number of attack events during the dry versus wet season.

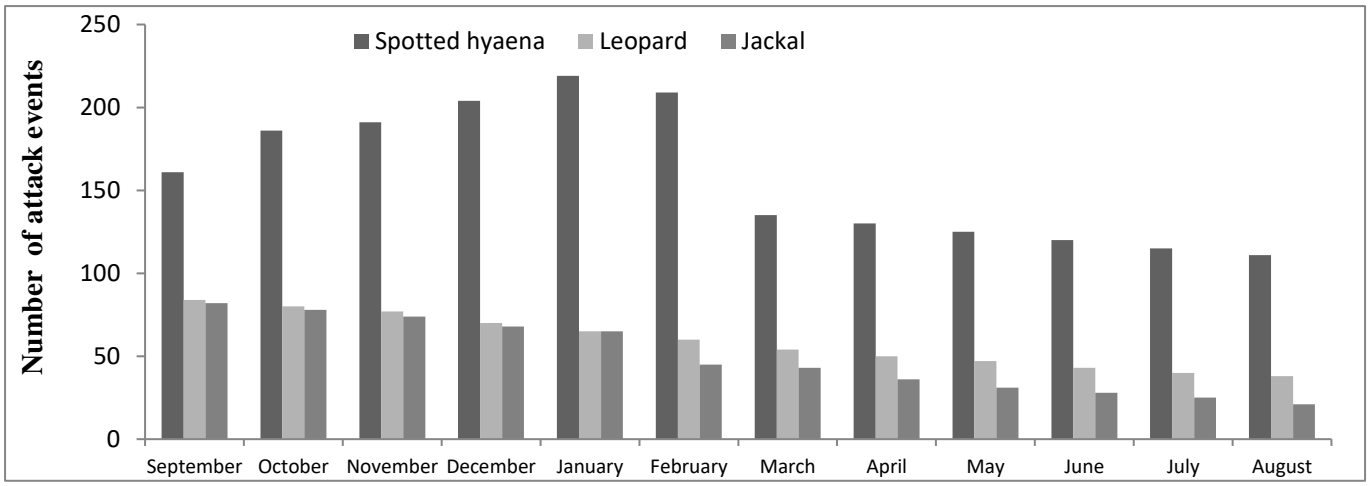

Fig 5. Monthly livestock depredation by spotted hyena, leopard and jackal during 2016-2020 in the Highlands of Southern Ethiopia, based on interviews (n =384)

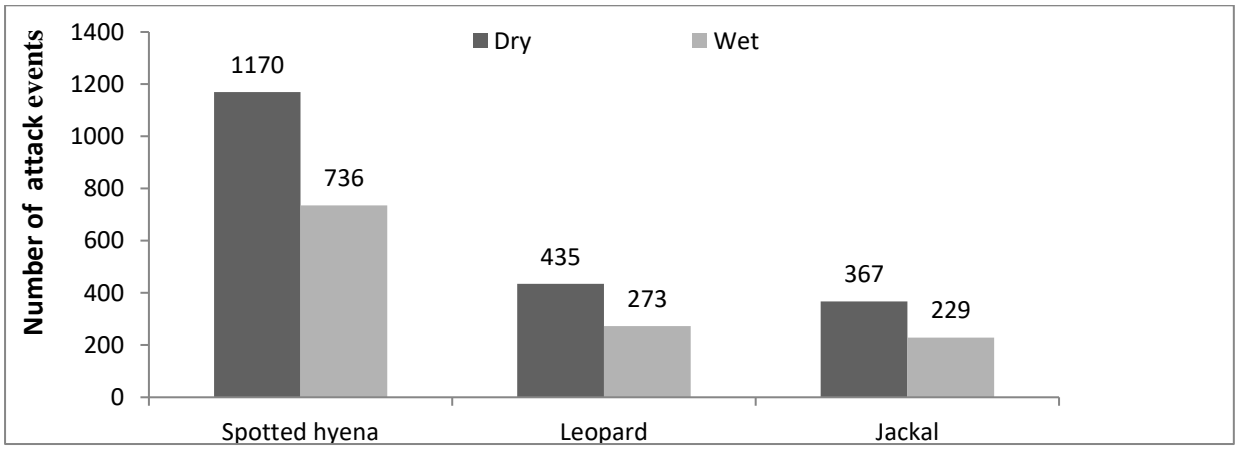

Fig 6. Seasonal livestock depredation by spotted hyena, leopard and jackal during 2016-2020 in the Highlands of Southern Ethiopia, based on interviews (n =384)

Discussions

Depredation of livestock

In our area of study, spotted hyenas and leopards were the most common predators. This might be related to livestock that were either grazing unguarded or left out in the veld overnight (Le Flore 2019). Children and teenagers will be in charge of guarding the livestock. However, as more teenagers begin to attend school, there are fewer young men available to guard the animals (Le Flore 2019). The low prey density which may lead to the switching of animals into livestock, as in the case in the Highlands of northern Ethiopia, Tigray (Gidey et al., 2012). According to Woodroffe et al. (2005), in areas with low numbers of wild prey, livestock farmers tend to experience increased livestock depredation compared to areas with large numbers of wild prey. Prey diversity and abundance enables different carnivore species to find their favorite wild game (Wegge et al. 2009).

Wild-prey diversity improves carnivore-human coexistence and results in low livestock depredation incidences (Carter et al., 2012). Spotted hyena and leopards were the most common predators of livestock that killed sheep, goats, and donkeys. In the Highlands of Wolaita, the frequency of livestock depredation by hyenas was higher than any other predator (i.e., leopard and jackal). Yirga et al. (2012) and Mwakatobe et al. (2013), stated that the incidence of livestock depredation by hyenas was higher than any other predator (such as leopards and jackals). Spotted hyenas were identified as predominant predators of goats and sheep (Bauer, De Iongh & Sogbohossou 2010; Sogbohossou et al. 2011; Yirga et al. 2012). In the current study, spotted hyenas and leopards prefer sheep to goats, according to the Jacobs index. This could be because the environment favors sheep herding. But, according to Yirga et al. (2012), jackals were the most severe predators, followed by a spotted hyena in the Highlands of Tigray. Livestock depredation by these large predators could be attributed to the depletion of the natural prey, loss of habitat, and proximity to human settlements (Yirga et al., 2012). According to a study conducted in Ethiopia's northern area, the natural prey bases are severely depleted, and spotted hyenas rely heavily on anthropogenic food sources (Abay et al. 2011 and Yirga et al. 2012). A study by Bagchi & Mishra (2006) has shown that livestock depredation is more common in areas of low prey density in the Trans-Himalayan region of Himachal Pradesh, India. Local environmental conditions such as rainfall (Patterson et al. 2004; Woodroffe & Frank 2005), livestock husbandry practices (Stahl et al. 2001; Madhusudan 2003; Ogada et al. 2003; Polisar et al. 2003; Rabinowitz 2005), and characteristics of attacked villages and livestock enclosures (David Mech et al. 2000; Ogada et al. 2003) have been found to influence livestock depredation. Livestock depredation occurs more frequently in deforestation frontiers (Crawshaw 2003) because carnivores respond to these problems by switching their diet to livestock (Woodroffe 2001). As a result, it is critical to research livestock depredation issues through interviews with local communities in order to establish strategies for managing effective livestock herding methods and wildlife conservation.

Prey preference among livestock species

In our study, the preferred species by spotted hyenas were goat, sheep, and donkey in decreasing order**.** According to Yirga and Bauer (2010), donkeys are the most vulnerable species for hyena predation. This might be due to the fact that donkeys are unable to defend during an attack (Yirga and Hans 2010). A study by Yirga et al. (2012), the depredated species by spotted hyenas were dog, donkey, goat, and sheep in descending order in Northern Tigray. In northern Ethiopia, spotted hyenas are highly adaptable and opportunistic scavengers and hunters (Yirga et al., 2012). They mainly scavenge on waste from butchers and households (Yirga et al. 2012). Leopards preferentially prey upon sheep and goat; which are within 10–40 kg (Hayward et al., 2006). Leopards are generally

thought to kill prey of medium body size (Mills & Harvey 2001). Studies by Patterson et al. (2004); Khlowski & Holekamp (2006); Kissui (2008) found that hyenas and leopards prey on small herds (goats, sheep, calves). In Greece and Israel, jackals prefer goat and poultry as their primary foods and easily hunt them (Lanszki et al. 2010). Similarly, Atickem et al. (2010) reported that jackals killed sheep and goats in the Bale Mountain, Ethiopia, while hyenas were reported to kill all the livestock types found in the Web Valley. However, leopards primarily killed the goat and occasionally sheep and cattle (Atickem et al., 2010). The more frequent occurrences of favourable species in a region, the more likely it is to be a prey (Schaller 1972).

Time and location and season of depredation incidents

We found that, livestock depredation was higher during the day time while herding, especially during the dry season. This might be due to carnivores then switch to the available domestic prey (Patterson et al. 2004). Prey preferences by some carnivores are that they are prey density-dependent (Okello et al. 2014). Mbise et al. (2018) also found higher livestock depredation during the dry season. This study found that, jackals attacked livestock in the grazing field during the day time. But, hyenas and leopards attacked livestock during the night and during the day time. Similarly, hyenas and leopards were the only carnivores to attack livestock at night in the papers by Yirga et al. (2012) and Atickem et al. (2010). Hyenas and leopards are highly adapted to human settlement and do not appear to be afraid of humans, especially at night and primarily do nocturnal (Khlowski & Holekamp 2006).

Economic valuation of loss

In terms of economic values of livestock depredated, the jackal was the most important as it killed mainly poultry. Spotted hyena was capable of killing the largest species, donkeys, which were the most valuable. Regarding economic losses, the value of livestock predation may be significant as the rural population is impoverished and chronically dependent on food aid (Yirga et al. 2012). The annual mean financial loss per household was about 5.8% of the average yearly income of households in the area. Studies on the economic value of livestock losses to large carnivores in Ethiopia are minimal (Yirga et al. 2012). However, those that exist indicate that the costs are high compared with the farmers' standards of living (Abay et al. 2011). Livestock depredation can cause considerable monetary losses (Bauer, De Iongh & Sogbohossou 2010). According to Van Niekerk (2010), the highest predation losses occurred in the Northern Cape Province, with a total loss of 6% and 13%. Most predation losses were incurred in lambs/kids. According to Thorn et al. (2012), predation losses in the North West Province of South Africa range from 0.46 to 0.73 percent for cattle farms and 0.37 percent for sheep farms. Cows, oxen and calves were killed most often in

Northern Botswana, with leopard responsible for 8% of investigated attacks, while spotted hyena accounted for 5% (Le Flore 2019). Farmers reported livestock loss estimated at US$1720 between October 2014 and December 2016 in Northern Botswana (Le Flore 2019). According to a study by Van Niekerk (2010), the direct costs of predation losses for small and large livestock in northern Botswana in 2019 were US$ 45 million and US$ 40 million, respectively. In our study area, in total, livestock's economic value worth US$13248 was lost per annum calculated from livestock depredation worth US$33.3 loss per family per year. The economic impact of the livestock depredation at Sodo Zuriya and Damot gale is high, and farmers may develop intolerance against large carnivores, without incentive for conservation. The economic impact to an individual livestock owner is disastrous, which might result in aggravating retaliatory killing of carnivores. Between 1988 and 2006, 20 of 83 hyena deaths of known causes in a part of the Maasai Mara National Reserve, Kenya, could be attributed unambiguously to humans, mainly by spearing, snaring, or poisoning event following a depredation incident (Pangle and Holekamp 2010). Pastoralists have had a long history of intolerance against large carnivores because of livestock loss to predators (Sillero-Zubiri & Laurenson 2001).

Conclusion

Studying human-carnivore conflict through local communities interviews is very important to develop actions for managing both effective livestock herding practices and improve wildlife conservation. The depletion of natural prey and the deforestation and fragmentation of the natural habitat owing to high human population pressure may be reasonable predictors of the extent of predation by large carnivores (Yirga et al. 2012). An increase in livestock predation was reported during the nighttime for spotted hyenas and leopards and daytime for jackals. Therefore, nighttime depredation is a high-risk period for hyenas and leopards and day time period for jackals. In addition, knowledge on the prey preference by each carnivore species can offer important insight into the effectiveness of depredation prevention measures (Yirga et al. 2012). It should be noted that the majority of these high-value losses to large carnivores occurred in the open grazing areas and while livestock are left unguarded. Therefore, mitigation on livestock depredation is highly recommended either through improved animal husbandry practices (Ogada et al., 2003), improving enclosures (Bauer, De Iongh & Sogbohossou 2010) and changing herding methods, by herding livestock with more than one herder or building strong bomas for livestock at night (Van Bommel et al. 2007). Governments and conservation organizations would be wise to assess damages prior to establishing mitigation strategies. Finally, compensation the local community for the loss of livestock could strengthen human-carnivore coexistence.

Conflicts of interest

The authors declare no conflicts of interest.

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Data Availability Statement

The data supporting this study are available in the article

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