Ecology and conservation of spotted hyena (Crocuta crocuta Erxleben 1777)in human dominated landscapes in Northern Ethiopia

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The Ecology of Large Carnivores in the Highlands of Northern Ethiopia

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Abstract

The degradation and fragmentation of the northern Ethiopian highlands has resulted in frequent encounters of large carnivores with humans and their livestock. We interviewed 500 randomly selected households to estimate the economic impact of livestock predation by hyena, leopard (*Panthera pardus*) and jackal (*Canis aureus aureus*) in the highlands of northern Ethiopia. The annual mean economic loss per household was approximately US $20.2, about 7% of the average annual income of households in the area. Households surveyed reported losses of a total of 3,122 livestock to hyena, leopard and jackal predation over the past five years. This loss equated to a total financial loss of US$ 50,381. Livestock predation incidents of hyena, leopard and jackal demonstrated that hyenas had a preference for dog, donkey, goat and sheep, leopards for goat, dog, and sheep, and jackals for goat and sheep. Livestock predation of hyenas and leopards were mainly during the night. We conclude that assessing depredation problems is important to develop actions for management, with either livestock practices or wildlife conservation.

7.1 Introduction

Human population growth is rapidly reducing and fragmenting the available habitat for large carnivores (Holmern et al., 2007). The increasing interface between large carnivores and humans is resulting in human–carnivore conflicts across the world (Treves & Karanth, 2003; Madhusudan & Mishra, 2003). Predation on livestock (Cozza et al., 1996; Woodroffe, 2000; Treves & Karanth, 2003) and attacks on humans (Kerbis Peterhans & Gnoske, 2002; Packer et al., 2005) are the most important factors causing the decline of most large carnivore species. Human conflict with carnivores is a serious management issue, often causing opposition towards conservation efforts (Holmern et al., 2007).

In the highland areas of Tigray, a regional state in northern Ethiopia, the mean population density is about 137 persons per km², much denser than the Tigray regional average of 63 persons per km² (Pander & Gebremedhin, 2004; Sara, 2010). Hyenas, leopards (*Panthera pardus*), and common jackals (*Canis aureus aureus*) are common in this landscape but other large carnivores are virtually absent. The degradation and fragmentation of the landscape has resulted in frequent encounters of large carnivores with humans and their livestock. The prey base of the area is greatly depleted and hyenas,

leopards and jackals are presumably largely dependent on anthropogenic food sources. The high human density and depletion of prey are perhaps the most important causes of human-carnivore conflicts in the area. It is known that human population growth increases human-carnivore conflicts (Graham, et al., 2005), and coincides with declines in carnivore population levels and contraction of their geographic ranges (Woodroffe, 2000).

Understanding ecological issues of human–carnivore conflict is important for the formulation of effective conflict resolution and conservation management strategies (Bagchi & Mishra, 2006), and this necessitates interdisciplinary applied research (Hotte & Bereznuck, 2001; Nyhus et al., 2003; Ogada et al., 2003). We therefore aimed to investigate livestock depredation of large carnivores in time and space and prey preference with regard to livestock in the highlands of northern Ethiopia.

7.2 Study area

The study was conducted in Degua-Temben district, situated in the highlands of northern Ethiopia (Figure 7.1). It is an area with an agricultural history of over 2000 years (McCann, 1995), characterized by high soil erosion rates (Hurni, 1993; Desta Gebremichael et al., 2005; Nyssen et al., 2007). The uppermost level of the landscape is at about 2,700-2,800 m a.s.l. (Nyssen et al., 2007). Degua-Temben district has an average annual rainfall of about 769 mm and covers slightly more than 1,100 km^2 with around 120,000 inhabitants (Segers et al., 2008). The district has 18 Tabyas, or sub-districts, which is the lowest formal administrative level. The main crops cultivated in the area are barley (*Hordeum vulgare* L.), wheat (*Triticum* sp.) and teff (*Eragrostis tef*), an endemic cereal crop (Nyssen et al., 2007). Low agricultural productivity, poverty and land degradation are very severe in the highlands of Tigray (Pender & Gebremedhin, 2004). The average farm size is about one ha, and most households subsist on incomes of less than one $US per day (Pender & Gebremedhin, 2004). According to Pender and Gebremedhin (2004), the average per capita income among the sampled households in the highlands of Tigray was less than $US 60 per year. A majority of households chronically depend on food aid for part of the year. Our study focused on one of the sub-districts, Adiwalka sub-district (Figure 7.1). The area is generally a barren landscape, and the prey base is highly depleted. There are a few established 'exclosures' in the district; these are very small protected areas mainly for environmental rehabilitation in sensitive areas.

Figure 7.1
Map showing the location of Adiwalka sub-district in Tigray region and Degua-Temben district

7.3 Methodology

We interviewed 500 randomly selected households from Adiwalka sub-district, northern Ethiopia. Random selection was done by numbering the households and drawing the numbers from a randomized table. Respondents were interviewed about number of livestock owned, livestock management, number of livestock lost to predation from 2006 to 2010 due to leopards, spotted hyenas and jackals. To quantify the economic cost of livestock depredation, the species, age, number and sex of lost livestock were recorded. Estimates of current average market values of different classes of livestock species by age and sex were obtained from traders. Prices were converted to $US at the exchange rate of the time of the study. Predation counts are based on reports by farmers and the financial costs are estimates based on these reports. Hence, the reported predation events or financial costs may not be entirely accurate. However, we tried to avoid under- or over-estimation during data collection by explaining the objectives of the study for informants to report the actual losses. In addition there have not been any incentives (monetary compensation for livestock depredation) in the study area for interview subjects to exaggerate depredation claims. Hyenas, leopards and jackals were the large carnivores causing depredation in this landscape. Farmers were able to identify which carnivores were responsible for the depredation of livestock based on sighting, spoor and call. They were able to identify spotted hyena, leopard and jackal spoors on pictures. Jacobs's indices were calculated to determine preference of each species compared to availability. Data obtained from interviews were used as the measure of prey abundance and reported depredations were used as the measure of prey selection. To identify the preferred species of livestock, Jacobs's indices were used i.e., $D = \frac{r - p}{r + p - 2rp}$ Where r is the proportion of the total kills at site made up by a species and p is the proportional availability of the prey species; the resulting value ranges from +1 to -1, where +1 indicates maximum preference and -1 indicates maximum avoidance (Jacobs, 1974). We used the $\chi 2$-test to test the observed frequency of predation on various types of livestock and contexts of livestock attack events by the three carnivores. The differences in livestock predation between hyenas, leopards and jackals were calculated according to the number of attack events on each type of livestock. All statistical tests were performed using JMP-5 Software (Yirga et al., 2012).

7.4 Results

7.4.1 Depredation of livestock

A total of 3,122 livestock were depredated by hyenas, leopards and jackals over the past five years: 48.2% (n = 1,505) by jackals, 34.2% (n = 1,067) by hyenas and 17.6% (n = 550) by leopards. Table 7.1 presents the number of attack events according to the type of livestock and valuation of livestock losses. Of the 252 attack events on dogs, 77% were by hyenas, 23% by leopards and none by jackals (Table 7.1). Jackals were responsible for 91.3% of the 346 attack events on poultry; 8.7% were by leopards and none by hyenas. The three carnivore species showed a significant difference ($\chi^2 = 896$, d.f. = 10, $P < 0.0001$; n = 3122) in the number of attack events on each type of livestock. The average livestock holding among the respondent households excluding poultry and dog from the analysis was found to be 12.1 head of animals per household. About 8.3% of stock was lost over the past five years. Mean annual livestock loss per household was 1.3 head of stock. There was no significant increase in livestock depredation by hyenas, leopards, and jackals over the last five years (Figure 7.2).

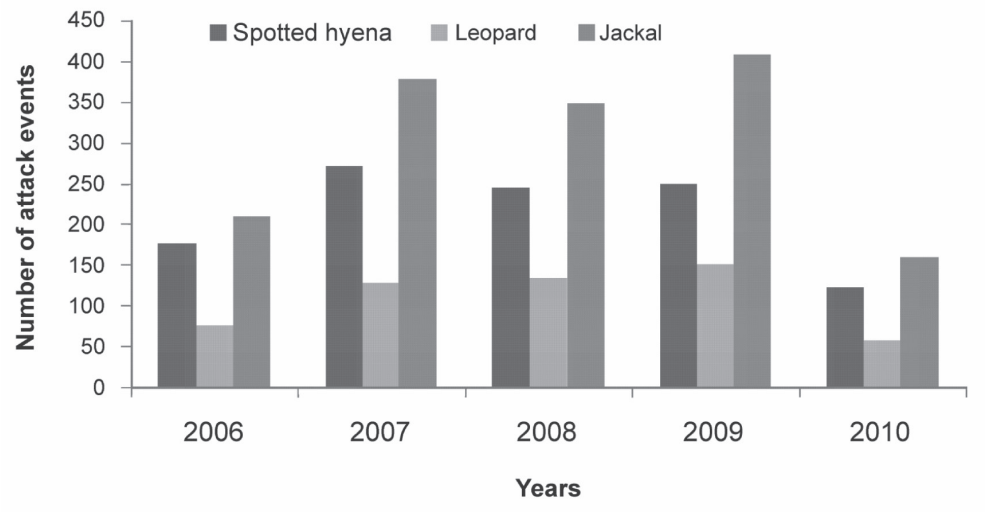

Figure 7.2
Trends of livestock losses by hyena, leopard and jackal from 2006-2010 in the highlands of northern Ethiopia, based on interviews (n = 500)

Table 7.1
Stock number and economic valuation of livestock depredation by large carnivores over the past five years in the highlands of northern Ethiopia, based on interviews (n = 500)

	Depredation (% of stock)					Economic valuation in $US (% of losses)			
Species	**Stock**	**Hyena**	**Leopard**	**Jackal**	**Total**	**Hyena**	**Leopard**	**Jackal**	**Total**
Cattle	1469	6(0.9)	8(1.2)	0(0)	14(2.1)	681	1080	0	1761(3.5)
Goat	2615	487(19)	348(13)	762(29)	1597(61)	8100	6771	12793	27664(55)
Sheep	1405	222(16)	106(8)	427(30)	755(54)	4139	1240	7738	13117(26)
Donkey	557	158(28)	0(0)	0(0)	158(28)	6149	0	0	6149(12.2)
Poultry	2035	0(0)	30(2)	316(16)	346(18)	0	88	958	1046(2.1)
Dog	439	194(44)	58(13)	0(0)	252(57)	549	95	0	644(1.3)
Total	**8520**	**1067(13)**	**550(7)**	**1505(18)**	**3122(37)**	**19618**	**9274**	**21489**	**50381(100)**

7.4.2 Prey preference among livestock

Jacobs's indices scores were derived from kills of seven prey species of livestock recorded as being prey of the hyena, leopard and jackal (Table 2). Livestock predation incidents of hyena, leopard and jackal demonstrated that spotted hyenas had a preference for dog, donkey, goat and sheep, leopards for goat, dog, and sheep, and jackals for goat and sheep.

Table 7.2
Prey preference of hyena, leopard and jackal based on analysis of 3,122 depredated livestock in the highlands of northern Ethiopia

	Prey preference index		
Species	**Hyena**	**Leopard**	**Jackal**
Cattle	-0.95	-0.87	–
Goat	0.31	0.59	0.4
Sheep	0.14	0.1	0.34
Donkey	0.43	–	–
Poultry	–	-0.69	-0.09
Dog	0.61	0.37	–

7.4.3 Time and location of depredation incidents

Overall, livestock predation occurred more during the night (53.6%) than during daytime (46.4%). Comparing day vs. night attacks, hyenas (95%, n = 1,014) and leopards (90%, n = 495) were more likely to attack livestock dur-

ing the night while jackals mostly attacked livestock during the day (89%, n = 1,341). Figure 7.3 shows the time of livestock depredation by hyenas, leopards and jackals. The three carnivore species showed a significant difference (χ^2 = 2133, d.f. = 2, P < 0.0001; n = 3,122) in the number of attack events during the day vs. night.

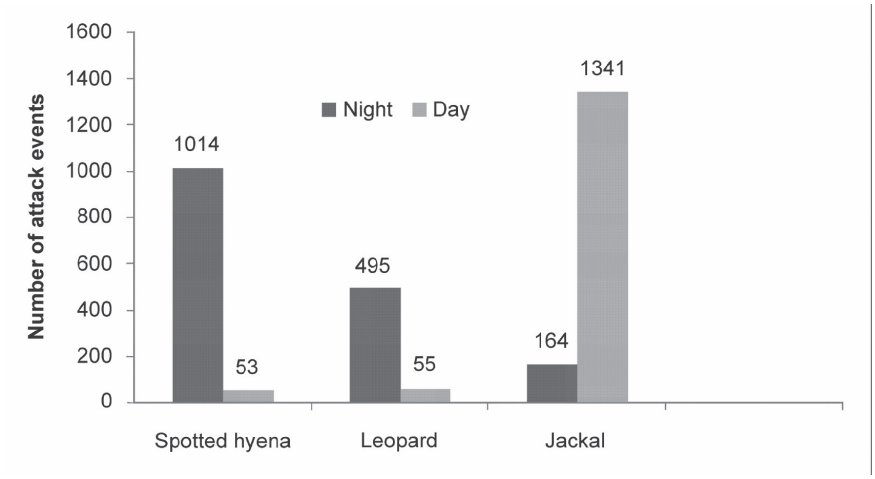

Figure 7.3
Time of livestock depredation by hyena, leopard and jackal over the past five years in the highlands of northern Ethiopia, based on interviews (n = 500)

With regard to place of predation, predation occurred in two distinct contexts. Livestock predation occurred in grazing fields during the day (64.2%, n=1,927) when livestock were separated from the herdsmen. Livestock predation also occurred inside traditional kraals (enclosures) during the night (35.8%, n=1,195) when hyenas break through kraals, while leopards can jump over the kraals. Figure 4 presents the principal contexts of livestock predation by jackals, hyenas and leopards. Comparing attacks in field vs. enclosures, 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 (χ^2=36, d.f.=2, P<0.0001, n=298) (Figure 4). .

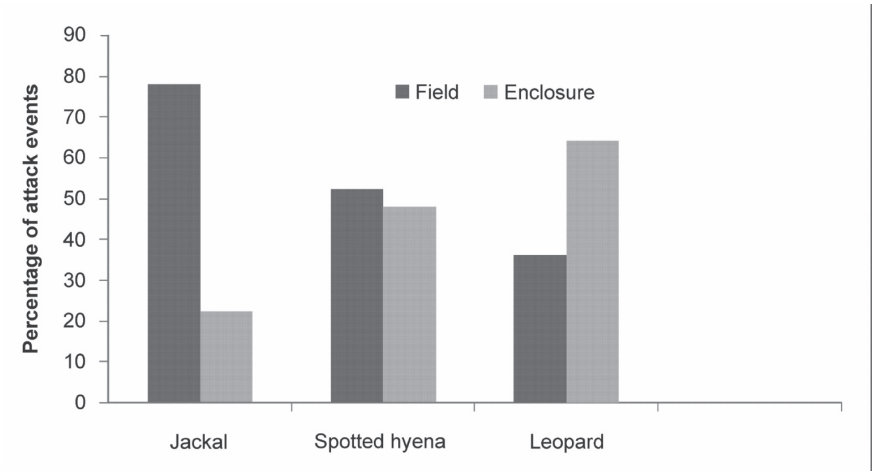

Figure 7.4
Principal contexts of livestock predation by jackal (n = 1,505), hyenas (n = 1,067) and leopards (n = 550)

7.4.4 Economic valuation of loss

The total estimated economic loss corresponding to the 3,122 predated livestock was US $50,381 (Table 1). Jackals, hyenas and leopards contributed to about 42.7, 38.9 and 18.4% of the economic value of livestock and dog kills, respectively. The annual mean economic loss per household was estimated to be US $20.2, which represents about 7% of the average annual income of households in the area. This was based on Pender & Gebremedhin (2004) who stated that the average per capita income among sampled households in the highlands of Tigray was less than $US 60. There was a significant difference in terms of economic valuation of losses of livestock species ($\chi 2=11$, d.f.=5, $P<0.047$, n=3,122) but there was no significant difference among the three carnivores in terms of their economic impact (Table 1).

7.5 Discussion

7.5.1 Depredation of livestock

The predominance of jackals, hyenas, and leopards as livestock-killing predators on the northern Ethiopian highlands is consistent with the results of Hawkes's (1991) survey of Bulilima Mangwe communal land and Madzudzo's (1994) survey of Tsholotsho communal land. In both of these studies, hyenas and jackals were the most common predators of livestock,

the former attacking cattle and donkeys, and the latter killing goats, whereas leopard predation was relatively rare. Hyenas were also identified as predominant predators of goat and sheep (Bauer et al., 2010; Abay et al., 2011; Sogbohossou et al., 2011). In our study, jackals and hyenas were predominant predators of livestock species. In terms of total numbers of livestock killed, jackals were the most serious predators, followed by spotted hyenas.

Livestock depredation by these large predators could be attributed to depletion of the natural prey, habitat loss and proximity to human settlements. In the northern region of Ethiopia, the natural prey base is highly depleted and hyenas are largely dependent on anthropogenic food sources (Abay et al., 2011; Yirga et al., 2012). Various studies have demonstrated that livestock depredation is more common in areas with low prey abundance (Sillero-Zubiri & Laurenson, 2001; Polisar et al., 2003; Treves et al., 2004; Rabinowitz, 2005; Bagchi & Mishra, 2006; de Iongh & Bauer, 2008). 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 (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 expanding their diets to include livestock (Woodroffe, 2001).

Some researchers (Sagor et al., 1997; Stahl et al., 2001; Stoddart et al., 2001; Madhusudan & Mishra, 2003) clearly documented increases in livestock depredation rates with increases in carnivore density and livestock population. With regard to hyenas, however, in spite of the absence of native prey and high densities of hyenas, the livestock depredation rate was remarkably low in Wukro district, northern Ethiopia (Yirga et al., 2013). Hyenas obtain more food from scavenging on urban and rural waste than from depredation in northern Ethiopia (Abay et al., 2011; Yirga et al., 2012).

7.5.2 Prey preference among livestock species

Preferred species of hyenas were dog, donkey, goat and sheep, in decreasing order. Hyenas mostly prefer prey with a body mass range of 56-182 kg, with a mode of 102 kg (Hayward, 2006). However, hyenas are known in northern Ethiopia to be highly adaptable and opportunistic scavengers and hunters (Yirga et al., 2012) that mainly scavenge on butchers' and household waste. Hyenas changed their diet opportunistically from scavenging on waste be-

fore and after fasting to predation on donkeys during the longest Christian fasting period in northern Ethiopia (Yirga et al., 2012).

In this study, of the 252 attack events on dogs, 77% were by spotted hyenas and the rest by leopards. A number of dogs were victims of predation in the Maasai steppe, Tanzania, especially by leopards (Kissui, 2008). Different reports have shown that dogs did not reduce nocturnal livestock predation by hyenas and lions (Kolowski & Holekamp, 2006; Ikanda & Packer, 2008). However, Woodroffe et al. (2007) and Frank et al. (2005) reported that dogs improved livestock security both in the day-time grazing fields and in the bomas at night. The presence of dogs was not associated with reduction of predation by leopards or hyenas (Ogada et al., 2003).

Leopards preferentially prey upon goat, dog and sheep, in decreasing order; upon species within a weight range of 10-40 kg (Hayward et al., 2006). Other researchers have also found that hyenas and leopards prey upon small stock (goats, sheep and calves) and dogs (Patterson et al., 2004; Kolowski & Holekamp, 2006; Kissui, 2008).

As for jackals, their preferred species were goat, sheep and poultry. This is consistent with results of Atickem et al. (2010) who reported that jackal killed only sheep and goats in the Bale Mountain, Ethiopia whereas hyenas were reported to kill all livestock types found in the Web Valley. However, leopards primarily killed goats and occasionally sheep and cattle (Atickem et al., 2010). The more abundant a preferred species in an area is, the more likely it is to fall prey (Schaller, 1972).

7.5.3 Time and location of depredation incidents

Hyenas, leopards and jackals showed divergent predatory behavior toward livestock with regard to the type of prey they attacked, time of day and location of livestock attacks. Comparing attacks inside traditional kraals vs. field (grazing areas), jackals were more likely to attack grazing livestock during the day while hyenas and leopards mostly attacked livestock at night. According to Atickem et al. (2010), hyenas and leopards were the only carnivores to attack livestock at night with characteristic methods of accessing the bomas at night in Bale Mountain, Ethiopia. Leopards jumped over the walls whilst hyenas penetrated the bomas by digging. Leopards were reported to kill livestock during both day (93 kills, 73%) and night (34 kills, 27%) while common jackal depredated during the day only (Atickem et al., 2010). On the other hand all hyena kills occurred at night (99%) with few

exceptions occurring when livestock approached a hyenas den. They are highly adapted to human settlement and do not appear to be afraid of humans especially at night (Kolowski & Holekamp, 2006).

7.5.4 Economic valuation of loss

In terms of values, jackal was the most important predator as it kills mainly poultry. Hyenas were capable of killing the largest species, cattle and donkeys, which were the most valuable. The question remains as to whether losses to large carnivores in the study area were substantial in comparison to other African studies. In terms of economic losses, the value of livestock predation may be significant as the rural population is extremely poor and chronically dependent on food aid. Despite being an estimate, and perhaps a conservative one, the annual mean economic loss per household was about US $20.2, about 7% of the average annual income of households in the area. However, the true severity of livestock losses to predators can only be estimated with accurate household income data from the study area and these were not collected by this study.

Studies of the economic value of livestock losses to large carnivores in Ethiopia are very limited. 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). For example, Mishra (1997) reported an economic loss of $15,418 from livestock depredation, or $128 loss per family per year among the Indian-trans Himalayan communities. Livestock depredation on a Kenyan ranch is estimated to represent 2.6% of the herd's economic value, worth $8,749 per annum (Patterson et al., 2004). Similarly Butler (2000) reported depredation losses of 12% of each household's net annual income ($13) in Zimbabwe. The economic impact of the current livestock depredation might be very considerable and farmers may become intolerant to large carnivores. The economic impact to an individual livestock owner is disastrous, which might result in damaging retaliatory attacks. For instance, in 1990, 16 hyenas were killed in a single poisoning event following a depredation incident in Maasai Mara National Reserve, Kenya (Holekamp & Smale, 1992). Because of livestock loss to predators, pastoralists have had a long history of intolerance against large carnivores (Sillero-Zubiri & Laurenson, 2001).

7.6 Conclusion and recommendations

Assessing depredation problems is an important step in developing proper management. The depletion of natural prey and the degradation and fragmentation of the habitat due to high human population pressure may be reasonable predictors of the extent of predation by large carnivores. More livestock predation was observed during the nighttime for spotted hyenas and leopards and daytime for jackal. In addition, knowledge of prey preference of each carnivore species with regard to livestock can offer important insights into the effectiveness of depredation prevention measures. It should be noted that majority of these high value losses to large carnivores occurred in grazing fields during the day. Mitigation of livestock depredation is highly recommended, either through improved animal husbandry (Ogada et al., 2003) or through ecosystem regeneration (Abay et al., 2011) which might restore the natural habitat and native prey species. Improving enclosures (Bauer et al., 2010) and changing herding methods, for example herding livestock with more than one herder, or building stronger bomas for livestock at night could decrease livestock depredation figures (Frank et al., 2005; Van Bommel et al., 2007).

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