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

8.1 Hyena diet

The main aim of my study was to study hyena-human interactions and the behavior of hyenas in a human-dominated landscape. The results of my study support the hypothesis that hyenas in Tigray survive in a human-dominated landscape because of a unique combination of adaptation to anthropogenic food and cultural tolerance towards hyenas.

During my research, I found that hyenas depended entirely on domestic prey species, partly through depredation but much more through scavenging on (peri-) urban waste (chapter 2). For hyenas in the study area, I found that anthropogenic foods are of major nutritive importance. About 99% of the hyenas' diet was found to consist of domestic animals, especially cattle, donkeys, goats and sheep. They obtain most of their food from scavenging on urban and rural waste; depredation accounted for <10% of food intake in Debri and Aynalem (Abay et al., 2011).

Scavenging is mutually beneficial. The hyenas benefit from the waste humans dispose of, while human communities are provided with a waste-clearing service. Despite their reputation as scavengers, hyenas acquired over 82% of their total food intake by hunting rather than scavenging in the Ngorongoro Crater, Tanzania (Kruuk, 1972). In the Serengeti (Kruuk, 1972) and throughout southern Africa (Cooper, 1990; Henschel & Skinner, 1990; Mills, 1990; Gasaway et al., 1991) hyenas typically acquire about 70% of their food by hunting and the rest through scavenging. These findings demonstrate that hyenas prefer wild prey, if available. However, in my study, the environment is prey depleted, as the habitat is degraded and fragmented as a result of intensive agriculture. Hyenas are flexible hunters, foraging alone for smaller items (Kruuk, 1970) up to 75% of the time (Holekamp et al., 1997). They are opportunistic predators with a high behavioral plasticity, hunting whatever species are locally most abundant (Susan et al., 1999).

As a consequence they are quick to take advantage of seasonally changing prey resources (Kruuk, 1972; Cooper, 1990; Mills, 1990). Hyenas are also known to exploit carrion as a food resource (Kruuk, 1972; Cooper, 1990; Mills, 1990). They can apparently switch between scavenging and hunting as the opportunity arises (Susan et al., 1999) and do not have clear dietary preferences, other than the avoidance of desiccated carcasses in drought situations (Cooper, 1990; Gasaway et al., 1991).

The relatively high abundance of hyenas at garbage dumping sites reflects their dependence on anthropogenic food and disease resistance. Animals that hunt and scavenge are likely exposed to a broad array of pathogens (Schulenburg et al., 2009). Hyenas have descended within the last million years from carrion-feeding ancestors (Werdelin, 1989; Lewis & Werdelin, 2000). They have been documented to survive anthrax and rabies infections, as well as outbreaks of several other viral diseases that decimated populations of sympatric carnivores (East et al., 2001; East et al., 2004; Harrison et al., 2004; Watts & Holekamp, 2009; Lembo et al., 2011).

Scat analysis was only suitable for detecting hairy mammals. Small fragments of bones were found together with the hairs, but we were unable to identify them to species level. Researchers have examined the diet of predators in Africa (Mills, 1992; Bailey, 1993; Hayward, 2006), in Europe (Gade-Jorgensen & Stagegaard, 2000; Jedrzejewski et al., 2000; Capitani et al., 2004) and in North America (Kohira & Rexstad, 1997; Marquard-Petersen, 1998) using scat analyses. The approach is inexpensive, relatively quick to apply, and large samples can be collected (Litvaitis, 2000). It is useful to construct a basic description of a carnivore's diet (Mills, 1996). Scat analysis is also a particularly useful supplement to radio-tracking, direct observation, and snow-tracking in studies of diet selection (Marucco et al., 2008). If the sample size is too small, tests of hypotheses lack power (Bros & Cowell, 1987; Sheppard, 1999), especially in tests to compare diets (Reynolds & Aebischer, 1991). When the sample size is very large, the power of a specific test may be adequate, but effort may have been wasted in collecting and processing so many scats (Marucco et al., 2008). Frequencies with which particular prey species occur among collections of scats are easily compiled to describe the diet, and can be used to compare diets between periods. The human hairs in the scats probably came from cemeteries and from garbage dumps on which hyenas scavenge. They were certainly not from the attacks on humans, as these are extremely rare. During my study I documented 10 attacks on humans but no fatal cases (Abay et al., 2011).

I found that hyenas are common in many parts of Ethiopia. In the region of northern Ethiopia the natural prey base is very low and hyenas are known to depend on anthropogenic food (Abay et al., 2011; Yirga et al., 2012). They are very common near urban environments, where humans provide them with organic waste. This confirms that they are highly adapted to the environment. Figure 8.1 demonstrates human-predator interaction in northern Ethiopia. Jackal and leopard are common livestock predators in northern Ethiopia, while other large carnivores are almost absent (Abay et al., 2011).

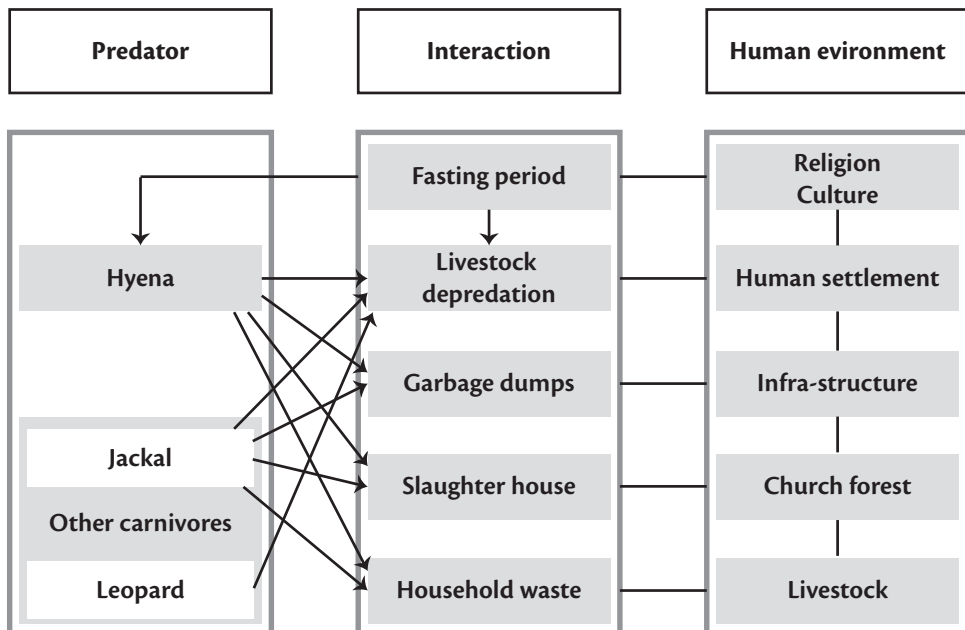


Figure 8.1
The interaction of large carnivores with humans in a human dominated landscape in northern Ethiopia

My study shows a significant change in diet of hyenas during the Orthodox Tewahedo Christians fasting period, from predominantly scavenging on waste to active predation on donkeys. The vegan diet of humans during fasting leads to a sharp reduction in available animal waste. This is apparently compensated for by increased donkey depredation. Changes in human diet have a dramatic impact on the diet of hyenas. By providing this unique insight into the effect of changes in human diet on local hyenas, the results illustrate that hyenas are highly adaptable and opportunistic scavengers and hunters.

Table 8.1
Percentage of occurrences of livestock and wild prey species in scats of large carnivores across Africa

Source	Location/country	Diet
Tumenta, 2012	Waza National Park, Cameroon	Wild prey 75 % Livestock 25 %
Cooper et al., 1999	Masai Mara National Reserve, Kenya	Wild prey 96 % Livestock 0 %
Sogbohossou, 2011	Pendjari Reserv, Benin	Wild prey 97 % Livestock 0 %
Breuer, 2005	Faro National Park/ Cameroon	Wild prey 98 % Livestock 0 %
Di Silvestre et al., 2000	Niokolo Koba National Park, Senegal	Wild prey 99 % Livestock 0 %
This study	Chebera Churchura National Park, Ethiopia	Wild prey 40 % Livestock 56 %
This study	Non protected area across Ethiopia	Wild prey 0.1 % Livestock 99.9 %
This study	Wukro, Ethiopia	Wild prey 1 % Livestock 99 %

Table 8.1 presents diet of large carnivores in various ecosystems across Africa. The hyenas in different ecosystems across Africa depend on wild prey species (Eloff, 1964; Kruuk, 1972; Bearder, 1977; Smuts, 1979; Tilson et al., 1980; Henschel, 1986; Mills, 1990).

8.2 Hyena-human coexistence

The conventional wisdom about large carnivores in general, that they depend on protected areas, does not apply to hyenas in Ethiopia. They are more abundant in human-dominated landscapes than in protected areas (Yirga et al., unpublished data). Hyenas are conventionally thought to be greatly dependent on protected areas or zones of low human density with sufficient numbers of suitable prey (Mills & Hofer, 1998). Hyenas can survive in environments from which other large predators such as cheetahs (*Acinonyx jubatus* (Schreber, 1775), lions, and wild dogs have disappeared (Mills & Hofer, 1998). Hyena density is strongly correlated with prey density in the Etosha National Park, Namibia (Trinkel, 2009). However, despite depletion of natural prey, the region of northern Ethiopia still supports a high density of spotted hyenas. The higher density of hyenas in garbage dumping

areas was perhaps due to highly concentrated scavengable food resources. Scavengable food availability and distribution is more likely to impact large carnivore abundance and distribution in human landscapes. Certain animal species have adapted to human-dominated habitats well and benefit directly or indirectly from human activities including food (Shochat et al., 2004; Faeth et al., 2005; Adams et al., 2006). Diet supplementation with anthropogenic food augmented predator's densities (Fedriani, et al., 2001). It has been reported that refuse and livestock carcasses at pastoral villages may influence the frequency of hyena visits to these areas (Mills & Hofer, 1998; Kolowski & Holekamp, 2007). Hyenas are frequent visitors to garbage dumps and other sources of scavengable food, including cemeteries (Sutcliffe, 1970; Horwitz & Smith, 1988; Leakey et al., 1999; Abay et al., 2011).

I found that the use of playback recordings to attract predators works effectively for estimating hyena and jackal abundance and distribution. It is a powerful method for estimating predator population sizes across Africa, and characterizing their spatial distributions (Mills, 1985; Sillero-Zubiri & Gottelli, 1992; Creel & Creel, 1996; Mills & Gorman, 1997; Ogutu & Dublin, 1998; Mills et al., 2001; Maddox, 2003; Ogutu et al., 2005). It would have been important to collect simultaneous data on hyenas and jackal abundance to compare how well response probabilities reflect true densities, using camera traps or other census methods.

My research also showed that hyenas live in significant numbers in proximity to human communities in Ethiopia and the cost of livestock predation to the local residents is relatively low. Various travelers' observations indicate that hyenas were more numerous in Ethiopia in the past (Gade, 2006). Examples include Bruce (1790), who wrote that the "plains are infested with hyenas. Gobat (1851) also wrote that hyenas were a plague in Abyssinia (former name for Ethiopia), in every situation in city and field. Therefore, coexistence must have developed over centuries. Behavioral flexibility of hyenas facilitates their adaptive adjustment to precarious lifestyles in proximity to humans (Woodroffe, 2000; Sunquist & Sunquist, 2001; Boydston et al., 2003). Increasing human population density is often associated with a decline or extinction of local carnivore populations (Woodroffe & Ginsberg, 2000). Growing human populations negatively affect habitat quality for carnivores (Gittleman & Harvey, 1982). It is important to understand how anthropogenic food resources can affect hyena abundance and distribution. Knowledge of the ecological effects of human-derived subsidies can aid conservation efforts in and around humanized landscapes (Ehrenfeld & Toth, 1997). Anthropogenic food sources would impact hyena abundance

and their viability. I conclude that changes in waste management might greatly affect hyena abundance and distribution. Other authors also suggested that changes in the availability of anthropogenic food affect carnivore population density (Borkowski et al., 2011).

As local people often perceive predators to be a direct threat to themselves or their livestock, sustained coexistence between humans and large carnivores is rarely possible outside of protected areas (Woodroffe & Ginsberg, 2000). Multiple studies have demonstrated carnivore avoidance of areas characterized by intense human activity (mountain lions – Van Dyke et al., 1986; coyotes – Gese et al., 1989; bears – Mattson, 1990; Reinhart, 1990; Olson, 1994; wolves – Thurber et al., 1994). Species exhibiting greater behavioural plasticity are expected to be able to adapt more readily than others to life in proximity to humans (Woodroffe, 2000).

Coexistence between humans and carnivores over a sustained period is a central issue in conservation science and policy (Woodroffe et al., 2005; Dickman et al., 2011). Conservation approaches such as state-managed reserves, community-managed areas, and privately owned sanctuaries have been suggested to promote coexistence between humans and carnivores (Berkes, 2007; Dudley, 2008). Protected areas are designed to facilitate coexistence at a regional scale (Dudley, 2008; Western et al., 2009) and community-based conservation approaches are designed to facilitate coexistence at smaller intermediate scales (Western et al., 1994; Berkes, 2007). The growing human population and a long history of competition between people and carnivores for limited resources such as food (Woodroffe et al., 2005) have led to a general conclusion among conservation practitioners and policy-makers that large carnivores cannot coexist with humans (Brashares et al., 2001; Parks & Harcourt, 2002; Karanth et al., 2010). Remarkably, I found that hyenas coexist in significant numbers in a human-dominated landscape. Such information is very important, as the world population is anticipated to increase with 1.4 billion people over the next two decades, forcing human and carnivore populations to share the same space (United Nations, 2010).

I found a density estimate of 52 hyenas per 100 km² outside of conservation areas. This density is even higher than densities found in some protected areas (Table 8.2). Hyenas are the most abundant large carnivore in Africa with current population between 27,000 and 47, 000 individuals (Honer et al., 2008).

Table 8.2
Hyena density in different parts of Africa

Source	Location/country	Density
Ogutu et al., 2005	Mara Ecosystem, Kenya	0.463/km ²
Mills et al., 2001	Kruger National Park/ South Africa	0.12/ km ²
Ogutu and Dublin, 1998	Masai Mara National Reserve/ Kenya	1.4/ km ²
Graf et al. 2008	Hluhluwe-iMfolozi Park/ South Africa	0.33/ km ²
Trinkel, 2009	Etosha National Park/ Namibia	0.02/ km ²
Sillero Zubiri, and Gottelli, 1992	Aberdare National Park in Kenya	1.34/ km ²
This study	Tigray, northern Ethiopia	0.52/ km ²

8.3 Livestock depredation in time and space

In general, depredation of domestic animals is low compared to other studies in Africa. The livestock loss reported in this study is among the lowest recorded. However, it can still be an economic constraint to households, as they are subsistence farmers who depend on food aid for part of the year. In general, depredation of domestic animals remains tolerable and people have a positive perception of hyenas. This would also contribute to hyena persistence in this environment. Various factors account for livestock depredation, such as livestock husbandry practices, low prey abundance, livestock enclosures and characteristics of attacked villages (Sillero-Zubiri & Laurenson, 2001; Madhusudan, 2003; Polisar et al., 2003; Ogada et al., 2003; Treves et al., 2004; Bagchi & Mishra, 2006; De Iongh & Bauer, 2008). In my study, dogs were reported as victims of hyena predation, which confirms that domestic dogs were not effective in protecting villages from hyena attacks.

In all studies reported above, livestock predation occurred in grazing fields during the day when livestock were separated from the herdsmen. Comparing attacks in the fields with attacks in enclosures, jackals and hyenas were more likely to attack grazing livestock during the day while leopards mostly attacked livestock during the night. In terms of total numbers of livestock killed, jackals were the most serious predators, followed by hyenas. Higher livestock predation was observed at nighttime for hyenas and leopards and during the day for jackals. Assessing depredation problems is an important step in developing actions for management. Fortunately, despite the occur-

rence of livestock predator conflicts, retaliatory killing of carnivores was not common in the study area.

Coexistence of hyenas in a human-dominated landscape in Ethiopia has several explanations. Ethiopia has more than 80 million domesticated hoofed animals (Mitchell, 2003). The depletion of wild prey has meant that livestock more readily supports carnivorous need for prey. Availability of waste, culture/religion, history and awareness of clearing role of hyenas have contributed to human-hyena coexistence. In my study hyenas scavenged on livestock that died from disease or by accident and also preyed on live domestic animals. Waste management is poor in many cities of Ethiopia and solid wastes are dumped along roadsides and in open areas (Tadesse et al., 2008). Hyenas with dens near towns or cities in Ethiopia live on garbage or other organic refuse (Gade, 2006). Hyenas are formally protected in Ethiopia and that people are not allowed to kill hyenas.

The relative abundance of hyenas is also associated with its accepted role in removing garbage and carrion from households and urban dumps. When feeding on waste, hyenas reduce fly and rat populations as well as fetid odors (Gade, 2006; Yirga et al., unpubl.).

Viable populations of large carnivores across the globe coexist in a landscape with people that bring anthropogenic resources (Linnell et al., 2001; Conover, 2002; Woodroffe et al., 2005). The ability of large carnivores to persist in human-dominated landscapes has stimulated debate in recent years (Woodroffe, 2000; Linnell et al., 2001; Basille et al., 2009). Human density, human activities and associated human–carnivore conflict are key factors determining large carnivores' occurrence and persistence in human dominated landscapes (Woodroffe, 2000; Woodroffe et al., 2005). In anthropogenic landscapes, the occurrence and persistence of large carnivores seem to be modulated by food availability (Fuller & Sievert, 2001; Basille et al., 2009), and factors that affect survival such as human activity or landscape context, which can reduce human pressure (Woodroffe & Ginsberg, 1998). My study has revealed an exceptional case of coexistence. In northern Ethiopia, high density of hyenas persists in anthropogenic landscapes where human densities are remarkably higher.

8.4 Conclusions

The following conclusions can be drawn from this study:

- 1 Hyenas in Tigray depend entirely on domestic prey species, partly through depredation but much more importantly by scavenging on (peri-) urban waste. Scavenging on waste and livestock depredation by hyenas occurs widely across Ethiopia. Spotted hyenas in Ethiopia predominantly depend on anthropogenic food sources rather than natural prey. Hyenas scavenge less and hunt more during fasting, selecting opportunistically for donkeys. My study showed a remarkable change in hyenas' diet during the fasting period, from predominantly scavenging on waste to active predation on donkeys. Hyenas are highly adaptable and opportunistic scavengers and hunters. They show fast reaction to change in human behavior.
- 2 A population of 535 hyenas lives close to human communities without any reports of retaliatory killing in Wukro district. This demonstrates a rare case of coexistence, where hyenas benefit from waste disposal and human communities benefit from the waste clearing. It also demonstrates the high adaptability of hyenas which in this case specialize entirely in waste consumption.
- 3 The use of playback recordings to attract predators works successfully for estimating hyena abundance and distribution. It is also effective for characterizing the hyena population's spatial distribution.
- 4 Under the particular local circumstances (solid wastes are dumped along roadsides and into open areas), continued coexistence between spotted hyenas and local communities appears possible, provided that livestock depredation remains tolerable.
- 5 The depletion of natural prey and habitat degradation and fragmentation due to high human population pressure may be reasons for livestock predation by carnivores. Assessing depredation problems is important in order to develop actions for managing either livestock practices or wildlife conservation. More livestock predation was observed at night for spotted hyenas and leopards and during the day for jackals., making night-time a high risk period for livestock depredation by hyenas and leopards, and daytime for livestock depredation by jackals.

8.5 Recommendation for management of waste dumps

Hyena population persistence is secure under the present conditions, as waste management is poor and solid wastes are dumped along roadsides and into open areas. Waste management changes from open to closed systems would immediately impact on the ecology and viability of the spotted hyena population. Hyenas in my study area live predominantly on garbage and other organic refuse. Reduction in the availability of waste could force hyenas to prey on live domestic animals, which might impact the human-hyena relationship. At this time, Mekelle city is considering improving solid waste management from an open to a closed system, by fencing the garbage dumps. For long term conservation, it is therefore recommended that dumps should have openings to allow hyenas to enter. Mutual benefit of hyenas and the municipality should be considered in the management of waste dumps. Hyenas are efficient means of sanitation; they remove garbage and carrion from the garbage dumps, reduce fetid odors, and help control rat and housefly populations.

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