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2

The Diet Ecology of the Ethiopian Wolf

Does livestock predation reflect negative local perceptions of Ethiopian wolves in South Wollo?
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Abstract

The conservation of rare and endangered carnivores in human dominated landscapes is particularly challenging when predators are perceived as a threat to livestock. This study verifies whether the human perception of Ethiopian wolves as predators of livestock accurately reflects the actual damage done by this specialist predator of highland rodents. With that purpose in mind, we quantified the contributions of prey species, including livestock, to the diet of Ethiopian wolves by analysing 118 scats. We then compared them to the reported livestock losses and attitudes in 300 households surrounding wolf habitat in the highlands of South Wollo in north Ethiopia. We found 10 prey species, totalling 222 prey occurrences in the study sample. The most common prey were diurnal rodents, with 79.2% of all prey occurrences. Only 5.4% were livestock (sheep) remains, a result similar to that obtained in other wolf populations. The proportion of households reportedly affected by Ethiopian wolf predation was relatively low (17%), and these households had lost an average of 1.0 sheep per year over the previous five years. Even though the proportion of households affected by livestock predation was relatively low, 88% of the households that reported losing sheep to Ethiopian wolves had a negative perception of the species, compared with only 9% of the households unaffected. Clearly current levels of livestock predation in South Wollo lead to widespread negative attitudes among the people affected, an emerging problem that requires the attention of conservationists and wildlife authorities.

Keywords

Afroalpine ecosystem, Borena Sayint National Park, faecal analysis, foraging ecology, human–wildlife conflict, rodents

2.1 Introduction

The conservation of rare and threatened carnivores in human-dominated landscapes is always challenging. Humans often modify habitats and perceive carnivores as a threat to livestock (Athreya *et al.*, 2013). The Ethiopian wolf (*Canis simensis*) is a rare and endangered canid, with an estimated total population of fewer than 500 individuals and restricted to six populations in the Afroalpine highlands of Ethiopia (Marino and Sillero-Zubiri, 2011). They are unusual among canids in that their diet is composed almost entirely of the small rodents that dominate the Afroalpine ecosystem of Ethiopia (Sillero-Zubiri *et al.*, 1995, Sillero-Zubiri and Gottelli, 1995, Ashenafi *et al.*, 2005, Marino *et al.*, 2010), yet emergent conflicts due to predation on livestock have been reported in some areas (Yihune *et al.*, 2008, Marino *et al.*, 2010, Eshete *et al.*, in press). The feeding patterns of carnivores, and thus diet composition, can change in response to variations in biotic and abiotic factors such as habitat, prey preference and density, predator density, season and weather (Hayward and Kerley, 2005, Stahler *et al.*, 2006, Bauer *et al.*, 2008) and, in the case of the Ethiopian wolf, the presence of humans and livestock in Afroalpine areas (Ashenafi *et al.*, 2005, Marino *et al.*, 2010). With increasing human and livestock densities within the Ethiopian wolf range, the likelihood increases that wolves will turn to livestock as prey. The potential for an escalation of human–wildlife conflict calls for a better understanding of the feeding ecology of these endemic animals living in remote small populations outside their prime range in the Bale Mountains.

Ethiopian wolves typically live in packs and communally defend a territory, but unlike most other carnivores they are solitary foragers (Sillero-Zubiri and Macdonald, 1998). In the Bale Mountains in the southern Ethiopia massif, the diet of Ethiopian wolves is dominated by the Bale-endemic giant molerat (*Tachyoryctes macrocephalus)* and three species of small Murinae grass rats (*Arvicanthis blicki*, *Lophuromys melanonyx*, *Otomys typus*), followed by Starck's hares (*Lepus starcki*) (Morris and Malcom, 1977, Sillero-Zubiri and Gottelli, 1995). Owing to the absence of giant molerats in the Central and Northern highlands, Ethiopian wolves there rely more heavily on the relatively smaller East African molerat (*Tachyoryctes splendens*) when this is available, and on other diurnal rats, including *A. abyssinicus*, *Lophuromys flavopunctatus,* and the swamp rat *O. typus* (Ashenafi *et al.*, 2005, Marino *et al.*, 2010).

It is expected that where the density of rodents is relatively low and where human interference is severe, Ethiopian wolves might become more crepuscular or nocturnal (Brown, 1964, Sillero-Zubiri *et al.*, 1997) and prey more frequently on livestock, leading to increasing conflict with local communities (Marino, 2003, Marino *et al.*, 2010, Eshete *et al.*, 2015). Indeed, Ethiopian wolves have been observed hunting sheep and small antelopes in small packs

(Harper, 1945, Sillero-Zubiri and Gottelli, 1995). However, discrepancies between alleged and real livestock losses to wild carnivores are not uncommon in human–carnivore conflict situations and, in general, conflicts tend to stem from perceived rather than real threats to property (Treves and Karanth, 2003). To aid the conservation of this endemic carnivore, increasingly threatened by human encroachment, it is important to examine whether pastoralists' perceptions of Ethiopian wolves are built on convincing evidence or unfounded belief.

This is particularly important for the Ethiopian wolf population in the South Wollo highlands, including the Borena Sayint National Park, an Afroalpine relict with an estimated wolf population of 50 individuals (EWCP, 2014) and under enormous pressure from agriculture encroachment, extensive grazing and firewood collection (Marino, 2003, EWCP, 2014). To assess actual predation we conducted a detailed analysis of the Ethiopian wolf diet from prey remains in scats, a non-invasive method commonly used to study feeding ecology in carnivores (Corbett, 1989, Klare *et al*., 2011, Maria *et al*., 2012) and to clarify predator–prey relationships (Jedrzeiewski *et al.*, 2002, Hayward and Kerley, 2005, Bauer *et al.*, 2008). We combined this with socio-economic surveys of shepherds and local people to quantify reported livestock losses; this method is especially valuable in verifying the human perception of livestock predation by wild carnivores (Marker *et al*., 2003).

We tested whether diurnal rodents remain the preferred prey of Ethiopian wolves in this human-dominated landscape, in comparison with the occurrence of livestock remains in scats and the losses reported by people, and whether human perceptions of Ethiopian wolves reflected the actual or reported damage to livestock in the South Wollo highlands.

2.2 Methods

2.2.1 Study area

The study was carried out in the Northern highlands of Ethiopia, encompassing almost the totality of Afroalpine habitats in South Wollo, including the original Borena Sayint National Park and its proposed extension area currently together called Borena Sayint National Park (BSNP), located between 10^{0}50'45.4"-10^{0}57'03" latitude and 38^{0}40'28.4"-39^{0}10'39" longitude (Figure 2.1).

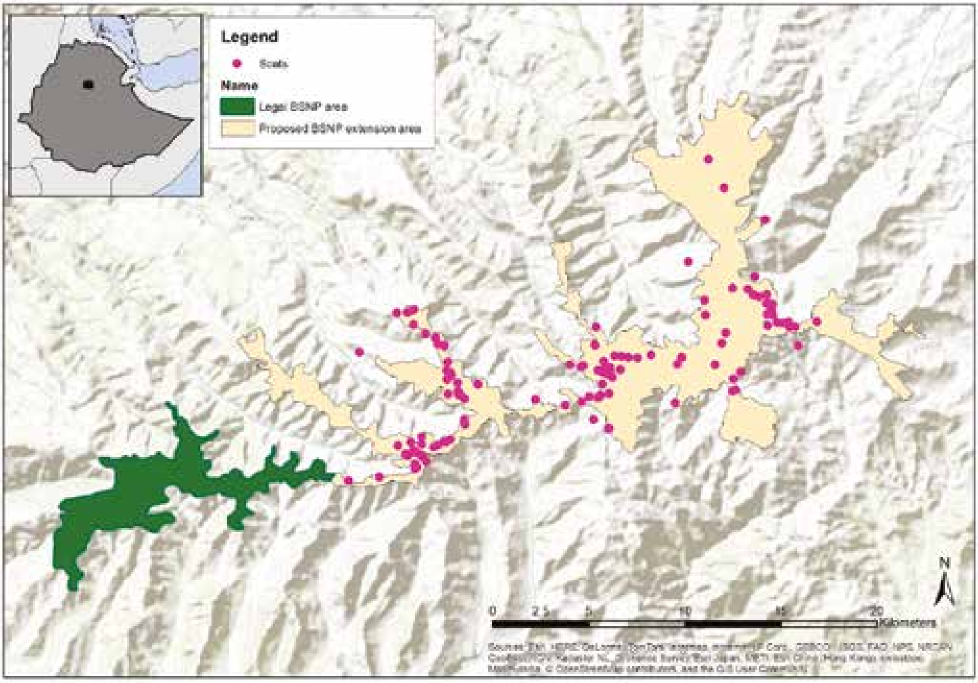

Figure 2-1
Study area in the South Wollo highlands of northern Ethiopia, showing the location of the Ethiopian wolf scats analysed in this study

The study site covers approximately 153 km^2 in an altitude range of 3200 to 4280 m asl (Adal, 2014). The original BSNP (~44 km^2) has been fully protected from livestock grazing and resource harvesting for several decades (Eshetu, 2014); the remaining Afroalpine areas are communal land used as pasture for livestock and to collect firewood and grasses, with some communities implementing some degree of natural resource management. The area is characterised by deeply incised valleys, mountain escarpments and plateaux. It has a bimodal rainfall pattern, with a long rainy season from June to September and a short rainy season from March to April, and the annual rainfall ranges between 655 and 1,165 mm (Yazezew *et al.*, 2011). The annual temperature in Ethiopia's Afroalpine ecosystem ranges from 7.5 to 11^{0}C and the climate is characterised by extreme temperature variations between day and night (ESP, 2001).

The study site provides a good representation of the high biodiversity of the Ethiopian highlands, endowed with endemic flora and fauna, but it is also subject to serious human influence resulting in habitat destruction and growing human–wildlife conflict (Eshetu, 2014). The area exhibits a mosaic of vegetation types including Afroalpine grasslands and meadows, dominated by *'guassa'* grasses (*Festuca* spp.) and heaths of *Euryops* and *Kniphofia* spp., and patches of *Erica* forest (Adal *et al.*, 2015). The area sustains a rich fauna with endemic birds and mammals including gelada baboon (*Theropithecus gelada*), Menelik's bushbuck (*Tragelaphus scriptus meneliki*), Starck's hare (*Lepus starcki*) and several Murinae and Spalacidae rodent species (five species trapped in 2014 and 2015 in the wolf habitats, Eshete *et al.* submitted). There are 23 large and medium-sized mammals in BSNP (Chane and Yirga, 2014, Yazezew *et al.*, 2011), including seven carnivores: leopard (*Panthera pardus*), spotted hyaena (*Crocuta crocuta*), golden jackal (*Canis aureus*), serval (*Felis serval*), caracal (*F. caracal*), wild cat (*F. silvestris*), and honey badger (*Mellivora capensis*); and the following herbivores: common duiker (*Sylvicapra grimmia*), klipspringer (*Oreotragus oreotragus*), the rock hyrax (*Procavia capensis*), and the colobus monkey (*Colobus guereza*). The tourist value of this area is potentially important, due to its endemic animals, scenery and historical sites. The Afroalpine habitat is bordered by six districts or woredas, namely: Borena, Sayint, Mehal Sayint, Legambo and Mekidella, which combined had a human population of 948,841 in 2015 and 1.6 million livestock including cattle, pack animals (donkeys, mules, horses), sheep and goat (DoFEAD, 2015). The current human and livestock population densities living in the six districts are ~138 people and ~233 heads of livestock per km^2 respectively. The local communities of South Wollo engage in small-scale agriculture and livestock rearing and depend on Afroalpine natural resources for firewood, building materials, drinking water, grazing, hay and thatch grass. These land uses are degrading many Afroalpine areas where Ethiopian wolves occur (Ashenafi and Leader-Williams, 2005, Eshete *et al.*, 2015).

2.2.2 Scat collection and analysis

A total of 118 Ethiopian wolf scats were collected during the dry seasons of 2015 and 2016 (December, February, and May) from the proposed BSNP extension area across the Afroalpine range outside the original BSNP (Fig 1), by the main author and two research assistants trained to identify Ethiopian wolf scats by shape, colour, and size (only adult sized scats were considered). The sample was considered to be representative of this small wolf population, and large enough to detect rare prey items (Trites and Ruth, 2005). Our survey routes traversed across the range of suitable wolf habitat only once, to diminish the likelihood that samples from one given area were derived from a few individuals, and collected one independent scat when multiple scats found in the same site to avoid pseudoreplication bias (Marucco *et al.*, 2008). To avoid mistakenly collecting domestic dog scats, areas near human settlements were avoided and also domestic dog scats look sufficiently different from wolf scat (Marino *et al.*, 2010). We restricted our sample to the dry season because previous studies in the Bale Mountains (Sillero-Zubiri and

Gottelli, 1995), Menz (Ashenafi *et al*., 2005) and Simien (Yihune and Bekele, 2014) found no differences in diet composition between dry and wet seasons. The scats were collected in plastic bags, promptly sun-dried and stored in sealed bags labelled with the GPS position, date of collection, place, and habitat type. Each dry sample was then broken carefully on a petri dish by hand. Macro components including large bones, jaws, teeth, hooves, hairs, wool, skin, feathers, plant matter, and others were separated and examined using a hand-held lens. Prey remains were categorised as follows: Murinae rats (small-sized grass rats), common molerat (large rat, Spalacidae), medium-sized mammals (such as hyraxes and hares), birds, and others. Murinae rats could be identified to the level of species by comparing jaws and teeth against a reference collection of rodent species trapped locally, a robust method to characterise the diet of Ethiopian wolves (Marino *et al*., 2010). Hairs of sheep, Starck's hare, and rock hyrax could also be identified microscopically comparing with reference hair collections of these species from the study area.

To describe the diet of the Ethiopian wolf we quantified the relative contribution of each prey type as a proportion of the total number of occurrences in the sample (hereafter named ''frequency of occurrence per prey type''= total number of occurrences of that prey divided by the number of all prey occurrences in the scat sample) (Lockie, 1959), and as a proportion of the number of scats (hereafter named ''frequency of occurrence per scat''= number of occurrences of a prey species divided by the total number of scats, multiplied by 100) (Lockie, 1959, Ciucci *et al*., 1996). Predators with large prey relative to their size can produce highly correlated clusters of scats. Conversely, carnivores that eat small prey like Ethiopian wolf produce fewer scats per individual prey item, which likely would lead to fewer problems with independence. In such cases, biomass calculation may be too biased for the small prey sizes consumed. Frequency of occurrence, however, can contribute useful additional information about rare food items and also help to understand a carnivore's ecology, such as its role as an opportunist or a specialist (Zabala and Zuberogoitia, 2003).

We used Jacob's index to determine the preferences of Ethiopian wolves for three common rodent prey species, based on the average population density of *L. flavopunctatus, A. abyssinicus,* and *S. griseicauda,* in the study area (derived from trapping data in 2014 to 2015 at BSNP by Eshete *et al*. 'unpublished'), Jacob's indices were calculated as follows:

Jacob's index (D) = r-p/r+p-2pr

Where r is the proportion of each prey species count in the diet of the predator, and p is the proportion of the same prey species availability in the environment/study area. The resulting value ranges from +1 to -1, where +1 indicates maximum preference and -1 indicates maximum avoidance. The preference of the Ethiopian wolf is associated with the largest value of D (Jacobs,1974).

2.2.3 Interviews

Structured interviews with the local Amharic language were conducted between March and April 2015 for 300 households selected randomly from a list of 3471 households living in six districts bordering the BSNP in South Wollo. We interviewed people who regularly visit the Afroalpine area to herd their livestock, collect grasses and firewood, fetch water, or who were en route through the habitat. Heads of households were asked the number of livestock they owned, and to report how many of their sheep had been killed by Ethiopian wolves in 12 months or five years prior to the interview. Heads of households were also asked about their attitude towards wildlife of the area, which wildlife they loved and which they hated, the reason for their hatred and love, any benefits they obtained and loss related to wildlife, and what they thought about Ethiopian wolves (for example, by means of a question, Is the Ethiopian wolf good (positive) or bad (negative)? For the households that reported predation by Ethiopian wolves, verification questions were asked to assess whether people were certain that wolves and not jackals were responsible for the reported killings.

2.2.4 Statistical analysis

Descriptive statistics and chi-square tests were conducted to describe and compare diet composition and people's attitudes, using the statistical package SPSS, version 16.0 (SPSS Inc., Chicago, IL, USA).

2.3 Results

2.3.1 Scat analysis

A total of 222 prey items, categorised into 10 prey species, were found in the sample of 118 Ethiopian wolf scats. Of those, 64.4% contained more than one prey species, and the remainder (35.6%) only one (average 1.88 prey type per scat). The remains identified in the scats were mammal bones, jaws, teeth, hooves, hair, sheep wool, skin, bird feather and undigested plant materials. Of the prey remains identified, 95% were mammals, comprising five species of rodents, two species of medium-sized mammals, and one species of livestock (sheep) (Table 2.1).

Table 2.1
Frequency of occurrences per prey item and per scat in the diet of Ethiopian wolves of South Wollo

Grouped prey items	Number of prey occurrences across all scats	Frequency of occurrence per prey (% FO/I*)	Frequency of occurrence per scats (% FO/S*)
Murinae			
Lophuromys flavopunctatus	53	24	45
Arvicantis abyssinicus	70	31.5	59.3
Stenocephalemys griseicauda	20	9	17
Otomys typus	17	7.7	14.4
Spalacidae			
Tachyoryctes splendens	36	16	30.5
Medium-sized mammals			
Livestock (sheep)	12	5.4	10.2
Rock hyrax (*Procavia capensis*)	2	0.9	1.7
Starck's hare (*Lepus starcki*)	4	1.8	3.4
Birds	3	1.4	2.5
Plant matter	5	2.3	4.2

*I = Total prey item occurrences = 222
*S = Total scat numbers collected = 118

Murinae rodents and East African molerats were the food items most frequently encountered, constituting 88.2% of all prey occurrences (Table 2.1); 79.2% were diurnal and 9% nocturnal rodents. Sheep was the only livestock species found in scats (identified from wool, teeth, hooves and/or skin) and this constituted 5.4% of all prey occurrences. Plant matter, Starck's hare, birds and rock hyrax contributed 2.3%, 1.8%, 1.4% and 0.9% respectively to the wolf diet (Table 2.1). Considering the relative frequency of occurrences of rodent prey, *A. abyssinicus, L. flavopunctatus* and *T. splendens* were the three most commonly consumed (Table 2.1) and *O. typus* was the least common. Rock hyrax was the mammal prey with the lowest frequency in the diet (Table 2.1).

Among the three most common Murinae rodents, the diurnal *A. abyssinicus* was the most preferred by the Ethiopian wolf, with a Jacob's index value of 0.4, while the nocturnal *S. griseicauda* seems to be avoided, with a Jacob's index value of –0.4 (Table 2.2).

Table 2.2
Ethiopian wolf diet preference for the three most commonly captured rodents in the study area. (*Density = n km^{-2} data for the three rodents was taken from Eshete *et al*. submitted)

Rodent species	*(n km^{-2})	p	r	Jacob's index value	Preference rank
Lophuromys flavopunctatus	9159	0.5	0.4	-0.2	2nd
Arvicantis abyssinicus	5451	0.3	0.5	0.4	1st
Stenocephalemys griseicauda	3136	0.2	0.1	-0.4	3rd

2.3.2 Interviews

Out of 300 households interviewed 247 (82%) owned sheep and some other livestock. Of those, 42 (17%) reported losing sheep to Ethiopian wolves, totalling 43 losses in the past year, and 118 over the past five years. This equated to a mean annual loss, across the households that owned livestock, of between 0.2 and 0.5 sheep per household, respectively (Table 2.3). Considering only the households that lost sheep, these suffered losses averaged 1.0 and 2.8 sheep per household in the last one and the last five years respectively. 110 (44.5%) households were lost 222 and 572 sheep in the last one and the last five years respectively by common jackal. This is 0.9 and 2.31 sheep per sheep owned households; and 2.0 and 5.0 sheep respectively per sheep lost households lone.

Table 2.3
Size of sheep flock and number of sheep reportedly killed by the Ethiopian wolf, per household, in South Wollo.

	Minimum	Maximum	Sum	Mean	Std deviation
Size of sheep flock owned	1	30	2664	10.8	6.07
Sheep killed by Ethiopian wolf in the last 12 months	0	5	43	0.17	0.62
Sheep killed by Ethiopian wolf in the last five years	0	17	118	0.48	1.81

There was a significant difference ($X^2 = 1.24$, df = 1, P = 0.0001) in attitudes towards the Ethiopian wolf among households that lost sheep to wolves and those that did not. Most heads of households that lost sheep to wolves reported a negative perception of the Ethiopian wolf (88% of 42 households), compared with only 9% of the 205 households that did not lose sheep (Figure 2.2).

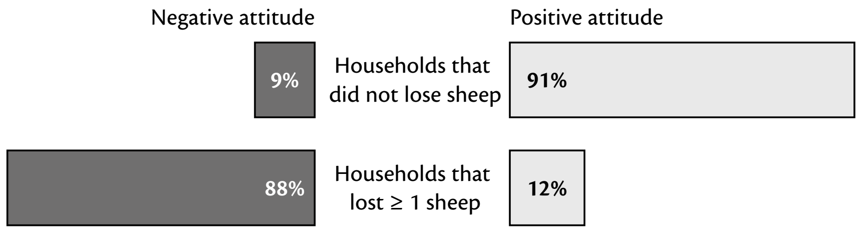

Figure 2.2
Attitude towards Ethiopian wolves amongst sheep-owning households (n=247; households with no sheep losses: n=205; households that lost sheep: n=42)

2.4 Discussion

Our study showed that the diet of Ethiopian wolves in South Wollo was composed of 10 prey species, predominantly rodents, and that livestock contributed only a small proportion (5.4%). The level of livestock predation coincides with findings from previous dietary studies, and confirms that livestock is not a dominant source of food for Ethiopian wolves, even in human-dominated landscapes with high density of domestic stock (Marino *et al.* 2010). The reported loss across all sheep owned households was also relatively low, and these lost on average was less than one sheep per year over the past five years. These results suggest that even low levels of livestock predation can result in negative perceptions towards Ethiopian wolves among the local communities. While this level of predation may not appear substantial per total sheep owned by households (2% of the total sheep flock owned by households), negative attitudes towards wolves among the affected people were prevalent, unlike the households not affected, which were the majority of the affected households presumably lost livestock to other predators and/or the loss is relatively large (10% of the affected household's flock).

As shown by previous studies and corroborated here, Ethiopian wolves in the highlands of South Wollo predominantly consume a few small mammal species. In view of its relatively large size, the East African molerat contributes an important proportion of the biomass consumed by wolves in South Wollo. Small rodents are an abundant food resource in the Afroalpine ecosystem, and require less searching effort and manipulation risk than a medium-sized or large herbivore. Clearly, small mammals remain more cost-effective to hunt than sheep or other herbivores, considering the metabolic energy requirements of a carnivore of less than 20 kg like the Ethiopian wolf (Mukherjee *et al.*, 2004, Carbone *et al.*, 2007).

Also in accordance with other studies, Ethiopian wolves in South Wollo were found to rarely consume Starck's hares and rock hyraxes (Sillero-Zubiri and Gottelli, 1995, Ashenafi *et al.*, 2005, Yihune and Bekele, 2014); birds were also uncommon. Plant matter found in scats might have been ingested by chance while swallowing other foods or was probably ingested to assist digestion and parasite control (Sillero-Zubiri *et al.*, 1997).

Ethiopian wolves in South Wollo do not depend on livestock to survive, and appear to consume livestock only opportunistically. However, if the current rate of Afroalpine habitat degradation continues, with declining rodent populations and increasingly availability of domestic stock, the Ethiopian wolf may switch to livestock as an alternative to its preferred natural rodent prey (Meriggi and Lovari, 1996). Current agriculture and livestock encroachment trends in many parts of the study area are a source of concern, as they may encourage livestock raiding by wild carnivores (Personal observation). Even at current perceived levels of livestock predation, Ethiopian wolves are causing concern among most of the households affected in South Wollo (nearly 90%).

The importance of livestock as a prey for other wolf species has been well documented globally (Fuller, 1989, Meriggi and Lovari, 1996, Vos, 2000) and in many cases wolves' dependence on livestock has led to human–carnivore conflict and persecution. In the case of the Ethiopian wolf, authorities and conservationists should consider actions to limit the dependence of wolf packs upon livestock, to avoid potential retaliation. On the other hand, Ethiopian wolves in South Wollo still maintain a diet composed predominantly of rodent species in a human-dominated landscape, demonstrating their ability to survive in close proximity to human habitation, as is also the case in Menz and in the Simien Mountains (Ashenafi *et al.*, 2005, Yihune and Bekele, 2014). *A. abyssinicus*, *L. flavopunctatus* and *T. splendens* remain common in these areas (Ashenafi *et al.*, 2005, Yihune and Bekele, 2014), while the swamp rat *O. typus* is seemingly less important as a food source, suggesting that its availability might be changing, probably in relation to the widespread degradation of wetlands in the highlands of Ethiopia. The contribution of nocturnal rodents to the diet of the Ethiopian wolves in South Wollo was found to be small, and thus does not provide any evidence in support of an expected propensity of Ethiopian wolves to forage at night in response to the presence of humans and livestock, as would be suggested by the wolves' diet in the Simien Mountains (Marino *et al.*, 2010).

Indeed, our analysis of food preferences indicated that wolves prefer *A. abyssinicus* and *L. flavopunctatus,* two diurnal rodents, over the nocturnal *S. griseicauda,* as also described for Menz and Simien (Ashenafi *et al.*, 2005, Yihune and Bekele, 2014).

2.4.1 Conservation implications

Our results confirm that Ethiopian wolves are specialist diurnal rodent predators in the Afroalpine ecosystem, but if rodent populations continue declining due to habitat degradation across this endemic canid's range, the wolves might increasingly switch to domestic livestock for food. The associated costs to local livelihoods could easily become unbearable for the affected households given their daily income of less than USD 1 (Bluffstone *et al.*, 2008). Habitat restoration to maintain and enlarge prey populations is therefore a major conservation priority. People in this area tend to be tolerant of Ethiopian wolves (most households reported positive views) but as negative perceptions were prevalent among those affected, in spite of the relative low incidence of livestock predation by wolves, these could soon lead to human–wildlife conflict in BSNP. Emergent conflicts could be curtailed by minimising predation by Ethiopian wolves, targeting the most vulnerable households. The support of the local population therefore is critical for the conservation of Ethiopian wolves in South Wollo, but conservation success will also depend on the successful maintenance of the wolves' natural prey and education to raise awareness of the need to protect this enigmatic endemic species.

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