

## Short Note

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# Wolf diet in an agricultural landscape of north-eastern Turkey

**Abstract:** In this study, we investigated wolf feeding ecology in Kars province, north-eastern Turkey, by analysing 72 scat samples collected in spring 2013. Ongoing camera trap surveys suggest that large wild ungulates are exceptionally rare in the region. On the contrary, livestock is abundant. Accordingly, scats analysis revealed that livestock constituted most of the biomass intake for wolves, although small mammals were the most frequent prey items. Wild ungulates were occasional prey, and although wolves make use of the main village garbage dump as a food source, garbage remains were scarce in scat samples. Wolf dependence on anthropogenic resources, primarily livestock, generates human-wildlife conflicts in the study area. Uncontrolled carcass disposal seems to boost this wolf behaviour. Synanthropy enhances the probability of wolf-human encounters and thus increases the risk of direct persecution, vehicle collisions, and hybridisation with dogs. When livestock is not available, small mammals are an important alternative prey for wolves. This may increase interspecific competition, particularly with lynx, which is also lacking natural prey in the area. Our preliminary results contribute to wolf ecology and conservation in the Anatolian-Caucasian range, where further studies are urgently needed to generate baseline data.

**Keywords:** generalist carnivore; human-wildlife conflict; livestock scavenging; scats analysis.

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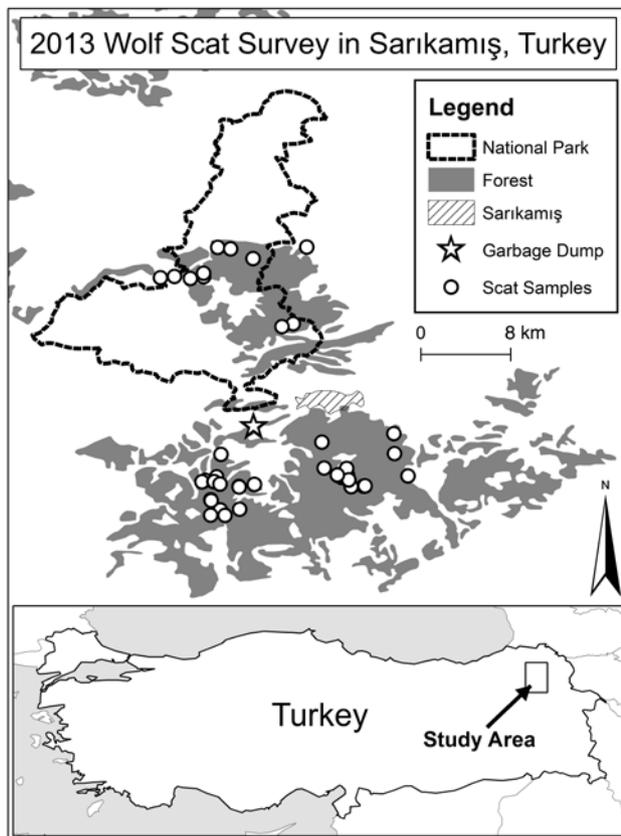
Wolves (*Canis lupus* Linnaeus, 1758) have been studied throughout their distribution, but very little is known about the Anatolian-Caucasian populations. Given its ecological and geographical continuity with vast areas of Central Asia and the Middle East, Turkey plays a central role in maintaining wolf populations throughout the region. The mountains of Turkey have served as a reservoir for the wolves surviving in Syria (Boitani 2003); yet, habitat loss, illegal killing, taking pups from the wild and vehicle collisions have resulted in a decline of wolves and other large-carnivore populations in Turkey (Şekercioğlu et al. 2011). Wolves are a species under protection from hunting according to the Article 4 of Turkey's Terrestrial Hunting Law (Tuğ 2005), and the Ministry of Forestry and Water Affairs is in charge for the management of this species (Anonymous 2012). Monitoring the status of the wolf population in Turkey is essential for the conservation of the species both in the country and over a broader area.

The local environmental organisation KuzeyDoğa Society ([www.kuzeydoga.org](http://www.kuzeydoga.org)), in collaboration with the General Directorate of Nature Conservation and National Parks, supported the creation of the first wildlife corridor in Turkey, eventually designated in 2011 with the Ministry of Forestry and Water Affairs (Şekercioğlu 2012). The corridor aims to connect isolated forest remnants through reforestation, to provide habitat connectivity and to facilitate the movements of large carnivores and their prey species. It will cover 22,346 ha and will extend for 136 km, from Kars province, north-eastern Turkey, to the extensive Caucasus forests on the Turkey-Georgia border. For the corridor to be effective, it is critical to improve the understanding of large-carnivore population dynamics and spatial ecology in the area.

Opportunistic surveys over the last decade suggested that primary prey species for wolf in Turkey are red deer (*Cervus elaphus* Linnaeus, 1758), roe deer (*Capreolus capreolus* Linnaeus, 1758), wild boar (*Sus scrofa* Linnaeus,

1758), brown hare (*Lepus europaeus* Pallas, 1778) and livestock (Can O.E. personal communication, Anonymous 2012). However, quantitative investigations on wolf diet and in particular on the relative share of wild and domestic ungulates have not been conducted to date.

In this study, we present the results of a quantitative assessment of wolf diet based on scat analysis conducted around Sarikamiş, Kars (Figure 1). Our goals are to contribute baseline data on large-carnivore ecology in the extended wildlife corridor area and to improve the general knowledge on wolf ecology in Turkey. The study area (approximately 550 km<sup>2</sup>) is located on a high plateau at the intersection of Caucasus and Irano-Anatolian global biodiversity hotspots. Altitude ranges between 1900 and 3120 m asl. The landscape is characterised by patches of forest spaced out by grassland. Although fragmented, forests cover approximately 60% of the study area. Only 15% (49.7 km<sup>2</sup>) of the forested areas is included in the Sarikamiş-Allahuekber Mountains National Park (hereafter SAM NP) (Figure 1).



**Figure 1:** Location of the study area: SAM NP and surrounding forest in north-eastern Turkey. The SAM NP is fragmented forest in a landscape dominated by human activity, mainly livestock grazing. We collected 72 wolf scats during a 1.5-month period in May–June 2013.

Forests consist almost exclusively of Scots pine (*Pinus sylvestris* Linnaeus, 1753), while understory vegetation is scarce, with consequent scarcity of food resources for browsers.

Based on extensive camera trap surveys, wild boar is present at low density, and roe deer is rare (Chynoweth et al. unpublished data). On the contrary, livestock is abundant. About 851,445 livestock heads have been registered in the Kars province in 2012 (Ministry of Food, Agriculture and Livestock, Republic of Turkey). Cattle (*Bos taurus* Linnaeus, 1758), sheep (*Ovis aries* Linnaeus, 1758) and goats (*Capra hircus* Linnaeus, 1758) roam freely on pastures from April to November in average climate conditions. Wolf, bear (*Ursus arctos* Linnaeus, 1758) and lynx (*Lynx lynx* Linnaeus, 1758) are present in the area. At the time of this study, at least two wolf packs occupied the area, and reproduction was observed in one of them (Chynoweth et al. unpublished data). The scarcity of natural prey species leads wolves, as well as brown bears, to feed at garbage dumps and on livestock, increasing the human-carnivore conflict.

During 3 weeks between May and June 2013, we intensively searched for signs of wolf presence and collected scats over a 307 km network of forest roads (Figure 1). We identified wolf scats on the basis of their size, shape, content and smell (Jedrzejewski and Sidorovich 2010). Scats of uncertain origin were discarded. Despite drawbacks pointed out for scat analysis and the related prey use indices (Klare et al. 2011), this methodology is helpful in preliminary surveys of carnivores' diet and is still widely used, which facilitates comparisons with results from different studies.

Given the limited sample size, we tested for adequacy of sample effort by calculating the Brillouin diversity index (Hass 2009), according to the equation  $H_b = \frac{\ln N! - \sum \ln n_i}{N}$  where  $H_b$  is the diversity of prey in the sample,  $N$  is the total number of individual prey categories in all samples and  $n_i$  is the number of individual prey in the  $i$ th category (Brillouin 1956). An  $H_b$  diversity curve was calculated by bootstrapping the sample 10,000 times with replacement to obtain a mean  $H_b$  and 95% confidence interval, varying the sample size from 2 to 100, in increments of 2. The  $H_b$  increment curve was then calculated from the incremental change in each mean  $H_b$  with the addition of two more samples. Adequacy of sample size was determined by whether asymptotes were reached in both curves when plotted against the sample size.

For every sample, the macroscopic components (hairs, bones, hooves, claws, garbage remains, etc.) were separated from the remaining matrix, and the volume of each item was visually estimated to the nearest 5%. In

most cases, mammal hairs were identified by examination of the medulla and cuticular surface structures under a microscope and compared with a specific hair atlas (Debrot et al. 1982). In few cases, hair and bones were compared with reference collections and museum specimens. For some samples, the species could not be determined, because of the poor quality of the remains or the lack of specific reference material.

The utilisation rate of different food items was calculated by frequency of occurrence per item (hereafter FO) and mean percent volume (hereafter MPV), following previous studies (Ciucci et al. 1996, Capitani et al. 2004). Remains contributing <5% of the total scat volume were considered as traces and not accounted for utilisation rate. Utilisation indices, in particular FO, tend to underestimate the share of big prey compared to the small ones and can be misleading when prey greatly differ in size (Klare et al. 2011). Therefore, we applied a biomass model to convert the equivalent number of scats in biomass and calculated the relative share of prey categories. Biomass models are sensitive to the weights of prey used during experimental feeding trials (Klare et al. 2011); thus, we chose the model which would cover the range of prey weights found in our sample (Table 1). We used the equation developed by Floyd et al. (1978),  $Y=0.02X+0.038$ , where Y is the kilograms of prey per collectable scat and X is the mean prey weight (kg). We excluded garbage remains and undetermined mammals that we could not estimate a mean weight. We calculated the biomass using the prey weights reported in

**Table 1:** Composition of wolf diet in SAM NP and surrounding forest in north-eastern Turkey, based on scats analysis (n=72; May–June 2013).

Food category	MPV (%)	FO (%)	BM	PW (kg)
Squirrel	19.4	17.5	4.6	0.5 <sup>a</sup>
Cattle	19.1	17.5	61.8	250 <sup>b</sup>
Hare	12.8	13.8	3.7	5
Small rodents	12.8	12.5	3.0	0.2
Sheep	10.4	11.3	7.4	40 <sup>c</sup>
Undetermined livestock	8.7	10.0	6.2	40 <sup>c</sup>
Wild boar	8.0	7.5	5.0	33.7 <sup>a</sup>
Undetermined mammal	4.2	5.0	–	–
Horse	2.8	2.5	8.0	220 <sup>c</sup>
Bear	1.4	1.3	0.5	13 <sup>d</sup>
Garbage	0.3	1.3	–	–
Total	100	100	100	

Prey abundance is quantified by MPV, FO and biomass share (BM) according to Floyd et al. 1978. <sup>a</sup>Mean weight of wild boar was estimated accounting for the weight classes identified in the scats, following Mattioli et al. (2011). Mean weights of prey (PW) followed previous studies: <sup>b</sup>Rigg and Gorman (2004), <sup>c</sup>Van Duyn et al. (2009) and <sup>d</sup>Tumanov (1998).

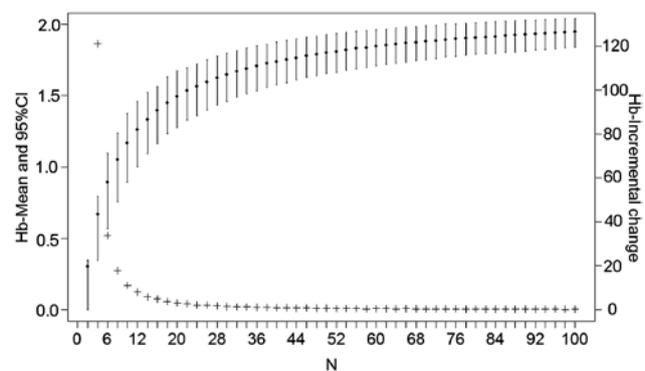
other studies (Rigg and Gorman 2004, Tumanov 1998, Van Duyn et al. 2009, Mattioli et al. 2011; Table 1).

Finally, we investigated the relationship between diet composition and livestock availability on pastures. In 2013, livestock was reported to begin grazing on pastures from the third week of April. We estimated the deposition time of our samples by collection date and degree of degradation). Samples with an estimated deposition time up to the third week of April were assigned to the season when livestock is not available to predators (hereafter season A). Remaining samples were assigned to the season when livestock are grazing on pastures and are vulnerable to predation (hereafter season B). We compared the use of two prey groups – specifically livestock and small mammals – and grouped the main food categories to maintain adequate sample size and to account for the undetermined categories within each group. We tested for seasonal differences in the mean volume of each group by applying the Wilcoxon rank-sum test.

Statistics were performed in R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>.

During the surveys, we collected 72 wolf scats useful for diet analysis, whose deposition time we estimated to vary from mid-March to mid-June. Fresh scats (deposition time <2 days) were not collected for the diet analysis since they were intended for other purposes. Both Hb index mean and incremental change curves reached an asymptote, and the incremental change declined below 1% at ≥36 samples (Figure 2), indicating that the sampling effort was adequate.

Given information collected through camera trapping (Chynoweth et al. unpublished data), we assumed that



**Figure 2:** The Brillouin diversity index (Hb) mean and 95% confidence intervals (CI) and incremental change curves. Mean and 95% CI were obtained by resampling with replacement 10,000 times. Mean and incremental change curves reached an asymptote, and the incremental change declined below 1% at ≥36 samples.

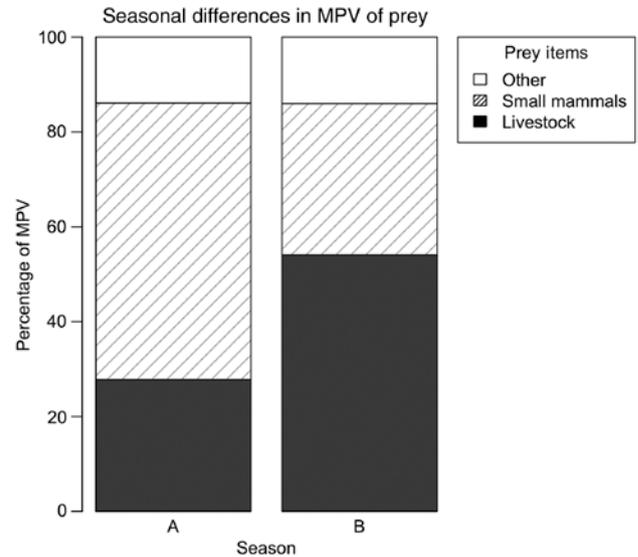
prey availability varies little across the study area and analysed the data cumulatively. Analysis of 72 scats documented a total of 80 food items, which were assigned to 11 food categories (Table 1). Only eight scats contained two different food items at the same time, and so MPV and FO resulted highly correlated (Spearman' correlation index,  $R_s=0.98$ ,  $p<0.01$ ).

The most frequent food categories were squirrel (*Sciurus vulgaris* Linnaeus, 1758 and *Sciurus anomalus* Gmelin, 1778) and cattle, followed by hare, sheep and small rodents (Table 1), which included black rat (*Rattus rattus* Linnaeus, 1758) and other undetermined rodent species. Overall, small mammals were the most abundant in scats, summing up to 45.2% of MPV. Livestock comprised 40.9% of MPV, including horse and other undetermined livestock remains, which most likely belong to either sheep or goat. Wild boar remains were found in six samples only, including one piglet. Though wolves have been frequently observed feeding at the main dump site of the village (authors' observations), garbage remains were rare; food remains taken at the dump could be difficult to recognise unless associated with undigested material. Finally, very exceptionally, one scat contained hairs and a claw from a bear cub.

As expected, biomass shares largely differed from utilisation indices (Table 1). Livestock represented 83.7% of biomass, while small mammals share totally amounted to 10.8% (Table 1). The use of livestock and small mammals differed between seasons A and B (Figure 3). Livestock increased from 27.8% of MPV in season A to 54.1% of MPV in season B (Wilcoxon test,  $W=477.5$ ,  $p=0.031$ ). On the contrary, small mammals decreased from 58.3% to 31.9% of MPV (Wilcoxon test,  $W=826.5$ ,  $p=0.025$ ).

According to our results, Sarikamiş wolves have a clear opportunistic feeding behaviour, using a wide variety of food items but mostly relying on anthropogenic resources, as found in other areas where wild prey are scarce (see Meriggi and Lovari 1996, Peterson and Ciucci 2003 for a review). Furthermore, our data suggest a seasonal variation in wolf diet due to the presence of free-ranging livestock on pastures, a behaviour that has been observed in other agricultural landscapes (Morehouse and Boyce 2011). The scarce use of wild ungulates confirms that the density of these species is very low in the study area. This scarcity of natural prey and the opportunistic feeding behaviour of wolves are probably leading to trophic niche overlap with other carnivores, particularly with lynx, which is also lacking natural prey in the area (i.e., roe deer) and whose diet can be influenced by wolf presence (Lelieveld 2013).

Our observations suggest that the wolves' feeding behaviour in Sarikamiş is related to local husbandry



**Figure 3:** MPV of prey found in 72 scats collected from SAM NP and surrounding forest in north-eastern Turkey in season A (mid-March to third week of April) and season B (fourth week of April to mid-June). Livestock increased from 27.8% in season A to 54.1% in season B (Wilcoxon test,  $W=477.5$ ,  $p=0.031$ ). Small mammals decreased from 58.3% to 31.9% (Wilcoxon test,  $W=826.5$ ,  $p=0.025$ ).

practices. Open-air disposal of livestock carcasses to some extent supports wolves that can scavenge on carcasses when live prey is not available (Blanco and Cortés 2007). These carcasses may also attract wolves to areas near livestock and could encourage livestock depredation (Morehouse and Boyce 2011, Tourani et al. 2014). The authors observed numerous openly disposed carcasses around Sarikamiş area and once in broad daylight wolves could be observed scavenging on a cattle carcass abandoned on the roadside a few kilometres from Sarikamiş village. Since conflicts are likely to be unevenly distributed across the landscape, assessing local conditions of farms and livestock husbandry practices is needed to provide specific mitigation tools (Rigg et al. 2011).

Synanthropy represents a major threat for wolves in Sarikamiş because wolves are more likely to approach human settlements to access trophic resources. This enhances wolf-human encounters probability and results in increased risks of direct persecution, vehicle collisions (Fritts et al. 2003) and hybridisation with dogs (Kopaliani et al. 2014). Human-induced mortality cases were often reported in the study area (Chynoweth et al. unpublished data), though detailed data on the wolf-livestock-human dynamics are currently lacking.

As proposed for other areas where wolves largely depend on anthropogenic resources, appropriate management of garbage dumps and of livestock carcass disposal

sites could reduce wolf-livestock conflicts and minimise the chances of human-wildlife conflict and consequent wolf mortality (Hosseini-Zavarei et al. 2013, Tourani et al. 2014). Such interventions should be realised in conjunction with actions for improving habitat suitability, for example, the current efforts of the KuzeyDoğa Society to improve habitat by increasing protected area coverage in the region and to reforest the newly designated wildlife corridor. Future efforts should also include management of wild ungulate populations to increase the density of wild prey, which could reduce livestock depredation to a certain extent (Meriggi et al. 2011). As a potential solution to mitigate human-wildlife conflict, wildlife managers should consider reintroduction of native wild ungulates (Meriggi and Lovari 1996), such as red deer that has been reintroduced to other parts of Turkey (Gümüshane Haberi 2013) and the Caucasus (World Wildlife Fund 2014).

Changes in socio-economic conditions could lead to an alteration of wolf-prey dynamics in the study area, where the number of livestock heads has dropped sharply in the last decade (-78.5% goats, -15.6% cattle in Kars province, source Republic of Turkey Ministry of Food, Agriculture and Livestock). In the overall region, cattle stock dropped from about 15 million to 900,000 heads in Kars, Iğdir and Ardahan provinces in the past 50 years (Nuri Vatan, personal communication). Looking at future scenarios, continued abandonment of livestock husbandry could exacerbate wolf-human conflict and, potentially, cause a decline of the wolf population due to persecution and lack of prey. On the contrary, proper management strategies could support an alternative scenario, where abandonment of mountain areas by humans and decreased grazing pressure by livestock would lead to the increase of forest cover, wild ungulates and ultimately biodiversity (Falcucci et al. 2007, Chapron et al. 2014).

The results of this study represent preliminary efforts to investigate wolf ecology in the study area, though we recognise that the low number of samples and the short collection period could have biased our results. Further investigations of year-round predator-prey dynamics, local husbandry practices and interspecific interactions are currently taking place. Long-term survey of wolf ecology in the study area is required to design locally tailored solutions to human-wildlife conflict, and, more generally, it can contribute to the escalating debate on large-carnivore conservation in human-dominated landscapes (Chapron et al. 2014).

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