



Research Article

Relative habitat use by the red fox (*Vulpes vulpes*) in Köprülü Canyon National Park, Southern Anatolia

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scent-station method
Turkey**Article history:**

Received: 25 May 2011

Accepted: 18 February 2013

Acknowledgements

We are grateful to Çağatay Tavşanoğlu for help with field work. We also thank Alper Ertürk, Alessandro Balestrieri and an anonymous referee for their improving comments on the manuscript.

Abstract

Habitat use by the red fox was investigated by the scent-station method in Köprülü Canyon National Park, southern Anatolia. Compositional analysis showed that, out of four main habitat types, Anatolian black pine forests were the most used one by red foxes. However no significant relation could be detected between the number of red fox visits and vegetation structure and elevation, conforming the generalist behaviour of the species.

Introduction

Being at the top of the food web (Gros et al., 1996), carnivore mammals are important indicators of ecosystem integrity.

In the Mediterranean basin, Turkey is the country with the highest number of carnivore mammals (Blondel and Aronson, 1999). The red fox (*Vulpes vulpes* L. 1758) is one of the most widespread carnivore species throughout the country (Turan, 1984; Demirsoy, 1997). Recently, several studies on the ecology of this species have been carried out in Turkey (Soyumert, 2004; Can, 2008; Akbaba, 2010; İlemin, 2010; Soyumert et al., 2010). Since information on habitat preference, distribution, population dynamics and status of carnivore mammals is essential for their conservation in the Mediterranean basin (Revilla et al., 2001; MacKay et al., 2008), we investigated habitat use by red foxes in Köprülü Canyon National Park one of the largest and most diverse protected areas of southern Anatolia (Ayaşlıgil and Duhme, 1993; Çetinkaya, 2002; Çetinkaya and Altan, 2002).

Materials and methods**Study area**

Köprülü Canyon National Park is located in Antalya province, southern Anatolia (37°87'–37°25'N, 31°3'–31°14'E) and covers 36614 ha, extending from 110 m to 2505 m above sea level (Ayaşlıgil and Duhme, 1993; Çetinkaya and Altan, 2002). Turkish red pine (*Pinus brutia*), Anatolian black pine (*Pinus nigra* subsp. *pallasiana*), cypress (*Cupressus sempervirens*), Lebanon cedar (*Cedrus libani*), fir (*Abies cilicica*) and juniper (*Juniperus* spp.) are the dominant tree species, forming pure or mixed forest stands depending on the elevation. In addition to woodlands, maquis shrublands cover wide areas up to 900 m a.s.l. The climate is Mediterranean, with a dry summer. Mean annual temperature is 16.0°C, total annual precipitation is 1100 mm and the xerothermic period lasts from May to September (Çukurçayır and Arabacı, 2000).

Scent-station surveys

The scent-station method was applied in the dry season, between May and November 2003, as rain can make the scent-stations inactive.

As some predators may avoid artificial materials (Gehring and Swihart, 2003), to obtain proper foot prints, scent-stations were prepared by cleaning up and sieving the soil to form a ~2 cm thick circle with ~1 m diameter. Chicken meat (~20 g) was placed at the centre of each circle as bait.

In each study site, eight scent-stations were established. To evaluate each station as an independent sampling point, the distance between two consecutive stations was approx. 300 m (Jaksic et al., 1990; Jimenez et al., 1996; Acosta-Jamett and Simonetti, 2004). Each scent-station was checked in the morning and foot prints were identified according to Brown et al. (1992). The soil was re-prepared and the station was re-activated with bait. Scent-stations were accepted as active unless no disturbance (e.g. raining) occurred from activation until the morning control. The coordinates and altitude of the scent-stations were recorded by global positioning system (GPS).

Habitat use

Four different main habitat types were surveyed: *Turkish red pine habitat*, dominated by mature *Pinus brutia* trees with dense maquis vegetation cover at the understory layer (mean altitude: 281 m a.s.l.); *Mediterranean maquis*, consisting of various evergreen maquis species and some phrygianic species at the understory layer (mean altitude: 622 m

Table 1 – The number of carnivore visits at scent-stations per habitat type. Percentages are given in brackets.

Species	Habitat type				Total
	Cedar	Black pine	Maquis	Turkish red pine	
<i>Vulpes vulpes</i>	5 (22.7)	4 (18.2)	7 (31.8)	6 (27.3)	22
<i>Meles meles</i>	3 (75.0)	0 (00.0)	1 (25.0)	0 (00.0)	4
Unidentified	1 (50.0)	1 (50.0)	0 (00.0)	0 (00.0)	2
Total	9 (32.1)	5 (17.9)	8 (28.6)	6 (21.4)	28

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Table 2 – Compositional Analysis matrix for the red fox.

Habitat type	Habitat type			
	Cedar	Black pine	Maquis	Turkish red pine
Cedar	x	-0.627	-0.112	0.347
Black pine	0.627	x	0.517	0.975
Maquis	0.112	-0.517	x	0.458
Turkish red pine	-0.347	-0.975	-0.458	x

Table 3 – Ranking matrix for each habitat type.

Habitat type	Habitat type				Rank
	Cedar	Black pine	Maquis	Turkish red pine	
Cedar		–	–	+	3
Black pine	+		+	+	1
Maquis	+	–		+	2
Turkish red pine	–	–	–		4

a.s.l.); *Anatolian black pine habitat*, dominated by mature Anatolian black pine trees and junipers (mean altitude: 1098 m a.s.l.); *Lebanon cedar habitat*, dominated by Lebanon cedar, which forms mixed forests with Anatolian black pine and junipers (mean altitude: 1500 m a.s.l.).

The relative habitat use of red fox was calculated by Compositional Analysis (Aebischer et al., 1993; Aunapuu and Oksanen, 2003; Acosta-Jamett and Simonetti, 2004):

$$d_i = \ln \left(\frac{X_{ui}}{X_{uj}} \right) - \ln \left(\frac{X_{ai}}{X_{aj}} \right) \quad (1)$$

where X_{ui} is the proportion of habitat use of a species in habitat i ; X_{uj} is the proportion of habitat use of the same species in habitat j ; X_{ai} is the proportion of habitat i in the sampling period; X_{aj} is the proportion of habitat j in the sampling period. The calculated d_i values were used to generate a matrix to rank the habitat types in order of use. $d_i > 0$ implies that habitat i is used more than expected, relative to habitat j . On the other hand, $d_i < 0$ for all habitat types means that habitat j is the most used habitat type compared to the other habitat types (Aebischer et al., 1993). Therefore, the number of positive d_i values in each row of the matrix was assessed to rank the relative use of the habitat types (Aebischer et al., 1993; Lariviere and Messier, 2000; Acosta-Jamett and Simonetti, 2004).

Vegetation analysis

To test whether there was any relationship between vegetation structure and habitat use by the red fox, plots 10 × 10 m in size centred on each scent-station, were sampled. Shrub and tree species richness and vertical vegetation cover were determined for each plot. In each plot total vegetation cover estimated as the cumulative percentage cover of individual species visually, therefore total vegetation cover may exceed 100% in a plot.

One way analysis of variance (ANOVA) and post-hoc Tukey HSD test were applied to compare the mean vegetation cover of the four habitat types. The relation between red fox visits on scent-stations and total vegetation cover and altitude a.s.l. were tested by Pearson and Spearman correlation analyses, respectively.

Results

A total of 175 scent-station nights (56 in Turkish red pine habitat, 48 in maquis habitat, 28 in black pine habitat and 43 scent-station nights in cedar habitat) was obtained. In black pine and cedar habitats some stations do not considered as active due to the rainy weather. Visits of carnivore mammals were detected 28 times, of which 22 were identified as red fox (Tab. 1). The matrix generated by Compositional Analysis, ranked the habitat types in the order: black pine > maquis > cedar > Turkish red pine (Tab. 2 and 3).

Turkish red pine habitat showed the highest richness in woody plants and mean vegetation cover ($F=16.06$, $sd=3$, $p<0.001$; Tab. 4). No significant correlation was found between red fox visits and vegetation cover ($r=0.15$, $p=0.401$, $n=32$) and altitude ($r_s=0.51$, $p=0.781$, $n=32$).

Discussion

Scent-station method was originally developed for determining the relative abundance of red fox (*Vulpes vulpes*) and gray fox (*Urocyon cinereoargenteus*) (Conner et al., 1983), and afterwards has been applied to assess the relative abundance of several carnivore mammals (Travaini et al., 1996; Sargeant et al., 2003; Acosta-Jamett and Simonetti, 2004). Being a low-cost technique which can be easily applied

Table 4 – Woody plant species richness and mean percentage of total vegetation cover in the study sites. Different superscript letters show statistical differences between habitat types (Tukey HSD test).

Habitat type	Richness	Mean percentage of vegetation cover (±SE)
Turkish red pine	15	157.5 ^a (±12.4)
Maquis	13	101.5 ^b (±11.2)
Black pine	5	54.5 ^c (±10.0)
Cedar	4	91.4 ^{bc} (±8.5)

in wide areas the scent-station method is one of the most used non-invasive techniques (Ray and Zielinski, 2008). Although this method does not allow identifying the individuals and is not a reliable diagnostic tool for some species, e.g. those of the genus *Martes*, it can be a useful tool for investigating the distribution, relative abundance and habitat use of several elusive carnivores (Ray and Zielinski, 2008). Since in the National Park there is no carnivore with footprints similar to those of the red fox, the scent-station method showed to be appropriate for our study.

Values of the mean percentage of total vegetation cover in the study sites indicate that the vertical foliage cover is the highest in Turkish red pine habitat and the lowest in the black pine habitat. Since the black pine habitat is at the first place in the rank of relative habitat use of red fox and the Turkish red pine habitat is at the last, it may indicate that red fox uses the habitats with low vertical foliage cover more frequently. Nonetheless no significant relation could be detected among the red fox visits on scent-stations and total vegetation cover, similarly to what reported for Italy and Spain (Cavallini and Lovari, 1994; Fedriani et al., 1999).

Even though we found that black pine habitat is relatively used more frequently by red fox than other habitat types, we do not further discuss this result due to low sample sizes at each habitat type. More research is needed to show the reasons of differential habitat use by red fox, especially in terms of food availability that a parameter which was not included in the present study.

Due to the presence of red fox in various habitat types in the study area, and no correlation among the habitat use of red fox and the habitat features such as altitude and vegetation structure in the present study, we concluded that red fox has habitat generalist behaviour in Köprülü Canyon National Park, confirming the other studies in the Mediterranean basin (Fedriani et al., 1999).

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Associate Editor: D.G. Preatoni