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Density of European Hare and Red Fox in Different Habitats of Kırıkkale Province (Central Anatolia), with a Low Level in Hare Number and an Expected Correlation in Spring

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Abstract: European hare (*Lepus europaeus*) and red fox (*Vulpes vulpes*) have an uninterrupted distribution in Anatolia. However, population data related to the density of the two species in Anatolia are still lacking. Detailed population studies are essential for the conservation of species. In the present study, spotlight counts were performed to determine the seasonal changes in the densities of hares (*Lepus europaeus*) and foxes (*Vulpes vulpes*) from six different districts of Kırıkkale Province (Central Anatolia) between 2012 and 2014. The results revealed that there were significant seasonal differences in the hare and fox numbers between different habitat types. According to the encounter rate index, active hares used predominantly forested areas during feeding activities. The densities of the two species were found to be positively correlated in spring ($r = 0.64$, $p = 0.004$). Comparing my results with previously reported data from other countries, I found that the red fox density from Central Anatolia was similar to the data from Europe and America. On the contrary, the hare density from Central Anatolia was much lower than the one in other European countries. These population density data are presented for the first time for Anatolia and may play an essential role when studying temporal changes of the two species from Anatolia in the future.

Keywords: Spotlight survey, *Lepus europaeus*, *Vulpes vulpes*, encounter rate index, correlation

Introduction

Hares and carnivores play a key role in ecosystems because of their position in the food chain (Chapman, Flux 2008, Hepcan 2012). Of these, the European hare, *Lepus europaeus* Pallas, 1778, and red fox, *Vulpes vulpes* (Linnaeus, 1758) are considered to be among the most wide-spread mammals in the world (Cavallini, Lovari 1994, Mitchell-Jones *et al.* 1999). Recently the number of the European brown hares have declined dramatically in Anatolia, like in many European countries, due to different factors such as climate change, increased predation, spread of diseases, habitat fragmentation and intensification of agricultural land use (Smith *et al.* 2005, Santilli, Galardi 2006, Reichlin *et al.* 2006, Sert 2006, Schai-Braun *et al.* 2013). As a consequence of the dramatic decline, for instance Switzerland has classified the species as threatened. Moreover, abundance and habitat characteristics of the species have been investigated annually since 1991 (Jenny, Zellweger-Fischer 2011). The European hare density in an agricultural area from Northern Switzerland has been recorded to be 5.7 ind./100 ha (Schai-Braun *et al.* 2013). Pintur *et al*. (2006) reported that the density of Croatian European hare in spring varied from 13 to 20.3 ind./100 ha of hunting ground. Oğurlu (1997) investigated habitat use and food habitats of *L. europaeus* in Çatacık forest, Central Anatolia. Demirbaş, Albayrak (2013) stated that Anatolian European hare density had decreased almost to complete disappearance in some areas of Anatolia. Nevertheless, detailed studies about population trends of *L. europaeus* in relation to habitat type and season have not been conducted in Anatolia yet.

On the other hand, the red fox faces several conservation problems in Anatolia and Europe because of habitat loss, hunting and poisoning (Can 2004). The seasonal variations in the density of red fox between three regions of rural Britain were discussed by Heydon *et al*. (2000). The authors reported that mean post production fox density was determined to be 0.90 ind./km^2, 2.62 ind./km^2, and 0.58 ind./km^2 in mid-Wales, East Midlands and East Anglia in spring. There are only a few studies on the distribution and relative habitat use of red fox in Anatolia (Temizer 2001, Hepcan 2012, Soyumert, Gürkan 2013, İbiş *et al*. 2014). Soyumert, Gürkan (2013) determined that there was no significant relation between the red fox visits and the vegetation structure in Köprülü Canyon National Park, Southern Anatolia. Even though the red fox causes commonly rabies epidemics in Anatolia (Vos *et al.* 2009, Ün *et al.* 2012), their population trends in Anatolia are not well known.

The main predator of the European hare in Europe is the red fox, with its densities increasing strongly in Europe over the last 50 years (Stiphout, Wagemaker 2003). Panek (2009) suggested that possibly there was a higher encounter rate between hares and foxes in poor habitats. Both species could be easily sighted in fields or open woodlands during the night. Therefore, spotlight counts based on line transects are an effective tool used commonly to monitor their abundances (Verheyden 1991, Panek, Bresinski 2002, Ruette *et al.* 2003, Zellweger-Fischer *et al.* 2011).

The aims of this study were: 1) to examine whether density estimates based on line transects showed seasonal differences in hare and fox numbers among different habitat types in Kırıkkale (Central Anatolia), 2) to compare the habitat preference of the two species during night based on encounter rate index, 3) to find out the seasonal correlations between densities of hare and fox.

Material and Methods

Study area

Spotlight counts were conducted in six districts of Kırıkkale Province (39°50'N, 39°30'E) in Central Anatolia during the period 2012-2014. The study region included Özdere, Kazmaca and Karacaali districts along the northern part, and Uzunlar, Gazibeyli and Çipideresi districts along the southern part. These included various habitat types. The elevation of the surveyed areas ranged from 916 to 1723 m a.s.l. The average annual temperature of Kırıkkale was 12.4°C and the average annual rainfall was 361 mm. Namely, the area is characterised by "semi-arid lower cold Mediterranean climate" and is dominated by steppe vegetation. However, there was a forest vegetation formed by *Quercus* scrubs and black pine (*Pinus nigra*) in Özdere and other forest vegetation formed by Turkey oak (*Quercus cerris*), downy oak (*Quercus pubescens*) and laurel-leaf cistus (*Cistus laurifolius*) associations in Uzunlar. Kazmaca and Gazibeyli were covered mainly by cropland where wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), sunflower (*Helianthus annuus*), sugar beet (*Beta vulgaris*), watermelon (*Citrullus lanatus*), melon (*Cucumis melo*) and oak clover (*Trifolium physodes*) were cultivated. Karacaali and Çipideresi were covered mainly by open steppes consisting of grass steppe and tragacanthic steppe (Dönmez 2002, Hamzaoğlu, Duran 2004, Hamzaoğlu 2005). Thus, in the present study three different habitats including two forested areas with access to cropland (approx. 200 ha), two croplands with no access to forest (approx. 200 ha) and two open steppes (approx. 200 ha) were surveyed. One correction was done for the two forested areas. As the animals could only be counted at ≤ 50 m distance due to the barrier of forest trees, the transect lengths in the forested areas surveyed were chosen to be approximately 40 km, while the transect lengths in the open areas surveyed were approximately 20 km. Wolf (*Canis lupus*), wild boar (*Sus scrofa*), Williams' jerboa (*Allactaga williamsi*), vole (*Microtus* sp.), grey hamster (*Cricetulus migratorius*) and Tristram's jird (*Meriones tristrami*) were other mammals that occurred sympatrically with the hare and the fox in the selected areas.

Spotlight counts

Detectability of hares and foxes was closely related to vegetation height so that spotlight counts could be performed only when cover height was low enough. For that reason, the choice of counting periods was dependent on the cover height in the habitats. In the three different habitats the counts were conducted during the last weeks of March in spring, August in summer, October in autumn and January in winter. The densities were estimated by counting the number of animals on the transect lines. Surveys began 2 h after nightfall and three different habitats were regularly counted within approximately 3-3.5 h before half of the whole night. All counts were carried out in similar weather conditions, and heavy fog, snow cover and full moon counts were omitted. The counts were repeated three times in each season to determine local densities and to explain changes in the seasonal abundance of the hare and fox.

Table 1. Seasonal densities of hares and foxes from six different districts of Kırıkkale Province evaluated on the basis of spotlight counts during the years 2012 to 2014

District	Habitat	*Lepus europaeus* Individuals/100ha ±SD					*Vulpes vulpes* Individuals/100ha ±SD			
		Winter	Spring	Summer	Autumn		Winter	Spring	Summer	Autumn
Northern part										
Özdere	Forest	5.3±0.6	3.0±1.0	7.6±1.2	7.6±0.6		3.0±1.0	4.0±1.0	4.0±1.7	2.7±1.5
Kazmaca	Cropland	3.0±1.0	3.6±1.5	3.3±1.2	4.0±1.7		3.6±1.5	1.6±0.6	8.3±1.5	9.3±3.1
Karacaali	Open steppe	4.0±0.0	2.3±0.6	4.0±1.0	3.6±1.6		2.3±0.6	7.6±1.5	5.0±2.6	2.3±0.6
Southern part										
Uzunlar	Forest	3.3±0.6	3.3±1.0	4.0±1.0	3.3±1.2		3.3±1.0	2.7±0.6	2.7±1.2	1.7±0.6
Gazibeyli	Cropland	2.0±1.0	2.7±1.2	3.0±1.0	1.6±0.6		2.7±1.2	2.0±1.0	3.0±1.0	1.3±1.2
Çipidersi	Open steppe	1.6±0.6	3.6±0.6	2.6±0.6	2.3±0.6		3.6±0.6	4.3±1.2	3.7±0.6	4.0±0.0

Table 2. Seasonal and annual densities of hares and foxes from the three habitats of Kırıkkale Province evaluated on the basis of spotlight counts during the years 2012 to 2014. Different superscript letters indicate statistically significant differences between the means

Period	*Lepus europaeus* Individuals/100ha ±SD			Results of ANOVA		*Vulpes vulpes* Individuals/100ha ±SD			Results of ANOVA	
	Habitat					Habitat				
	Forest	Cropland	Open steppe	F	p	Forest	Cropland	Open steppe	F	p
Winter	4.33^{A}±1.21	2.50^{B}±1.05	2.83^{AB}±1.33	3.962	0.042	3.00±0.89	3.17±1.33	3.00±0.89	0.050	0.952
Spring	4.50^{A}±1.05	2.33^{B}±0.82	4.17^{A}±1.83	4.773	0.025	3.33^{A}±1.03	1.83^{A}±0.75	6.00^{B}±2.19	12.461	0.001
Summer	5.67^{A}±2.07	3.17^{B}±0.98	3.33^{B}±1.03	5.582	0.015	3.33±1.51	5.67±3.14	4.33±1.86	1.581	0.238
Autumn	5.50±2.51	2.83±1.72	3.00±1.26	3.696	0.050	2.17±1.17	5.33±4.84	3.17±0.98	1.828	0.195
Annual	5.00^{A}±1.79	2.71^{B}±1.16	3.33^{B}±1.40	15.463	0.000	2.96±1.20	4.00±3.22	4.13±1.92	1.911	0.156

Data analysis

Seasonal densities of hare and fox were calculated as the mean number of animals, observed during the consecutive three-night counts in each of the areas surveyed, scaled to 100 ha (Bertolino *et al.* 2011). The seasonal density of red fox was also estimated per kilometre according to Mitchell, Balogh (2007). Correlations between densities of hare and fox were calculated using Pearson's correlation coefficient. Significant differences in individual densities between different habitat types were determined using analysis of variance (ANOVA) and compared with Tukey post-hoc test. Habitat preference of hare and fox during feeding activity in different seasons were evaluated considering the proportion of their availability (encounter rate index) in the study areas. Statistical analyses were conducted using IBM SPSS STATISTICS v.21 software (2012).

Results

Hare and fox numbers from the six different districts of Kırıkkale Province remained stable during the two years of the study. Therefore, the density data of the two years for both hares and foxes were given together in Table 1.

The results showed that there were significant seasonal differences between the densities of hare and fox from different habitats (Table 2).

When the densities of hare populations in each season were compared between different habitats, their density in cropland areas in winter was significantly lower than in forested areas. In this season, the differences between fox densities in different habitats were not significant. In spring, while the density of hare in cropland areas were significantly lower than in the other habitats, the density of fox in open steppes were significantly higher than in the other habitats. In summer, even though the density of hare in forested areas were significantly higher than in other habitats, the density of fox among the three habitats was not significantly different. Also, there were no significant differences neither in the density of hare nor that of fox among the habitats in autumn.

The annual density of hare among the habitats was found to be statistically different. The density of hare in forested area was significantly higher than in cropland areas and open steppes. On the other hand,

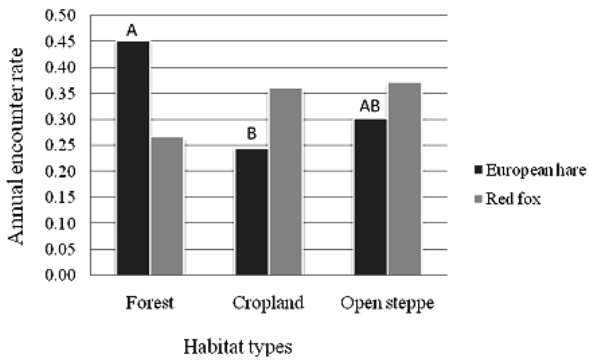

Fig. 1. Means of annual encounter rate with hare and fox in different habitat types. Different letters show statistical differences between the means

there was no difference between the densities of fox in different habitats. Consequently, forested areas were used more frequently by hares than other habitat types (Fig. 1).

Since the fox is a potential predator of hare (Reynolds, Tapper 1995; Panek *et al.* 2006; Stiphout, Wagemaker 2013), the present study also presents prey-predator relationships in the surveyed areas. There was no significant correlation between the annual densities of the two species (r = 0.15, p = 0.207). However, the densities of the two species in spring were positively correlated (r = 0.64, p = 0.004), while there was no significant correlation between the densities of the two species in winter and summer (r = - 0.014, p = 0.590; r = - 0.062, p = 0.808, respectively). There was also no significant correlation between the densities of the two species in autumn (r = 0.19, p = 0.939).

Discussion

Although the red fox can survive in various habitat types, in America it prefers areas with a mixture of plant communities and its density varies between 0.1 ind./km^2 to 0.3 ind./km^2 (Ables 1975, Voigt 1987, Lariviera, Pasitschniak-Arts 1996). Density of fox in various parts of Northern Europe varies between 0.08 ind./km^2 to 3.7 ind./km^2 (Hewson 1986). Coman *et al.* (1991) reported that red fox density in Australia ranged from 1.2 ind./km^2 to 3.9 ind./km^2 seasonally. The present study showed that the red fox density in Central Anatolia ranged seasonally between 0.15 ind./km^2 and 0.22 ind./km^2. Similar to the results given by Soyumert, Gürkan (2013), there was no significant relationship between the fox densities and habitats in Kırıkkale Province, Central Anatolia.

The population dynamics of the European hare are known to be strongly related to habitat diversity, as hares require habitat heterogeneity to supply their requirements (Tapper, Barnes 1986, Meriggi, Verri 1990; Pépin, Angibault 2007). The detailed relationship between agricultural land and hare abundance throughout Europe is discussed in Smith *et al.* (2005). Their results showed that although there was no significant difference between hare numbers in arable (48±37 ind./100 ha) and mixed habitats (29±17 ind./100 ha) in autumn, hare numbers in spring were lower in mixed habitats (6±4 ind./100 ha) than in arable habitats (80±31 ind./100 ha). According to Bertolino *et al.* (2011), the Italian European hare was mostly observed in open fields such as meadows, winter crops, and natural herbaceous vegetation. Pintur *et al*. (2006) reported that in North-western Croatia the European hare density ranged between 13 and 20.3 ind/100 ha, which corresponds well with data given for other European countries. My study revealed that hares used predominantly forested areas during night. Actually, the European hare mostly prefers open areas where it could move fastly according to Bertolino *et al.* (2011). This may indicate that hares from Central Anatolia can satisfy easily their requirements in forested area with access to cropland where the landscape has not incurred habitat destruction. Nevertheless, it is worth noting that density of hare in Central Anatolia was much lower than in other countries. Demirbaş, Albayrak (2013) also reported that hares in some districts of Northern Anatolia were seen rarely, only on plateaus in forested area with their low density due to agrochemicals using by farmers to expand their farmlands.

It is known that arable land, habitat heterogeneity, fallow habitat and temperature are positively correlated, while monoculture, precipitation and predators are negatively correlated with hare abundance (Hackländer *et al.* 2002, Smith *et al.* 2005). Stiphout, Wagemaker (2013) stated that most leverets are captured by foxes in spring and summer, and adult hares seem to be more vulnerable to predation mainly in spring and winter. According to Panek (2009), proper management of fields may decrease fox pressure and lead to increased numbers of hares, especially in areas with low-density populations. The present study showed that the abundances of the two species in spring were significantly positively correlated. This relationship might probably have caused the fact that positive correlation between hare abundance and habitat heterogeneity in spring is exist (Hackländer *et al.* 2002, Smith *et al.* 2005), and a vixen during gestation or lactating consumes more food in spring than during the other seasons (Stiphout, Wagemaker 2013).

In conclusion, comparing my results with previously reported data from other countries, I found that the density of red fox from Central Anatolia was

similar to the data from Europe and America. On the contrary, the hare density from Central Anatolia was much lower than the one in other European countries. The low density in Anatolian hare may be due to the loss of habitat heterogeneity because of the intensification of agricultural land use. Following the indications obtained from local hunters about the decline in the number of hare over the last ten years, Central Hunting Commission of Turkish Ministry of Forest and Water Affairs have decided recently to forbid hunting of the species in many parts of Anatolia. Moreover, population data concerning temporal changes in densities of the two species in Anatolia are still lacking and it is known that detailed population studies are important for conservation of species. For that reason, to obtain realistic estimates of population trends of mammalian species with low density, particularly in hares, the counts might be converted into long-term programs in large areas of Anatolia following the example of the Swiss European hare monitoring.

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