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CAN THE DISTRIBUTION OF RED FOX BURROWS INDICATE THE CHAFER LARVAE DENSITY?

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ABSTRACT
Due to their general occurrence the European badger and the red fox have an important role in most of the ecosystems of the Carpathian basin. Both species use burrows for resting and cub rearing. Based on the previous studies, differences were found in the burrow site selection of these predators. The disparity was proven regarding the vegetation type, the soil texture and the density of primary food sources. This knowledge is essential for wildlife managers and nature conservationists, but could be useful for other sectors (e.g. agriculture, forest management) as well. In the present study, we took a plant protection approach. Our question was the following: does the chafer larvae density differ in the surrounding of badger and red fox burrows? The study area is located between Gödöllő and Valkó, in the Gödöllő Hills. Its size is 3728 ha and mainly (96%) covered by forests. Two methods were used during the study. At first strip transect method was implemented to localize the burrows. 81 burrows were found in total, from which 14 were used by badger and 14 by red fox, 53 of them were abandoned. The second method was the chafer larvae density and biomass measurement. Eight samples were taken per each active burrow, it means 224 samples in total. Our results showed higher chafer larvae density and biomass in case of red fox burrows, compared to badger burrows. We conclude that the soil texture could be in the background of this difference.

Keywords: chafer larvae, red fox, European badger, burrow, plant protection

INTRODUCTION

The European badger (*Meles meles*) and the red fox (*Vulpes vulpes*) are common species in the Carpathian basin (HELTAI, 2010). They have stable and dens populations (CSÁNYI ET AL., 2019), which highlights their important role in most of the ecosystems in Hungary (HELTAI, 2010). Although the two predator species belong to the same guild, they coexist in the same area. In the background, fine-scale niche segregation could be found, which manifests in the burrow site selection of these predators (MÁRTON ET AL., 2014). Previous studies have found differences in the pattern of the vegetation type, the soil texture and the density of primary food sources in the surrounding of the burrows (MÁRTON, 2018). For example the density of earth worms - as primary food sources of badger (GOSZCZYŃSKI ET AL., 2000, CLEARY ET AL., 2009) - was higher in the surrounding of badger burrows compared to red fox burrows (MÁRTON, 2018). In the Mediterranean region of Europe, studies have shown the importance of insect larvae in the badger's diet (CIAMPALINI AND LOVARI, 1985; LUCHERINI AND CREMA, 1995). This knowledge is important for wildlife managers and nature conservationists, but could be useful for other sectors as well, for instance in case of agriculture (crop production) and forest management. Larvae of certain insect species are also known as plant pests, for example the common cockchafer (*Melolontha melolontha*), which can also cause serious damage in agricultural and forested areas (BENKER AND LEUPRECHT, 2005).
In present study we took plant protection approach based on this knowledge. Perhaps the distribution of badger burrows can indicate the chafer larvae hotspots in the field. Our hypothesis was the following: the density and biomass of chafer larvae are higher in the surrounding of European badger burrows compared to red fox burrows.

MATERIALS AND METHODS

Study area

The study area is located between Gödöllő and Valkó, in the Gödöllő Hills. Its size is 3728 hectare and mainly (96%) covered by forests (*Figure 1*). The dominant tree species is the black locust (*Robinia pseudoacacia*, 24%), but the Turkey oak (*Quercus cerris*, 19%) and the English oak (*Quercus robur*, 19%) also have high proportions. Based on the soil texture the area could be separated into two classes: loamy soil (northern part), sandy soil (southern part).

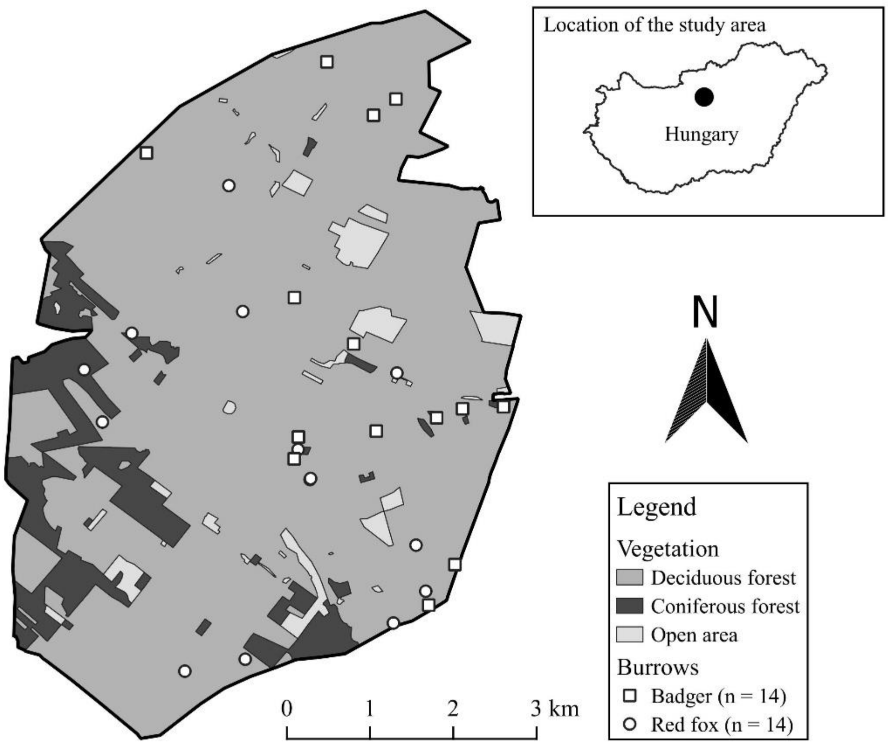

Figure 1. Study area and burrow locations

Data collection and processing

Two field methods were used during the study. In March of 2016 and 2017, strip transect method was implemented to localize the badger and red fox burrows (HELTAI AND SZEMETHY, 2010). The status (used or abandoned) of burrows found in 2016 were checked again in 2017. 81 burrows were found in total. In 2017, 14 of them were used by badger and 14 by red fox (*Figure 1*), 53 of them were abandoned. The second method was the chafer larvae density and biomass measurement. Eight sample plots were taken per each active burrow, it means 224 samples in total. The spatial distribution of the sample plots per active burrow were the following: two sample plots were taken per each cardinal directions. The closer was 100 meters and the further was 300 meters from the burrow. One sample plot was 50x50 cm wide and 15 cm deep (MÁRTON, 2018). We have counted the number of larvae and then the biomass was measured in every case. We did not use species-specific identification of larvaes. Typical control sites were not involved, because the whole study area could be used by badger and red fox. We have had no chance to use exclosures during the study. For data processing we have used Quantum GIS 3.4.4, Microsoft Excel 2016, R 3.3.1 and GraphPad InStat 3 software. Both badger and red fox burrows and also the loam and sand soil texture were compared by the chafer larvae density and biomass. According to the results of Kolmogorov-Smirnov normality test Mann-Whitney U test was used for this analysis (REICZIGEL ET AL., 2010). Fisher's exact test was used to investigate the distribution of two carnivores' burrows (REICZIGEL ET AL., 2010) based on the environmental factors (vegetation, soil type, depth of the topsoil, soil texture). The spatial pattern data of these factors were originated from forest stand data of the local forestry (Pilisi Parkerdő Zrt.).

RESULTS

The total number of chafer larvae was 52 in case of badger burrows and 133 regarding red fox burrows. In the first step of the analysis our results showed higher chafer larvae density (Mann-Whitney U test: U = 5148.500, U' = 7395.500, p = 0.018, n = 224) and biomass (Mann-Whitney U test: U = 5105.000, U' = 7439.000, p = 0.014, n = 224) in case of red fox burrows, than in case of badger burrows (*Table 1*).

Table 1. The chafer larvae density and biomass in the surrounding of burrows. Legend: Min = minimum, Q1 = lower quartile, Q3 = upper quartile, Max = maximum, SD = standard deviation, n = number of sample plots, grey cellcolor = rows containing statistics data equal with zero only

Statistics	Chafer larvae density (thousand pcs./ha)		Chafer larvae biomass (kg/ha)	
	Badger (n = 112)	Red fox (n = 112)	Badger (n = 112)	Red fox (n = 112)
Min	0	0	0	0
Q1	0	0	0	0
Median	0	0	0	0
Q3	0	40	0	20
Max	280	520	200	260
Mean	19	48	9	27
SD	47	93	29	56

As a second step of the analysis, we have investigated the factors could explain the discrepancy in chafer larvae density. No significant difference was found regarding the distribution of two predator's burrows based on the vegetation (Fisher's exact test: p > 0.999, n = 28), the soil type (Fisher's exact test: p = 0.098, n = 28) and the depth of the topsoil (Fisher's exact test: p = 0.516, n = 28). However, significant difference (Fisher's exact test: p = 0.021, n = 28) was found in case of soil texture. The badger burrows were mainly located on loam soil (10/14 pcs., 71%) in contrast, the red fox most frequently used the sand soil texture (11/14 pcs., 79%). *Table 2* shows the results of comparisons the soil texture classes (based on the chafer larvae density and biomass). Significantly higher values are proved in case of sand soil texture than on loam (density: Mann-Whitney U test: U = 4160.500, U' = 8022.500, p < 0.001, n = 224, biomass: Mann-Whitney U test: U = 4118.500, U' = 8064.500, p < 0.001, n = 224).

Table 2. The chafer larvae density and biomass in the soil texture categories. Legend: Min = minimum, Q1 = lower quartile, Q3 = upper quartile, Max = maximum, SD = standard deviation, n = number of sample plots, grey cellcolor = rows containing statistics data equal with zero only

Statistics	Chafer larvae density (thousand pcs./ha)		Chafer larvae biomass (kg/ha)	
	Loam (n = 131)	Sand (n = 93)	Loam (n = 131)	Sand (n = 93)
Min	0	0	0	0
Q1	0	0	0	0
Median	0	0	0	0
Q3	0	40	0	20
Max	320	520	220	260
Mean	21	50	13	26
SD	62	88	41	50

DISCUSSION

The analysis showed contrary results to our hypothesis. The density and biomass of chafer larvae were higher in the surrounding of red fox burrows compared to badger burrows. Another primary result was the overlap between the spatial pattern of red fox burrows and the chafer larvae density. This overlap could not be explained by the predator-prey relation. Low importance of invertebrates was shown by most of the studies on red fox' diet (HELTAI ET AL., 2000; LANSZKI ET AL., 2006). Possible reasons are the following: (1) food sources for chafer larvae are denser on sandy soils than on loam soils. The black locust is the dominant tree species on sand. These forests could have higher density herbaceous layer thus more consistent root system (BARTHA ET AL., 2008), than the oak forests with closed canopy which are dominating on loam soils. (2) In case of red fox the burrow digging could be easier on sandy soils than on loam soils. It is important because the vixens can save more energy for cub rearing (MÁRTON AND HELTAI, 2017). (3) Badger regulates the chafer larvae density by consumption on loam soils. Majority of studies showed that the primary food sources for badgers are invertebrates (CIAMPALINI AND LOVARI, 1985; LUCHERINI AND CREMA, 1995; LANSZKI, 2002, VIRGÓS ET AL., 2004, ALVES ET AL., 2007).

Further studies are needed to clarify the reasons. However, one thing is certain: forest managers can use the red fox burrows as indicators of higher chafer larvae density in the present study area. Based on this knowledge they can make detailed measurements to predict the gradation of different chafer beetles (DEMIÁN ET AL., 2014) or to make decision about the treatment of larvae (ÉGETŐ, 2014).

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