SZENT ISTVÁN UNIVERSITY

Study on burrow site competition of the European badger and the red fox by different field-biology methods

Theses of Ph. D. dissertation

Mihály Márton

Gödöllő

2018

Doctoral school

Name:	Doctoral School of Animal Science
Field:	Animal Science
Head:	Dr. Miklós Mézes Professor, Member of Hung. Acad. of Sci. Szent István University Faculty of Agricultural and Environmental Sciences Institute of Base Animal Sciences Department of Nutrition
Supervisor:	Dr. Miklós Heltai Professor, DSc Szent István University Faculty of Agricultural and Environmental Sciences Institute for Wildlife Conservation

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approval of the head of the doctoral school	approval of the supervisor

1. Background and objectives of the study

Almost all species of European carnivores have undergone a significant decline by the middle of the XXth century. The main causes of decreasing abundance were intensive hunting and habitat loss due to anthropogenic impacts (HELTAI 2010). Consequently, the number of human-carnivore conflicts were also decreased, which resulted a paradigm shift in human-carnivore coexistence after a few decades. The changing attitude towards carnivorous mammals offered a great potential for stimulate relevant conservation and scientific purposes (CSÁNYI 2000). More and more studies discovered the importance of carnivores in ecosystems, especially in top-down control processes (BESCHTA and RIPPLE 2012, RIPPLE and BESCHTA 2012). Beyond the classical predator-prey interactions, interspecific relationships among carnivore species were also observed in many studies, which highlighted the complexity of these systems. Impact of carnivore species on ecosystems was proven by several studies. Since lifestyle, feeding habits, habitat selection, predator-prey, and predator-predator relations of these species determine all levels of associations (CROOKS and SOULÉ 1999, GLEN et al. 2007), investigation and understanding of predator-predator and predator-prey relations are essential in determining well grounded conservational measures and treatments (GLEN et al. 2007, RIPPLE and BESCHTA 2012). Interactions between carnivore species are diverse. In some cases bigger sized carnivore regulates the number of smaller carnivore in direct and indirect ways (top-down) (CROOKS and SOULÉ 1999, MILLER et al 2001, GLEN et al. 2007). This regulation may manifest in the way of territorial signs by exclusion from the territory (ARJO and PLETSCHER 2004, HELLDIN and

DANIELSSON 2007), by forcing dietary shifting, by changes in daily activity or simply by treating smaller carnivore as a prey (PALOMARES et al. 1995, PALOMARES and CARO 1999, GLEN et al. 2007, KOWALCZYK et al. 2009, KOWALCZYK and ZALEWSKI 2011). These relations apply to carnivores at the same trophic levels. Between the same sized carnivore species, instead of competition by direct interactions, indirect niche segregation realizes. Species living at the same habitats, having similar body sizes and diets may segregate in their habitat use spatially (FEDRIANI et al. 1999, HOLMALA and KAUHALA 2009), in time (FEDRIANI et al. 1999, BIRÓ et al. 2004, GLEN et al. 2007), or in the role, what the common prey species plays in the predator’s life history (KAUHALA et al. 1998, LANSZKI et al. 1999, LANSZKI et al. 2006). In case of such commonly widespread species such as Eurasian badger or red fox, we know little about these interactions. Some literature data and study refer Eurasian badger to be stronger in this relation (MACDONALD et al. 2004, KOWALCZYK et al. 2008). Several studies have proven, that, partial winter hibernation and monogamist upbringing of cubs mean reproductive asset for raccoon dog (*Nyctereutes procyonoides*) against red fox. Based on this it is presumable, that, this reproductive asset may appear in case of the larger body sized and similar behaviour showing Eurasian badger (KRUUK 1989, NEAL and CHEESEMAN 1996, HELTAI 2010). Nonetheless, in most of the European countries as well as in Hungary, both Eurasian badger and red fox count to be common, and are present with high abundances (MITCHELL-JONES et al. 1999, HELTAI et al. 2001, KRANZ et al. 2008, MACDONALD and REYNOLDS 2008, HELTAI 2010). This strongly suggests, that, between the two species using the same habitats, having similar sheltering and feeding habits, must be a particular niche segregation, that allows high abundances for the red fox too.

Broadening the knowledge about habitat selection and potential niche segregation of red fox and European badger forms the central aim of my research. These ecological processes were studied by the spatial burrow distribution of both species at different spatial scales (nation-wide; game management unit; home range). The area of study sites are approximately equal to an average sized game management unit in Hungary. My research is based on one main hypothesis and four sub-hypotheses:

- Differences in vegetation structure, soil parameters and food supply are the key extrinsic factors of burrow site selection and niche segregation between red fox and European badger.
    - The European badger burrows can be reach higher ratio in the coniferous forests than the red fox burrows.
    - The European badger burrows can be found mainly in old, closed forests, while the red fox use mostly the young forests and scrubs for digging burrows.
    - The European badger use mainly the loamy soils for burrow site, while the red fox preferred mostly the sandy soils.
    - In the surrounding of European badger burrows the density of small rodents is less and the earthworm density is higher than in case the red fox burrows.

I focused on the following questions to test the main hypothesis and the sub-hypotheses:

1. How do vegeteation patterns shape the burrow site selection of red fox and European badger at a nationwide scale? Does vegetation type have specific effect on burrow site selection?

2. How do soil parameters and vegeteation patterns shape the burrow site selection of red fox and European badger at the scale of a single game management unit? Do these factors have a specific effect on burrow site selection?
3. What sort of habitat parameters (vegetation, soil texture and prey density) do burrow sites and their surroundings have?
4. Is there any evidence of niche segregation in burrow site selection (vegetation, soil texture and prey density) between red fox and European badger at the home-range scale?
5. How strong is the correlation between abundance (biomass) and hole density of small mammal species?

2. Materials and methods

2.1. Analysing the effects of vegetation on burrow site selection of European badger and red fox in Hungary

I collected and arranged the basic data of the former relevant studies (e.g. MÁRTON et al. 2016) for a full range analysis. The number of available data sources was n = 11 for badger and n = 9 for red fox, which originated from various habitats of Hungary (Table 1).

Table 1. The summarized data of the study areas
(Abbreviations: D - deciduous forests, C - coniferous forests, O - open areas)

Study area	Geographical region	Total size (ha)	Sample area (%)	Landscape	Mean altitude (m a.s.l.)	D-C-O (%)
Szob	Börzsöny	1257	40	hilly	238	51 - 3 - 46
Valkó	Gödöllő Hills	3728	21	hilly	233	86 - 10 - 4
Pécel	Gödöllő Hills	1430	29	hilly	237	19 - 11 - 70
Veszprém	Bakony	3769	47	hilly	320	70 - 12 - 18
Fonó	Transdanubian Hills	2350	32	hilly	143	5 - 0 - 95
Jászfényszaru	Jászság	5894	17	lowland	108	25 - <1 - 75
Debrecen	Erdőspuszta	2922	23	lowland	121	23 - 34 - 43
Püspökladány	Hortobágy	9961	25	lowland	85	6 - 0 - 94
Kunszentmiklós	Kiskunság	3777	42	lowland	99	8 - 1 - 91
Soltszentimre	Kiskunság	3000	24	lowland	93	3 - 0 - 97
Kétújfalu	Dráva Plain	2050	25	lowland	113	29 - 0 - 71

I created 3 habitat category for burrow-site preference analysis: 1) deciduous forests (including shrublands); 2) coniferous forests; 3) open habitats (farmlands, lawns and other herbaceous vegetation).

At 4 out of 11 sites (Fonó, Kétújfalu, Püspökladány, Soltszentimre) the preference analysis was conducted only with deciduous forests and open habitats, due to the absence of coniferous forests. Only active burrows' locations were utilized for data evaluation. I used Fisher's exact test (FISHER 1922), Chi-square goodness of fit test (REICZIGEL et al. 2010) with Bonferroni Z test (BYERS et al. 1984) and Jacobs' preference index (JACOBS 1974) for statistical analysis.

2.2. Burrow density estimation on the study area of Szob and data analysis

Strip transect method was implemented for estimate burrow density (HELTAI and SZEMETHY 2010). 55 burrows were found in total, 13 of them were used by badger and 18 by red fox (Figure 1). Two burrows were occupied by both species, therefore the data of these burrows were excluded from further analysis.

The burrow site preference was calculated in case of the vegetation, some soil parameters (soil type, hydrology) and the habitat types (covered, opened, mixed). I used Fisher's exact test, Bonferroni *Z*-test and Jacobs-index for statistical analysis.

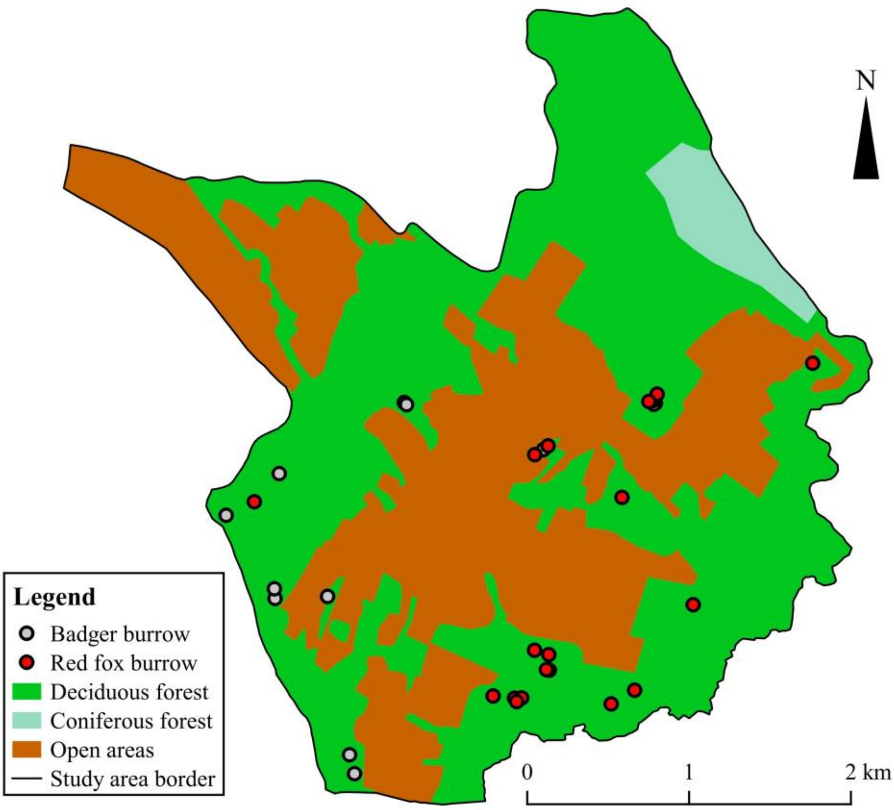

Figure 1. The location of the active burrows and the vegetation types at Szob

I also performed the data analysis in home range scale (buffer method) based on the habitat types. According to this method three buffers whit different radius (1200, 800, 400 meters) were designated around the active burrows (badger: n = 13, red fox: n = 18) and the active large burrows (badger: n = 9, red fox: n = 7, Figure 2). The areas of the buffers were equal with the home ranges of the two predators, which were measured in the Continental climate zone. (WEBER and MEIA 1996, TUYTTENS et al. 2000, KOWALCZYK et al. 2003, KOWALCZYK et al. 2006).

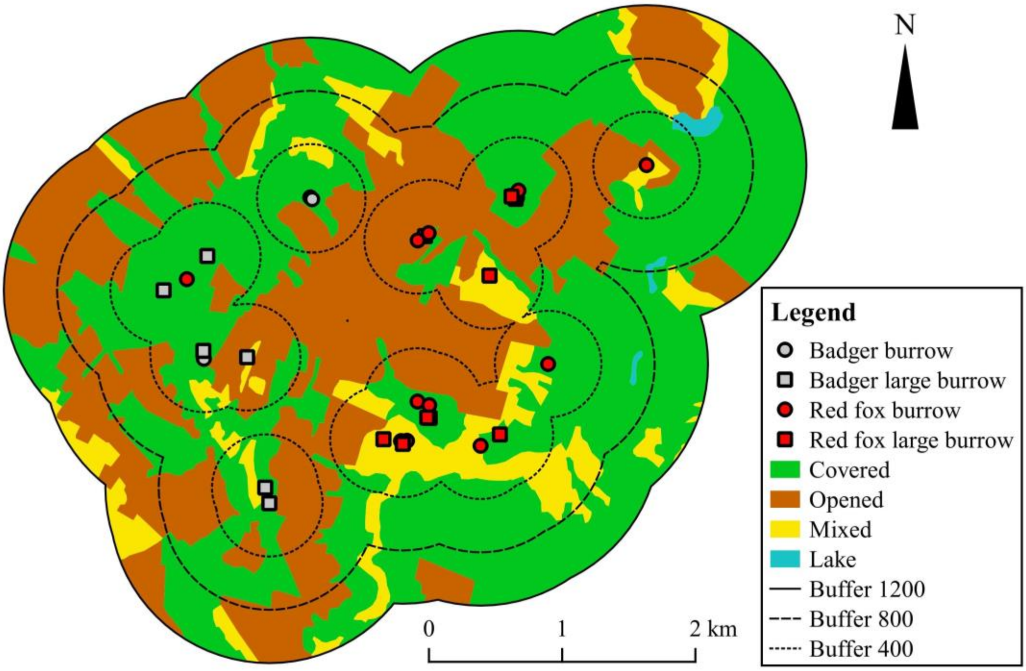

Figure 2. The location of ecological habitat categories within the buffer zones at Szob

The average ratios of the different habitat types were compared within the buffers and the average ratios of the same habitat type were compared between the different buffers (HOLMALA és KAUHALA 2009). I used repeated measures ANOVA with Tukey-Kramer post-hoc test and Friedman test with Dunn's post-hoc test for statistical analysis (REICZIGEL et al. 2010). For the comparison of the average ratios of the habitat types which surrounded the badger and red fox burrows I used Student's t-test, Welch's t-test and Mann-Whitney U test (RUXTON 2006).

Within the buffer 400 the small mammal hole density was also measured. The densities in case of the two predators were compared using Mann-Whitney U test. For testing the correlation between the ratios of the habitat types and the small mammal hole densities I used Pearson's correlation and Spearman's rank correlation (REICZIGEL et al. 2010).

2.3. Burrow density estimation on the study area of Valkó and data analysis

Strip transect method was implemented for estimate burrow density (HELTAI and SZEMETHY 2010). 81 burrows were found in total, 14 of them were used by badger and 14 by red fox (Figure 3). Two burrows were occupied by both species, therefore the data of these burrows were excluded from further analysis.

Figure 3. The location of the active burrows and the vegetation types at Valkó

The habitat selection of badger and fox was studied in accordance with the vegetation and soil parameters (soil type, hydrology, thickness, texture), and habitat types. I used Fisher's exact test, Bonferroni *Z*-test and Jacobs-index for statistical analysis.

Differently from Szob study area, I found, that analising surroundings of active burrows is unnecessary during circular buffer analysis (Figure 4), by reason of the low sample size (badger n = 3, red fox n = 1). Aside from this, the habitat based data evaluation were completely identical to the method used at Szob study area (vide 2.2. subchapter).

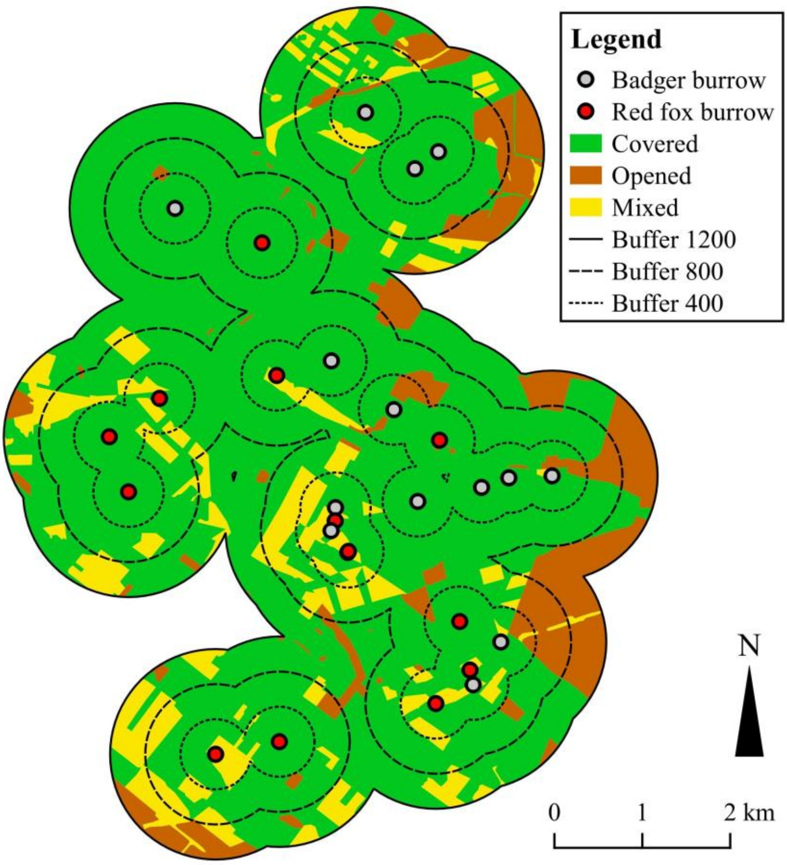

Figure 4. The location of ecological habitat categories within the buffer zones at Valkó

Compared to the field studies at Szob, broadened measures were implemented within the narrowest buffer (radius = 400 m) at Valkó study area. Beyond the estimation of small mammal hole density, soil texture (consistency) and earthworm density were also specified here. I used Wilcoxon matched pairs test and Mann-Whitney U test for statistical comparisons (REICZIGEL et al. 2010).

Spearman's rank-order correlation test (REICZIGEL et al. 2010) was used to evaluate the relationship of habitat types and soil texture distribution with small mammal hole density and earthworm density.

2.4. Analysing the relationship between hole density and population density of small mammal species

The strength of relationship between actual small mammal abundance and our hole density estimations was unknown. Hence, five locations were designated for live trapping and hole estimation (2 area in Szob and 3 in Jászfényszaru) to reveal the accuracy of this hole index. Field studies were repeated at some area, therefore the total number of sampling occasions were 12. I expressed the measured parameters of small mammals, as follows: abundance: number of unmarked individuals through 100 trap nights; biomass: weight of catched individuals (in grams) through 100 trap nights; hole density: discovered holes per 1 hectare. I used the non-parametric Spearman's rank-order correlation test for compare the measured parameters at each sampling period (REICZIGEL et al. 2010).

3. Results

3.1. Burrow site selection of two predators by the vegetation in Hungary

Dispersion of the Europen badger's burrow showed significant difference compared to the expected value (Fisher's test) by the rate of vegetation types in seven cases/areas from eleven. It means the species' selection by the main vegetation/habitat type in these study areas. The badger's burrow site preference is statistically characterized/proven by the avoidance of the open fields by the results. Broad-leaved forest is a mostly prefered habitat while coniferous forest seems diverse from this point of view. Burrow site selection of the red fox was evincible in for study areas from nine. Results showed the avoidance of open fields and coniferous forests while the broad-leaved forests were preferred habitats. Dispersion of the two predator's burrow site by the vegetation type was differed in one study area in total.

Results of the country-wide analysis also showed the den-site selection of the red fox and also the europen badger by the vegetation type. Both predators avoided the open fields and preferred the broad-leaved forests. Coniferous forest was preferred detectably by the badger whilst the red fox used it according to its territoral rate. Dispersion of the carnivores' burrow site selection by the vegetation type showed significant difference (Chi2 - test), it was proven in all three types by the Bonferroni Z-test.

3.2. Burrow site selection of the two predators in Szob study area

Burrow site selection of the europen badger by the vegetation is shown in Szob study area. Badger preferred broad-leaved forest and avoided coniferous forest as well as open areas. The same selection of the red fox is also varifiable. Selection wasn't proven neither the badger nor the red fox by the genetic soil type and the hidrological quality but it was significant by the ecological habitat categories. Territorial dispersion of their burrow wasn't shown by the vegetation or ecological habitat types.

Results of the buffer method seemed to show the importance of covered and open habitats in the surroundings of badger burrows. Mixed habitats represented less than 10% within all three buffer categories. Proportion of the covered and opened habitats was high (35-45%) within the 800 m and 1200 m buffers of the fox burrows. Rate of the mixed habitats increased approching to the burrow. Significant difference wasn't shown yet within the 400 m buffer neither the used burrows nor the hugh badger holes in the proportion the three habitat categories. Significant difference of the mixed habitats around the burrows was established during the comparison the average rate of ecological habitat categories. The area of this habitat type was significantly larger in the surrounding of red fox burrows.

The estimated small mammal hole density was much higher within the 400m buffer zone of the large fox burrows than the badgers' (Figure 5).

Results of the relationship examination showed the strong positive correlation between small mammal hole density and mixed habitat (presence).

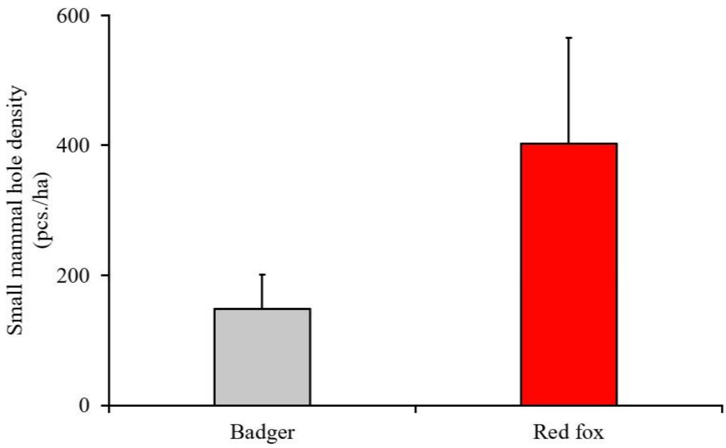

Figure 5. The small mammal hole density (mean + standard deviation) within the buffer zone 400 of active large burrows at Szob

3.3. Burrow site selection of the two predators in Valkó study area

Burrow site selection wasn't proven in the Valkó study area during the Game management unit scale survey neather the badger nor the red fox by the involved habitat factors (vegetation, genetic soil type, hidrology, depht of top-soil, physical soil type, ecological habitat type). The burrow distribution of the two predators was different only based on the physical soil type.

Results of the buffer method showed the highest average proportion of the covered habitat in the surrounding of both predators' burrow within all three buffer zones. Significant difference between the average rate of ecological habitat categories within each buffers wasn't found around the burrows. Proportion of soils which had been heavier than sand was higher around the badger burrows while red fox burrows were found primary in sandy soils.

Significant difference between the estimated hole density of potential food sources (small mammals) within the 400 m buffer zone of the badgers' and the red fox' burrows wasn't recorded. The estimated density and biomass of earthworms was significantly higher around the badger burrows than the red fox' (Figure 6).

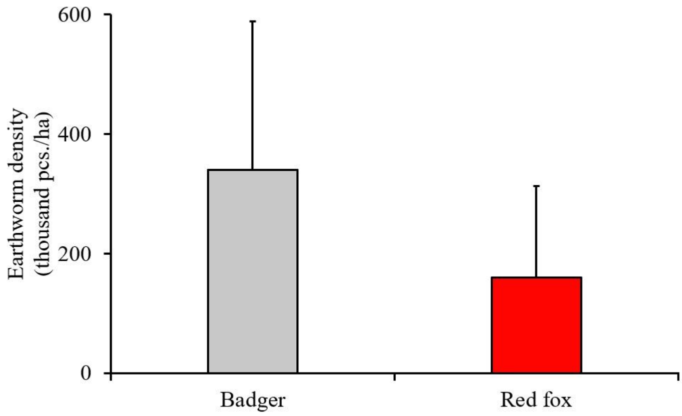

Figure 6. The earthworm density (mean + standard deviation) within the buffer zone 400 of active burrows at Valkó

The estimated small mammal hole density didn't show correlation neither the area-proportion of the ecological habitat categories nor the rate of physical soil types during the relationship examination. The earthworm density showed temperate positive correlation with the proportion of open areas and soils which were heavier than sand whilst had a negative correlation with rate of sandy soils. Significant correlation was found with open areas exclusively by the earthworm biomass.

3.4. Results of the correlation test between small mammal hole and individual density

Strong positive corrrelation was found not only between the small mammal hole density and the individual density but the individual density and the estimated biomass (Figure 7).

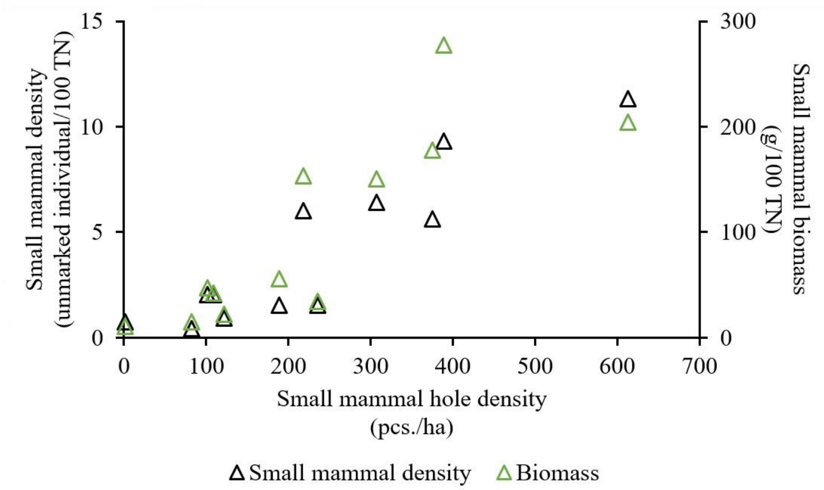

Figure 7. The correlation of small mammal density and the biomass whit the hole density
(Abbreviation: TN - trap night)

3.5. New scientific results

1. I have elaborated a new, simple, low technical- and low money-consuming methodical system that provides good quality and publishable data on the burrow site selection of the European badger and the red fox. The main elements of the methodical system are: (1) habitat analysis based on the buffer zones, (2) estimation of small mammal and earthworm density in the vicinity of the active burrows.
2. I have proved that the analysis of burrow site selection is more efficient on home range scale, than on game management unit scale.
3. Based on the summarised data of many wildlife management units I have verified that the burrow site selection of the European badger and the red fox is differ in case of the coniferous forest.
4. I have proved that at the study area of Szob in the surrounding of the red fox burrows the ratio of scrubs and young forests (mixed habitat type) is higher than in case of the European badger burrows.
5. I have verified that the loamy soils in the case of European badger burrows and the sandy soils in the case of red fox burrows can be found in higher ratios.
6. I have proved that at the study area of Szob in the surrounding of the red fox burrows the small mammal density is higher than in case of the European badger burrows.
7. I have verified that at the study area of Valkó in the surrounding of the European badger burrows the earthworm density and biomass are higher than in case of the red fox burrows.
8. With quantified and statistically verified data, I have pointed out the possible role of the microhabitat differences in the reduction of the

burrow site competition between the European badger and the red fox.

9. Based on the case study I have proved that the small mammal hole density can indicate the density and biomass of small rodents.

4. Conclusions and suggestions

4.1. The burrow site selection of the two predators based on the vegetation

Analyzing the baseline data of the study areas, it can be said that badger prefers the deciduous and coniferous forests, in contrast, avoids open areas. In the case of red foxes, it was detectable preferences of the deciduous forests and the avoidence of open areas, they use the coniferous forests according to their area proportion to digging burrows. The dispersion of two predators' burrows has a significant difference in the three main vegetation types. This result shows that badgers and red foxes burrow site selection strategies based on the vegetation in large territorial unit (nationally), primarily differ from the preference of the forest habitats. The background of difference can be some reasons: terrain, type of soil, hydrological conditions, composition and spatial distribution of food species (NEAL and CHEESEMAN 1996, FULLER et al. 2004, ROSALINO et al. 2005b, LANSZKI et al. 2006).

4.2. The burrow site selection of the two predators at Szob and Valkó

4.2.1. The burrow site selection at game management unit level

In the examined study area of Szob, the selection could be detected only based on the vegetation. Both the badgers and red foxes preferred deciduous forest, as well as avoiding coniferous forests and open habitats. In the genetic soil type and the soil hidrology categorias I found the burrows by their appropriate territorial distribution ratio. However, this probably does not mean that the two predators do not choose based on these habitat factors, it is more likely to be assumed that in the examined area, and within the forest areas, neither the genetic soil type nor the soil hydrology is considered a limiting factor, or at least their effect is not expressed (MATYÁŠTÍK and BIČÍK 1999). In case the study area of Valkó, the examined habitat characteristics increased by two additional factors (physical soil, layer thickness). Selection can not be detected. In case of the main vegetation categories (decidouos forest, coniferous forest, open areas), genetic soil type, soil hydrology and the thickness of the soil layer for this reason it can be assumed the optimum composition to dig burrows, which may mean that these habitat factors do not appear as a limiting factor in Valkó (PHILLIPS and CATLING 1991, SMAL 1995, NEAL and CHEESEMAN 1996, ADKINS and STOTT 1998, ROSALINO et al. 2008).

Summarizing the subsection, it can be concluded that in a game management unit sized study area no statistically supported differences in case the burrow site selection of badger and red fox.

4.2.2. The burrow site selection at home range level

At Szob statistical difference can be detected in the habitat structure based on the comparison of ecological habitat ratios of the two predators' inhabited burrows' environment. The difference is mainly based on the mixed habitat category. Foreign studies which are based on the location of burrows and radiotelemetry shows exclusively in the Mediterranean region the mixed habitats (shrubs, young forests) for the badger as a preferred area (FEDRIANI et al. 1999, REVILLA et al. 2000, 2001). In the case of red fox, many studies from many countries characterize this habitat type as a preferred one (JONES és THEBERGE 1982, CAVALLINI és LOVARI 1991, LUCHERINI et al. 1995, ADKINS és STOTT 1998, FEDRIANI et al. 1999, WHITE et al. 2006). Another statistical difference is in the case of small mammal hole density in the surrounding of the two species' burrows within a buffer of 400 meters radius. The hole density is twice larger in the surrounding of red fox burrows than the badgers'. Based on the results of the small mammal case study the higher hole density can indicate higher small mammal density and biomass. It can serve as an explanation for the role of small mammals, especially mouse- and vole species in the two predators' nutritional composition. For foxes, this species are the basis of the food supply (SERAFINI and LOVARI 1993, BALTRŪNAITĖ 2006, LANSZKI et al. 2006).

In the area of Valkó, compared to the environment of the two predators' burrows, the habitat structure can be considered the same. In the case of the physical soil type badger selected the loamy soils for digging burrows, while the fox is shifted towards the sandy soils. In the case of badger, a study in the Czech Republic have similar results (MATYÁŠTÍK and BIČÍK 1999), it shows that most of the badger burrows (79%) appeared in the loamy soils. Based on the supply of food sources, small mammal holes in both predators can be regarded as low, based on this, no significant difference can be detected. The density and biomass of the earthworms were statistically higher in the surrounding of badger burrows. Based on the former studies this food source can be at Valkó the basis of the badgers' food supply (GOSZCZYNSKY et al. 2000, LANSZKI 2002, BALESTRIERI et al. 2009a). The earthworm abundance showed a positive relationship with the proportion of loamy soil and negatively correlated with the occurrence of sandy soils. The result is in line with foreign researches which are correlate the habitat use of badgers with the earthworm density (KRUUK et al. 1979, KOWALCZYK et al. 2003).

It can be said as a comprehensive conclusion to the subsection, when the analysis of European badger and red fox burrow site competition was carried out in the home range scale of the two predator instead of the wildlife management unit sized study area (WEBER and MEIA 1996, TUYTTENS et al. 2000, KOWALCZYK et al. 2003, KOWALCZYK et al. 2006), the differences become visible. In microhabitat scale their habitat selection is influenced by the different spatial pattern of the main prey species. (PHILLIPS and CATLING 1991, KOWALCZYK et al. 2003, LANSZKI et al. 2006, BALESTRIERI et al. 2009a). This complex system can be the background of the niche segregation between the European badger and the red fox in the hilly areas of Hungary.

4.3. Suggestions

Based on the results of my research I suggest to the further studies which are dealing with the burrow site competition between the European badger and the red fox:

- for a more detailed exploration of niche overlap / segregation, in addition to the previous wildlife management unit level analyzes, the general use of the buffer method,
- expansion of the range of habitat variables analyzed by the buffer method (e.g. water courses, temporary water flows).

I suggest to researchers, practitioners of game management and nature conservation who are dealing with the European badger and red fox burrows:

- the use of the burrow separation method described in my dissertation

I suggest to practitioners of game management and nature conservation in case of the red fox burrow estimation:

- the more detailed exploration of areas with sandy soils, mixed habitat types and high small mammal densities to find more effectively the burrows

5. Author's publication related to the subject of the dissertation

Article in scientific journal with impact factor:

Márton M., Markolt F., Szabó L., Kozák L., Lanszki J., Patkó L., Heltai M. (2016): Den site selection of the European badger, *Meles meles* and the red fox, *Vulpes vulpes* in Hungary. Folia Zoologica, 65 (1): 72-79. (IF 2016/2017 = 0,739)

Márton M., Markolt F., Szabó L. & Heltai M. (2014): Niche segregation between two medium-sized carnivores in a hilly area of Hungary. Annales Zoologici Fennici, 51 (5): 423-432. (IF 2014 = 0,855)

Heltai M., Horváth Zs., Kiss Á., Nagy A., Markolt F., Szentkirályi P., Lanszki J., Kozák L. & Márton M. (2013): Habitat-Dependent Burrow Preference of the Eurasian Badger in Its Original and New Occurrence Areas of Hungary. Acta Zoologica Bulgarica, 65 (4): 487-492. (IF 2012 = 0,309)

Article in referred journal:

Márton M., Bőti Sz., Heltai M. (2016): A sárganyakú erdeiegér júliusi élőhelyhasználata egy jászsági erdőben. Tájökológiai Lapok, 14 (2): 183-189.

Márton M., Heltai M. (2016): Kisemlős populációk vizsgálata a Börzsöny déli oldalán. Természetvédelmi Közlemények, 22: 73-83.

Heltai M., Márton M., Szemethy L., Csányi S. (2016): A ragadozógazdálkodás értékelése az elmúlt évtized adatai alapján. Vadbiológia, 18: 51-62.

Márton M., Heltai M. (2015): Kisemlősök állománysűrűségének vizsgálata különböző élőhely-együttesekben. Vadbiológia, 17: 78-89.

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Márton M., Markolt F., Szabó L. & Heltai M. (2013): Burrow densities of Eurasian badger (*Meles meles*) and red fox (*Vulpes vulpes*) in Börzsöny mountains. Review on agriculture and rural development, 2 (1): 79-84.

Hungarian papers:

Márton M., Szabó L., Markolt F. & Heltai M. (2012): Az eurázsiai borz (*Meles meles*) és a vörös róka (*Vulpes vulpes*) élőhelyválasztása a börzsönyben. In: Bodnár Á & Falusi E. (Szerk.) (2012): „Tehetségnap – 2012”. Gödöllő, 35 p.

Article in book (Hungarian):

Heltai M., Palánki G., Zuborecz T., Márton M. (2016): A kisemlősök táplálékhálózatokban betöltött szerepe és irtásuk lehetséges következményei. In: Pechtol János (szerk.) Vadászévkönyv, pp. 145-149.

Other paper:

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