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Habitat-Dependent Burrow Preference of the Eurasian Badger in Its Original and New Occurrence Areas of Hungary

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Abstract: We examined the habitat preference of the Eurasian badger (*Meles meles*) in three relevantly different habitat types of Hungary. Mountainous and hilly sample sites represented the original habitat, while lowland areas are the recently occupied habitat type of the species. Based on the distribution according to vegetation types at the locations of the burrows, there was no significant difference between the original and the new habitat types. Badgers preferred forested areas to open fields. Among forest habitat types, the preference of pine-forests was higher than that of deciduous vegetation. The explanation for this result is the easily diggable sandy soil on which pine-forests are planted. Open field habitats in lowland areas were less avoided. The same was proven by the countrywide habitat preference of the species – shown by the collected data of all the sample areas: there was no total avoidance of this kind of habitat. These all predict that badgers will be able to live in open fields just as densely as they do now in hilly regions.

Key words: *Meles meles*, habitat selection, vegetation type, burrow, Hungary

Introduction

The widely distributed Eurasian badger (*Meles meles*) can be found from Ireland to Japan, from Finland to China. It occurs up to the altitude of 1600–1700 m above sea level. As an opportunistic and generalist predator, the badger is capable of finding suitable life conditions in pine, deciduous and mixed forests, as well as in shrublands and agricultural areas (Michell-Jones *et al.* 1999, Zabala *et al.* 2002). Wozencraft (2005) in his last-edited summary particularly emphasises the recently experienced significant increase of population size in Ukraine and in the British Isles. According to Holmala, Kauhala (2006), the population growth of the species is a common phenomenon throughout Europe, the reason for which may be the immunisation against rabies. The Eurasian badger was protected in Hungary between 1973 and 2001, since then it has become fair game with a hunting season from the 1st of June to the last day of February. Nevertheless, its population and its range have been constantly growing – with occasional minor stops since 1987. In Hungary the spreading of badgers appears to have ended, they live in every region of the country nowadays (Heltai 2010). The reason for its wide European and Hungarian dispersal, as well as for the population increase both in Hungary and in several other European countries is the adaptability and flexibility of this species to habitat and feeding conditions (Neal, Cheeseman 1996). Burrows play a key role in the life of badgers, especially concerning cub-rearing, protection against predators and the time of winter inactivity (Neal, Cheeseman 1996, Kauhala, Holmala 2006).

As a consequence, the occurrence of the species is definitely influenced by the availability of the types of soil suitable for digging burrows, and the vegetation cover of the area (Cresswell *et al.* 1990, Heltai 2010). Several research projects have pointed out that the increase of food sources reduces, while the decrease of food sources expands the home range areas of animals (Kruuk, Parish 1982, Da Silva *et al.* 1994). Other studies, however, have claimed that the changes of food resources do not necessarily modify the territorial structure (Roper *et al.* 1986). In the case of the main setts used for rearing the cubs, Neal, Cheeseman (1996) found vegetation cover a particularly important factor. The selection and the use of habitat are both influenced by the adequate soil-structure for digging burrows, the cover of the area and the available food resources.

In order to understand the reasons behind the spreading of this species, and to establish the principles of its management it is necessary to learn about its habitat selection and its motivations. To achieve this, we examined the preferred and avoided habitat types along with the characteristics determining the occurrence of the badger in three significantly different Hungarian habitat types (mountainous, hilly and lowland areas) at 5 sample sites on the basis of the location of burrows. At 3 of these sample sites, in the mountainous region of Bakony, the hilly areas of Gödöllő and Börzsöny, the presence of badgers was continuous during the course of the last century, whereas in the lowland landscapes of Kiskunság and Erdőspuszta badgers appeared only at the end of the 20th century.

Material and Methods

Study area

The mountainous study area in Bakony (Table 1) is a fenced game reserve near Veszprém (Fig. 1). The majority of the site has an unstructured terrain. The average valley density is between 2.5 and 2.6 km/km². The soil consists of low productive leptosols on limestone and dolomite bedrock with a thin level of loess. This area has the highest forest cover percentage of all the 5 sites (Table 1), forests are supplemented with diverse sizes of clearings, meadows, agricultural areas and watercourses. Turkey oak (*Quercus cerris*) is the dominant tree species of the woodlands. The plough land of almost 400 ha is used as game field with mainly alfalfa (*Medicago sativa)* cultivation.

The sample site in Börzsöny lies on a southern slope near Márianosztra. Its terrain is structured with several trenches, hills, stream banks and ravines running across. The lowest point of the area is at 140 m a.s.l., the highest one reaches 335 m a.s.l. Dominant tree species of the highly forested area are the Turkey oak and the Sessile oak (*Quercus petraea*), but we can find here a great amount of European hornbeams (*Carpinus betulus*) and Scots Pines (*Pinus sylvestris*) as well. Woodlands have rich shrub layers. The majority of the open fields (73.9%) is used for agricultural cultivation, about one half of which is meadows, the other half is used for grain production purposes. The remaining part of it is tallgrass shrublands (26.1%).

Erdőspuszta sample site is located near Debrecen, in a protected area, representing the Erdőspuszta Habitat, one of the typical habitats of the Pannonian Biogeographical Region. Forest cover is high (Table 1), woodlands alternate sporadically with clearings, grasslands, plough lands, lakes and watercourses of various sizes. Typical tree species are the Scots Pine, the Black Locust (*Robinia pseudoacacia)* and the English oak (*Quercus robur*). Maize (*Zea mays*) is the dominant plant of agricultural areas, but Common wheat (*Triticum aestivum*), Triticale (x Triticosecale) and Horseradish are also cultivated. This is entirely a lowland region with sand dunes and mild slopes providing some variety. The subsoil is predominantly sand, though one can find more compacted types of soil sporadically.

The study area in Gödöllő Hills is situated between Isaszeg and Pécel. The subsoil of this hilly region used to be loess, which later became covered by various layers of diluvial sand deposited by water, therefore both kinds of subsoil can be found here. The degree of soil erosion is significant; the surface is typically dry. There are several fishponds and water reservoirs inside and outside of the forests. The percentage of cultivated fields is rather high (69.5%).

The sample site examined in Kiskunság between Kunpeszér and Kunszentmiklós can be divided into two parts. One of them is a protected area characterised by solonchak barrens, saline meadows and pastures. A high level of groundwater is typical in early spring, but by the beginning of summer it more or less dries up due to evaporation and the sewage system. Water balance is insufficient, heavy soil dominates over a few sand dunes. The other part of the region consists of agricultural areas with some

Table 1. The most important characteristics of the study areas

Study area	Size (ha)	Level of processing (%)	Landscape	Mean altitude (m a.s.l.)	Forest cover (%)	Proportion of main habitat types (B-P-G) (%)
Bakony	3769	47.3	mountainous	320	81.6	70-12-18
Börzsöny	1257	40.0	hilly	238	54.8	52-3-45
Erdőspuszta	2922	22.7	lowland	121	56.7	23-34-43
Gödöllő Hills	1430	28.9	hilly	237	30.5	20-11-69
Kiskunság	3777	42.2	lowland	99	9.4	8-1-91

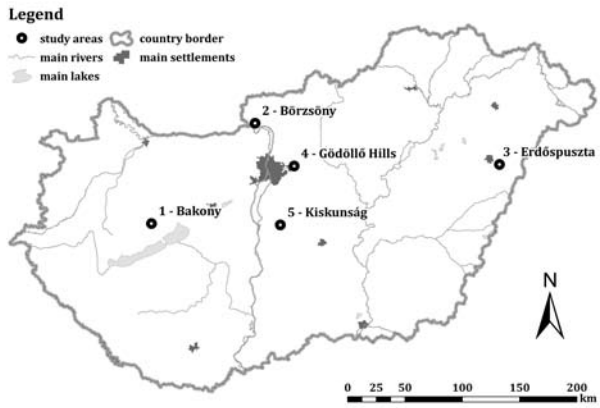

Fig. 1. Locations of the study areas in Hungary

woodland patches and farmyards making the landscape more diverse. The soil of the lowlands is almost exclusively sand.

Burrow estimation and the calculation of habitat preference

Burrows were estimated by randomly selected, parallel, North-South oriented stripped transects in the case of all 5 study areas. Except for the Börzsöny site, where in addition to the above-mentioned method, we also walked around every habitat type of the region unplanned, looking for new burrows. The decision whether the found den was inhabited or not, and whether the inhabiting species was Eurasian badger or red fox, was based on the surrounding indirect indices (footprint, latrine, smell). The widths of the respected track-sections were continuously recorded as well. During the implementation, data recording and the evaluation of our field work we used the methods given by Heltai, Kozák (2004) and Heltai, Szemethy (2010).

After determining the exact locations of the badger-burrows found in the five different study areas, the scales of preferences were counted according to the Ivlev's formula (Strauss 1979): Px=(A-B)/(A+B) where 'A' is the rate of burrows of the species in the respective habitat type; 'B' is the rate of the given habitat type within the whole area; 'Px' is a value of preference/avoidance of the respective habitat type (range [-1;1]). (+1) means total preference, whereas (-1) suggests overall avoidance. Habitat types were grouped into three larger categories (deciduous forests; coniferous forests and mixed forests together; open fields: grasslands and plough lands together), because the size of certain vegetation types compared to the total size of the study areas proved inadequate, and it would have decreased the validity of the Chi^2-test. After creating these three categories, we used the Chi^2-test to determine whether the distribution of the burrows differs from what was expected based on the proportional sizes of the given habitat types. The validity of the preference values was checked using Bonferroni Z-test ($Z(3) = 2.40749$, $P < 0.05$) (Byers, Steinhorst 1984). Following this, we used the Chi^2-test to compare the study areas according to the distribution of the habitat types.

Results

The results of habitat selection based on the spatial distribution of burrows demonstrate that their distribution significantly differs from what could be expected based on the proportional sizes of the actual habitat types. This means that the badger had clear preferences among vegetation types in all of the five study areas (Bakony: $\chi^2 = 6.487$, $df = 2$, $P < 0.05$, $n = 20$, Börzsöny: $\chi^2 = 12.290$, $df = 2$, $P < 0.005$, $n = 13$, Erdőspuszta: $\chi^2 = 18.580$, $df = 2$, $P < 0.001$, $n = 20$, Gödöllői Dombság: $\chi^2 = 62.985$, $df = 2$, $P < 0.001$, $n = 27$, Kiskunság: $\chi^2 = 139.532$, $df = 2$, $P < 0.001$, $n = 20$). Preference values were counted for the merged habitat categories using Ivlev's-index. Results showed avoidance of grasslands and cultivated fields in all five cases. Pine-forest habitat was preferred in the sample sites of Bakony, Erdőspuszta, Gödöllő Hills and Kiskunság, whereas in Börzsöny

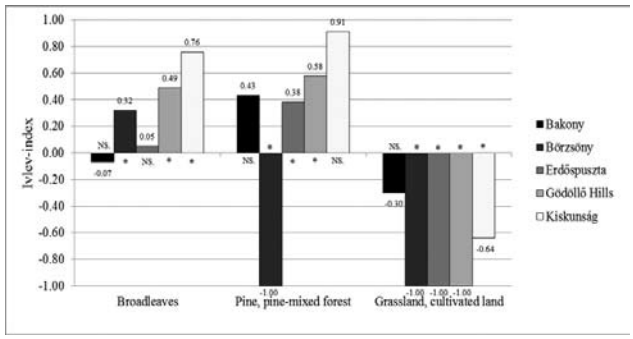

Fig. 2. Habitat selection of the Eurasian badger based on the three merged vegetation types.

total avoidance was found of this type of vegetation. With the exception of Bakony, deciduous forests were preferred everywhere (Fig. 2). Using Bonferroni Z-test the preference and avoidance values for the three habitat types were not proven significant statistically in Bakony, whereas all three values of Börzsöny and Gödöllő proved valid. In the study area of Erdőspuszta preference of broadleaf forests was shown but did not prove significant. In Kiskunság the preference of pine and pine-mixed forests was invalid (Fig. 2).

Comparing the distribution of the burrows of the study areas by using the Chi^2-test our results showed significant differences between the following pairs: Bakony and Börzsöny, Bakony and Erdőspuszta, Börzsöny and Erdőspuszta, Börzsöny and Gödöllő Hills, Erdőspuszta and Gödöllő Hills, Erdőspuszta and Kiskunság, and finally Gödöllő Hills and Kiskunság (Table 2). A statistically proven difference was not detectable between Bakony and Gödöllő Hills, Bakony and Kiskunság, and Börzsöny and Kiskunság (Table 2).

Table 2. Comparison of burrow-distribution based on habitat types in the study areas

Study areas	χ^2
Bakony-Börzsöny	P < 0.05
Bakony-Erdőspuszta	P < 0.025
Bakony-Gödöllő Hills	N.S.
Bakony-Kiskunság	N.S.
Börzsöny-Erdőspuszta	P < 0.001
Börzsöny-Gödöllő Hills	P < 0.005
Börzsöny-Kiskunság	N.S.
Erdőspuszta-Gödöllő Hills	P < 0.05
Erdőspuszta-Kiskunság	P < 0.001
Gödöllő Hills-Kiskunság	P < 0.025

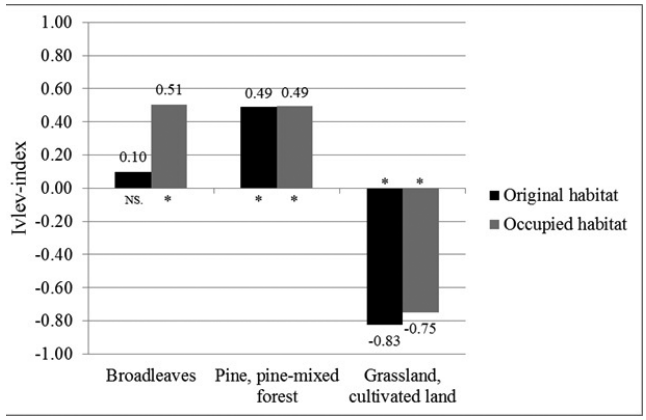

Fig. 3. Habitat preference of the Eurasian badger in its original and new habitats.

Following this, we collected all the data we had from the study areas of the badger's original habitat (Bakony, Börzsöny, Gödöllő Hills), and from the ones occupied recently (Erdőspuszta and Kiskunság). We found that badgers do have preferences of vegetation types both in their original (χ^2 = 41.688, df = 2, P < 0.001, n = 60), and in their new habitat (χ^2 = 68.460, df = 2, P < 0.001, n = 40). In their original habitat of hilly landscape they significantly preferred pine-forest vegetation, while avoiding grasslands and cultivated fields (Fig. 3). In their new lowland habitats their preference of deciduous and coniferous forests was statistically detectable, pastures, meadows, plough lands, that is to say open fields were significantly avoided (Fig. 3).

There was no significant difference between the original and the new habitat of the badger concerning the distribution of the burrows by vegetation types (χ^2 = 5.220, df = 2, P < 0.05, n = 100).

Discussion

Based on the results of burrow-preference calculations, badgers avoided open field habitats in every sample site (Fig. 2), whereas they preferred broadleaves and pine forests with one exception to both (Fig. 2). In the case of deciduous vegetation, the avoidance in Bakony was not supported by the result of Bonferroni Z-test, nevertheless it validated the significant avoidance of pine forests in Börzsöny. That study area clearly differs from all the ones (Table 2) where the preference of coniferous forests was statistically proven (Fig. 2), as far as the distribution of burrows is concerned. Preference of pine forests appears to be in contrast with the experiences of similar investigations in England. Those results

define this vegetation type as a "for want of better" choice (Neal, Cheeseman 1996). The reason behind the preference of coniferous forests in our research is the fact that in Hungary pine species were planted in soft and easily diggable sandy soil (with insufficient water balance and low productivity). Thus preference of pine forests is supposed to be the result of the badger's "for want of better" choice in Hungary, too. According to the map of the Institute for Soil Sciences and Agricultural Chemistry, Hungarian Academy of Sciences, and to the data of the local Forestry Unit, coniferous forests in Börzsöny were planted on luvisol soil instead of sand. On the basis of this, when given the choice between the vegetation of broadleaf or pine forests on the same type of soil, badgers opted for deciduous forests with better productivity than coniferous forests (Kauhala *et al.* 1998). There was no statistically supported difference of habitat preference between the original hilly, and the recently occupied new lowland habitat, which was conquered during the population growth that began in the late 1980's (Heltai 2010). Preference of pine forests proved more or less equal in both types of areas, and the preference of the vegetation of deciduous forests in lowlands was higher than that of coniferous forests (Fig. 3). Although there was no detectable difference between the two types of areas concerning the distribution of burrows, in the original habitat of the species avoidance of open field habitat type was higher than in the recently occupied areas. This difference becomes clearly contrastive when examining the proportion of open field habitats in the new (70%) and the original (35%) occurrence areas. Avoidance is decreasing in spite of the higher proportion of open fields, which means that

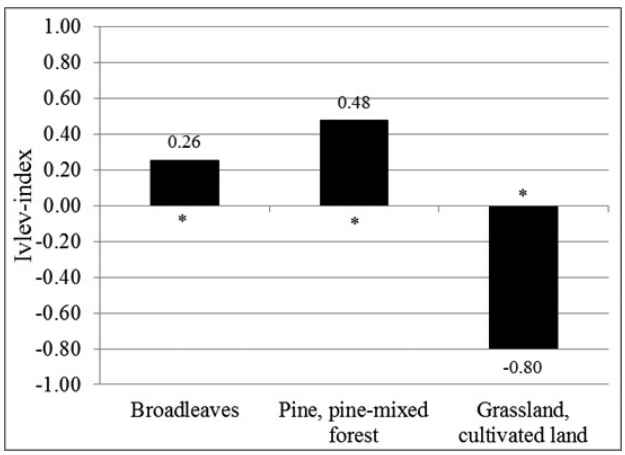

Fig. 4. Habitat selection of the Eurasian badger in Hungary

badgers have started to adapt to open site habitats in lowland areas. On the basis of the cumulative data of all the study areas, which thus show countrywide tendencies, it is suggested that the Eurasian badger has detectable preferences of habitats ($\chi^2 = 99.781$, $df = 2$, $P < 0.001$, $n = 100$). It significantly prefers the vegetations of deciduous and coniferous forests, and it shows statistically supported avoidance of open field species (Fig. 4).

Preference of broadleaf forests can be considered weak (26%), while that of pine forests can be labelled moderate (48%). It confirms our hypothesis that forest cover of a woodland habitat is just one of several factors influencing the selection of burrow location. Geological and hydrological parameters also play an important role (Neal, Cheeseman 1996), in addition to the availability of food resources, which we did not examine in this research, but which can determine the size of home ranges (Da Silva *et al.* 1994, Kruuk, Parish 1982).

Based on our results of habitat preferences concerning the quality of vegetation and the percentage of plant cover, we claim that knowing these environmental parameters alone does not provide sufficient explanation for the occurrence and rapid spreading of the badger. Although the species does have a detectable preference towards forested areas, generally speaking badgers do not avoid grasslands and plough lands completely. Consequently, in the foreseeable future spreading of the species can become so substantial in both open fields and woodlands that intervention could be needed on behalf of wildlife management and/or nature protection (Heltai, Kozák 2004). Increasing density may become crucially important from the point of view of human and animal medicine. This is particularly true in the UK, where the density of the badger population is extremely high, and they may play a major role in spreading tuberculosis and rabies among domestic animals, in addition, badgers are susceptible to the causative agent of anthrax (Kruuk *et al.* 1979, Cheeseman *et al.* 1989). In the course of a survey carried out in Hungary eight worm species were found in the examined badgers. Three of the eight species were zoonotic ((Takács *et al.* 2012).

The results of our study, on the whole, have shown that badgers have a preference towards forested areas both in their original and new habitats. In the recently occupied lowlands, however, avoidance of open field habitat types was lower than in

their original occurrence area, the hilly regions. This predicts that badgers will be able to settle down at higher density in lowland areas too, thus monitoring their population density and learning every possible detail about their habitat preference is inevitable for establishing the management of this species.

References

Byers C. L., R. K. Steinhorst 1984. Clarification of a technique for analysis of utilization-avability data. – *Journal of Wildlife Management*, **48** (3): 1050-1053.

Cheeseman C. L., J. W. Wilesmith and F. A. Stuart 1989. Tuberculosis: the disease and its epidemiology in the badger, a review. – *Epidemiology and Infection*, **103** (1): 113-125.

Cresswell P., S. Harris, and D. J. Jefferies 1990. The history, distribution, status and habitat requirements of the badger in Britain. Nature Conservancy Council, Peterborough. 84 p.

Heltai M., L. Kozák 2004. A borz kotoréksűrűségének felmérése két alföldi területen. – *Vadbiológia*, **11**: 83-91.

Heltai M. 2010. Emlős ragadozók Magyarországon. Mezőgazda Kiadó, Budapest. 240 p.

Heltai M., L. Szemethy 2010. A róka és a borz kotoréksűrűségének felmérése egy kijelölt területen. In: Szalkay Cs., K. Penksza (ed.): Természetvédelmi, környezetvédelmi és tájökológiai praktikum. Műszaki Könyvkiadó Kft., Budapest. 218 p.

Holmala K., K. Kauhala 2006. Ecology of wildlife rabies in Europe. – *Mammal Review*, **36** (1): 17-36.

Kauhala K., P. Laukkanen and I. von Rége 1998. Summer food composition and food niche overlap of the raccon dog, red fox and badger in Finland. – *Ecography*, **21** (5): 457-463.

Kauhala K., K. Holmala 2006. Contact rate and risk of rabies spread between medium- sized carnivores in southeast Finland. – *Annales Zoologici Fennici*, **43**: 348-357.

Kruuk H., T. Parish, C. A. J. Brown and J. Carrera 1979. The Use of Pasture by the European Badger (Meles meles). – *Journal of Applied Ecology*, **16** (2): 453-459.

Kruuk H., T. Parish 1982. Factors affecting population density, group size and territory size of the European badger, Meles meles. – *Journal of Zoology*, **196** (1): 31-39.

Mitchell-Jones A. J., G. Amori, W. Bogdanowicz, B. Krystufek, P. J. H. Reijnders, F. Spitzenberger, M. Stubbe, J. B. M. Thissen, V. Vohralik and J. Zima 1999. The Atlas of European Mammals. Academic Press, London. 250 p.

Neal E., C. Cheeseman 1996. Badgers. T and AD Poyser Ltd., London. 271 p.

Roper T. J., D. J. Shepherdson and J. M. Davies 1986. Scent Marking with Faeces and Anal Secretion in the European Badger (Meles meles): Seasonal and Spatial Characteristics of Latrine Use in Relation to Territoriality. – *Behaviour*, **97** (1/2): 94-117.

Silva J. Da, D. W. Macdonald and P. G. H. Evans 1994. Net costs of group living in a solitary forager, the Eurasian badger (Meles meles). – *Behavioral Ecology*, **5** (2): 151-158.

Strauss R. E. 1979. Reliability Estimates for Ivlev's Selectivity Index, the Forage Ratio, and a Proposed Linear Index of Food Selection. – *Transactions of the American Fisheries Society*, **108**: 344-352.

Takács A., L. Szemethy, A. A. Takács, P. T. Takács, M. Heltai 2012. Adatok az eurázsiai borz (Meles meles) parazitákkal való fertőzöttségéről Magyarországon. – *Magyar Állatorvosok Lapja*, **134** (2): 106-110.

Wozencraft W. C. 2005. Order Carnivora. – In: Wilson D. E., D. M. Reeder (Ed.): Mammal Species of the World. The Jones Hopkins University Press, Baltimore, 532-628.

Zabala J., I. Garin, I. Zuberogoitia and J. Aihartza 2002. Habitat selection and diet of badgers (Meles meles) in Biscay (northern Iberian Peninsula). – *Italian Journal of Zoology*, **69** (3): 233-238.

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