THE IMPACT OF THE LESSER BLIND MOLE RAT [*NANNOSPALAX* (SUPERSPECIES *LEUCODON*)] ON THE SPECIES COMPOSITION AND DIVERSITY OF A LOESS STEPPE IN HUNGARY

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Abstract. Our aim was to investigate the species richness and diversity of a loess grassland influenced by the digging of the lesser blind mole rat [*Nannospalax (*superspecies *leucodon*)] and to study the effect of this disturbance to diversity. The study was conducted in the Külső-gulya loess grassland (Körös-Maros National Park), which is unique in Hungary due to its excellent soil quality and the large spatial extent of natural loess meadow steppe.
We recorded the cover of species in 50x50 cm plots. Altogether 12 plots were sampled on mounds of mole rat and 12 plots as a control in the area with no mounds. Differences in species richness, Shannon-diversity, evenness and total cover between disturbed and control plots were tested by One-Way ANOVA. There were no significant difference neither in the number of species, nor in the Shannon-diversity and evenness. There were differences in the species composition detected by PCO ordination. We can conclude that the presence and disturbance of the mole rat influence the composition of the grassland significantly but it does not cause a difference in the species richness, diversity and total cover. Our results suggest that this grassland has adapted to these natural disturbances.
Keywords: *loess grassland, diversity, disturbance, subterranean rodents, Nannospalax (superspecies leucodon)*

Introduction

Grasslands in Europe are among the most diverse ecosystems (Habel et al., 2013). Dry grasslands can be emphasized within this group (Janišová et al., 2011) because of their high importance in biodiversity conservation in Hungary (Kun, 1998; Valkó et al., 2013a). Grasslands evolved with herbivores, burrowing animals and experienced recurrent fire and adapted to natural disturbances by various life forms and plant behavioural types (Knapp et al., 1998; Strauss and Agrawal, 1999; Gibson, 2009, Valkó et al., 2013b). Several studies concluded that high diversity of grasslands is positively related to the complexity of the disturbance regime (e.g. Collins and Barber, 1986;

Collins, 1987; Belsky, 1992; Noy-Meir, 1995; Savadogo et al., 2008). The most diverse semi-natural grasslands have been found in Europe in traditionally landscapes with complex and patchy pattern of grazing, mowing and burning (Bartha, 2007; Wilson et al., 2012).

To maintain the high diversity of dry grasslands, in particular loess steppes, it is essential to ensure proper management mainly by grazing and mowing (Illyés and Bölöni, 2007; Kiss et al., 2011). Grazing and other natural disturbances help for sustaining high diversity (Olff and Ritchie, 1998; Hickman et al., 2004). Several studies reported degradative vegetation changes in the absence of such natural disturbances (Virágh and Bartha, 1996; Somodi et al., 2004; Enyedi et al., 2008). Recently Hungarian grasslands are strongly affected by the abandonment of traditional grazing managementdue to the decreasing number of sheep and cattle since the 1960s (KSH, 2012).

The strictly protected Külső-gulya loess grassland (also known as Kis-gulya, Tompapusztai-löszgyep) is one of the largest ancient loess grasslands remained in Hungary. Its unique nature conservation value has been reported by several botanical and zoological studies (Csathó, 1985, 1986, 2005; Csathó and Csathó, 2007, 2009; Csathó and Jakab, 2012; Herczeg et al., 2011; Kertész, 1996; Molnár, 1997; Molnár et al., 2007). The area is covered by loess steppe grassland community (*Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1964) characterised by high species diversity and structural richness (Bartha et al., 2011a). The published flora list (Csathó and Csathó, 2009) contains 272 vascular plant species. Based on former studies in dry grasslands we assumed that the extraordinary diversity developed at Külső-gulya loess steppe is a consequence of the complex land-use history of this site (McNaughton, 1985; Collins, 1986; Knapp et al., 1998; Bartha, 2007). It was revealed that the site was managed by low intensity cattle grazing and regular mowing (Bartha et al., 2011b; Bartha et al., 2012). Nowadays only the regular mowing once a year has been continued. However it was revealed that this management not enough to maintain high diversity.

The presence of the lesser blind mole rat (mole rat hereafter) and its mounds are characteristic to the area (Németh et al., 2009). Both its mowing activity and mounds might contribute to preserve diversity an patch dynamics in loess grasslands. Mole rats are considered as serious pests for agriculture in the Mediterranean region due to their foraging of underground organs of vegetables (Moran, 1998). However, no information about the magnitude of such damage has been reported for the natural vegetation.

Ecosystem engineers are organisms which modify, maintainor create habitats for other species (Jones et al., 1994). Subterranean rodents like mole rats also belong to this group (Huntly and Inouye, 1988; Reichman and Seabloom, 2002; Zhang et al., 2003; Hagenah and Bennett, 2013). These species can modify vegetation composition (Ellison and Aldous, 1952; Foster and Stubbendieck, 1980; Reichman and Smith, 1985; Huntly and Reichman, 1994; Nosal et al., 2010; Case et al., 2013), microtopografical features of the soil (Inouye et al., 1997) and bulk density (Kerley et al., 2004). Furthermore they can also change the structure, organic matter and moisture contents of the soil (Mielke, 1977), and they can even reduce the proportion of available soil nitrogen (Inouye et al. 1987).

The *Spalacinae* subfamily (which has two genus, the small *Nannospalax* and the gross *Spalax*) consists of several populations with different chromosome numbers (Nevo, 1961; Savić and Soldatovic, 1984; Savić and Nevo, 1990; Nevo et al., 2001, Hadid et al., 2012). In Hungary four endemic forms exist (Németh et al., 2009) that belong to the lesser blind mole rat species complex [*Nannospalax* (superspecies *leucodon*)]. The study area is inhabited by the Hungarian blind mole rat (*Nannospalax* (*leucodon*) *hungaricus*) (Németh et al., 2009, Németh, 2011). This species leads a subterranean lifestyle (Watson, 1961) with excavating burrows (Heth, 1989).

Very scarce research (in particular about Asian and African mole rat species) focused on the effects of mole rat mounds on the vegetation (but see Cox and Gakahu, 1985; Reichman and Jarvis, 1989; Hongo et al., 1993). There are some other subterranean rodents with similar way of living, which can be used as reference and can help to understand the disturbing impact caused by the mole rats. For example prairie dogs (*Cynomys* spp.) change the species composition of their habitats (Agnew et al., 1986; Whicker and Detling, 1988). Pocket gophers (*Geomys* spp.) also alter some vegetation characteristics like species composition (Inouye et al., 1987; Huntly and Inouye, 1988). Bartha (2001) detected a negative relationship between the mound of pocket gophers and the amount of litter and dominant grass species in regenerated grasslands. Williams et al. (1986) and Martinsen et al. (1990) detected higher diversity on pocket gopher mounds than in their surroundings. Hagenah and Bennet (2013) also found that the presence of the mole rats enhanced species diversity.

Our aim was to study the species richness and diversity of the grassland influenced by the mound forming of the lesser blind mole rat and study the effect of this disturbance to the diversity.

Our hypotheses were the followings:

(i) The species composition of the mounds differs from the control area.

(ii) Diversity is higher on the mounds than in the control areas.

Material and methods

Description and land-use history of the study site

The research was done in Külső-gulya loess steppe which is located in the south-eastern part of Hungary, in Battonya-Tompapuszta (46º21'N, 20º58'E). The 20.9-ha-sized area is characterised by a continental climate with 600 mm mean annual precipitation and 10.6ºC mean annual temperature and with a high number of sunny hours (2000 hours/year). The soil type is chernozem developed on loess bedrock (Barczi et al., 2011).

The map of the first military survey shows Külső-gulya loess steppe as a grassland (Anon., 1785). The area was marked as a part of a large pasture in the map of the second military survey (Anon., 1869). The third military survey showed Külső-gulya grassland in its current size, as it can be seen that it was still used as a pasture (Anon., 1887). The Külső-gulya grassland in Battonya-Tompapuszta has been a nature conservation area since 1989, and its status changed to strictly protected in 1997. It is the part of the Körös-Maros National Park.

Sampling methods and data analysis

The sampling was made in 50×50 cm quadrats where the cover scores of species were recorded on the basis of the modified method of Braun-Blanquet (1964) using cover scores estimated by a percentage (%) scale. In determining quadrat size the extent of the mounds of a mole rat was taken into consideration. This size reflects the inner heterogeneity of the community (Virágh and Bartha, 1996). Altogether 12 plots were made on mounds (disturbed) and 12 plots in the area with no mounds (control).

The scores of Shannon-diversity and evenness were calculated as well as the total cover and the number of species in each of the plots. Rank-abundance curves based on the relative abundance of the species were also calculated. To compare the community parameters (total cover, diversity, evenness, number of species) between disturbed and control plots One-Way ANOVA and Tukey-test were used. These analyses were made in the R statistical environment (R Development Core Team, 2008). Species composition was analysed with PCO ordination with SYNTAX 5.0 program package (Podani, 1993) using Bray-Curtis similarity.

Results

The mean number of species (p=0.163) and the mean total cover (p=0.487) did not showed significant differences between the disturbed and the control sites (*Fig. 1, Table 1.*).

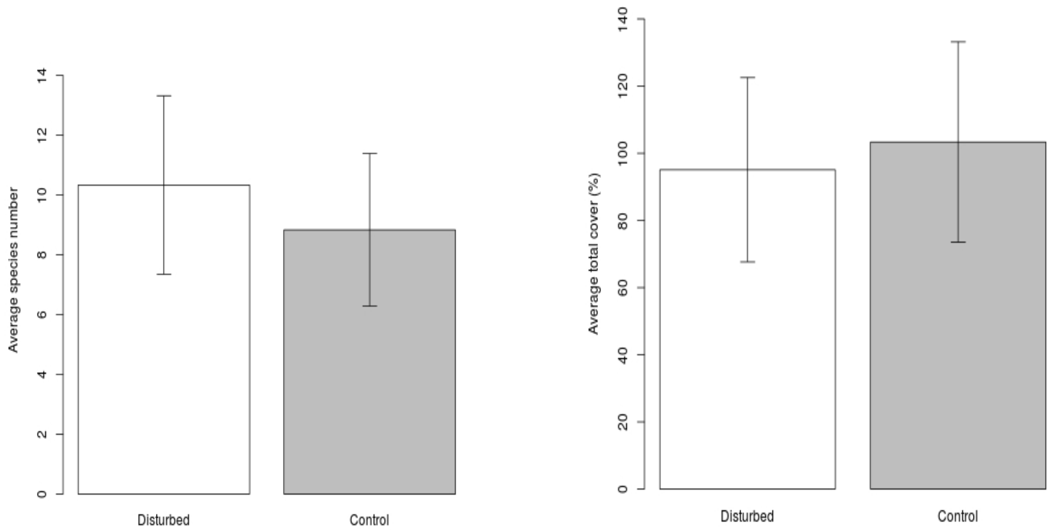

Figure 1. *The average number of species and the average cover values on the disturbed and control sites (mean±SE)*

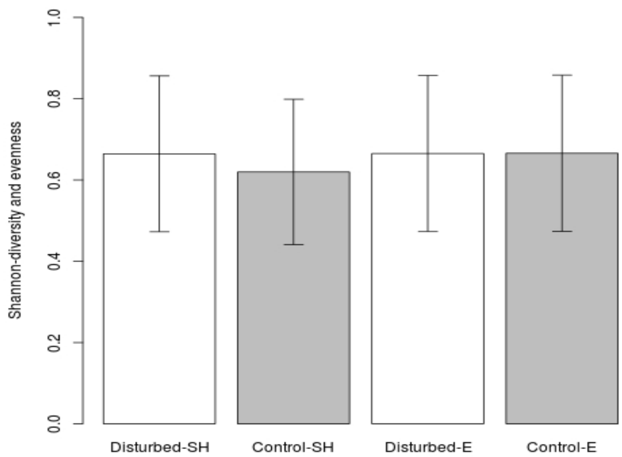

Figure 2. *The Shannon-diversity (SH) and evenness (E) on the disturbed and control sites (mean±SE)*

There was also no significant difference (*Fig. 2., Table 1.*) neither in the Shannon-diversity (p=0.373) nor in the evenness (p=0.44).

Table 1. *Results of the One-Way ANOVA of the species number, total cover, Shannon-diversity, evenness and the cover of grass species, legumes, litter and Teucrium chamaedrys*

Source	**Df**	**MS**	**F**	**P**
Species number	1	13.5	2.0867	0.1627
Total cover	1	416.67	0.4989	0.4874
Shannon-diversity	1	0.011989	0.8263	0.3732
Evenness	1	0.0086398	0.6184	0.44
Grasses	1	12553.8	41.405	1.788e-06 ***
Legumes	1	119.707	3.0464	0.09487 .
Teucrium chamaedrys	1	6337.5	12	0.002206 **
Litter	1	5787.7	8.6561	0.007538 **

The comparison of the rank-abundance curves did not reveal distinctions between the sites (*Fig. 3.*).

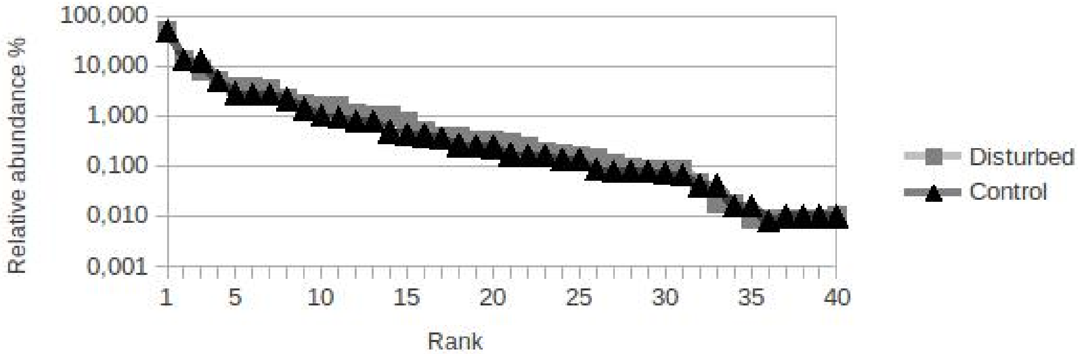

Figure 3. *Rank-abundance curves based on the relative abundance of the species*

The control and disturbed plots differ significantly based on the the PCO ordination (*Fig. 4.*). But if we have a closer look at the proportion of certain species groups (legume species, grasses) and the litter, the difference is remarkable (*Fig. 5.*). Legume species (*Astragalus cicer, Genista tinctoria, Lathyrus pratensis, Lathyrus tuberosus, Vicia angustifolia*) characterised the mounds (p=0.095) whilst the cover of the grasses (*Festuca valesiaca, Poa angustifolia, Carex praecox*) were much higher on the control sites (p=1.788e-06). The accumulation of the litter was more pronounced on the control sites as well (p=0.0075). Some dicots (*Teucrium chamaedrys* – p=0.0022, *Galium verum*, *Fragaria viridis, Thymus glabrescens*) occurred in higher cover on the mounds.

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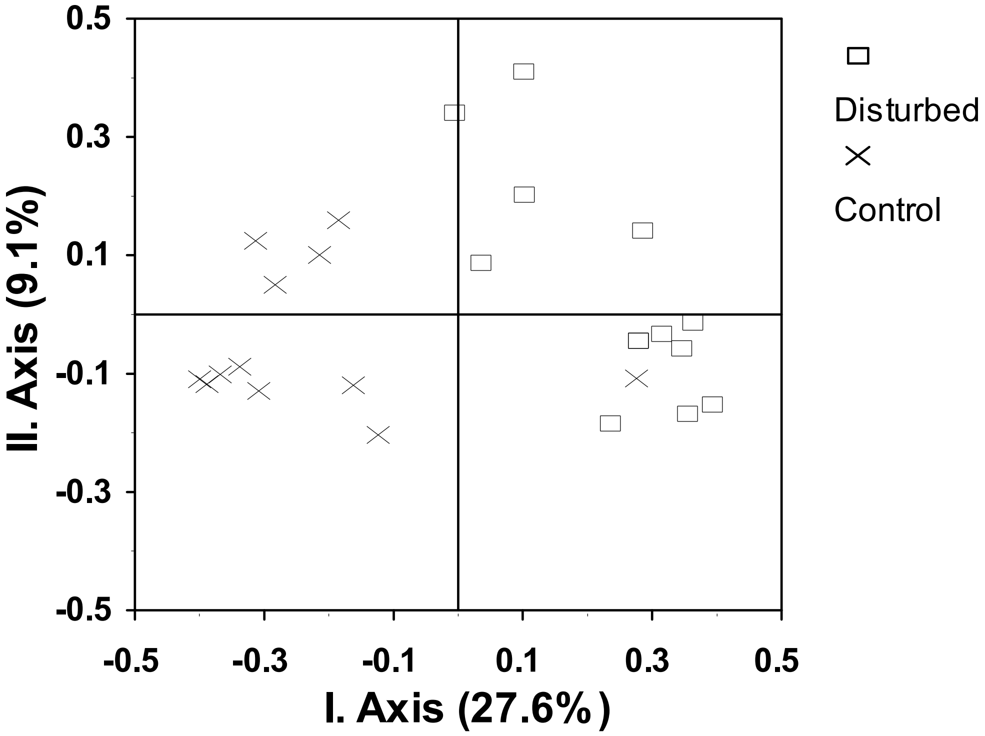

Figure 4. *Compositional differentiation between disturbed and control plots analysed by PCO ordination*

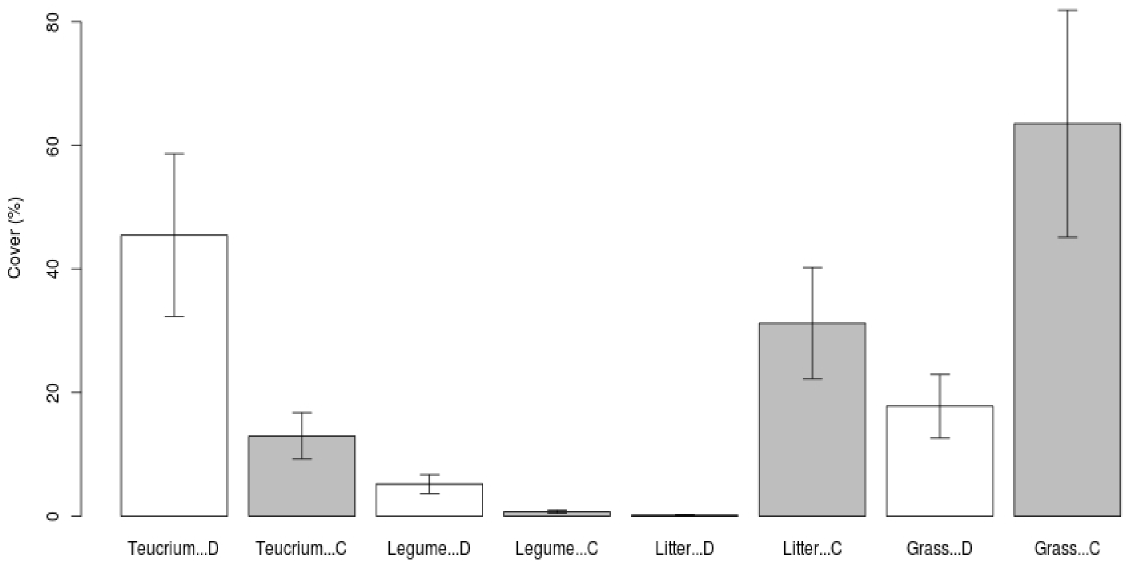

Figure 5. *The cover of particular species (Teucrium chamaedrys) and and functional groups (legume species, grasses and litter) on the disturbed (D) and control (C) sites (mean±SE)*

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Discussion

Our first hypothesis was confirmed by the results as remarkable differences were detected in the species composition between the disturbed and the control plots. The distinction is caused probably by the traits of dominant matrix species. Open surfaces are formed due to the activity of the mole rats and colonized by legumes as Hagenah and Bennett (2013) also confirmed. These open spaces also suitable for species with high seed production, and high vegetative and generative dispersal capacity (Bartha, 2007). We found that the cover of grasses was significantly lower on the mounds as it was also detected by Sigler et al., (2011). The disturbance of fossorial rodents can increase the amount of dicots (Spencer et al., 1985). It was found that the amount of litter also decreased on open surfaces, while litter accumulated in grass dominated swards. These patterns were also confirmed by a former study (Rebollo et al., 2002) analysing *Microtus* species' mounds. They found that the amount of total cover, litter and perennial species was also lower on the mounds than in the surroundings.

Although we found cleardifferences at the population and functional group levels, the community-level characteristics (total cover, species number, diversity) did not show significant differences. Thus, our second hypothesis was not supported. Other research related to pocket gophers (*Geomys bursarius*), having similar lifestyle to mole rat, showed higher species number on mounds (Deets et al., 2010). Sherrod et al. (2005) and Case et al. (2013) found higher species diversity on mounds while in contrast Rezsutek and Cameron (2000) and Rogers et al. (2001) did not find significant differences between the diversity of the disturbed and control plots.

The presence of the mole rats and their disturbance is characteristic to the area. This type of disturbance is a natural process which can highly contribute in maintaining diversity in dry grasslands (Sousa, 1984; Pickett and White, 1985). Disturbance was obtained by the foraging and trampling of the grazing animals for a long time. On the basis of our results the activity of the mole rats can supplement the lack of the grazing animals after the abandonment of grazing.

The abundance of rodents usually fluctuates in time. In case of a drastic increase in their population size they can have a negative effect on the vegetation composition and cover. Hagenah and Bennet (2013) detected such decrease of species diversity due to the increasing disturbance by the mole rats. The mole rat is a valuable species from the nature conservation point of view, thus it is important to state based on our results that their mounds do not affect negatively the diversity of the protected steppe grassland. Moreover, they enrich the disturbance regime and converge it to the complex disturbance regime of the natural grasslands.

In the studied grassland the only grassland management activity is mowing once a year. According to former studies, mowing once ayear should be appropriate to preserve diversity in dry Pannonian grasslands (e.g. Illyés and Bölöni, 2007). We found that mowing once a year was not effective to prevent litter accumulation, which was considerable even in dry years. Thus, especially in abandoned or not properly managed grasslands diversity generated and maintained by the disturbance of mole rat can be very important.

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Appendix

Nomenclature: Király (2009) for taxa, Borhidi (2003) for syntaxa