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In stable, unmanaged grasslands local factors are more important than landscape-level factors in shaping spider assemblages

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ABSTRACT

Previous studies reported that landscape-level factors are vital to support diversity of spiders in strongly modified arable lands and disturbed habitats such as managed semi-natural grasslands. Cropland management (ploughing, fertilization, and pest management) and agricultural practices (mowing and grazing) destroy and/or modify regularly the spider assemblages; thus, continuous recolonization from the surrounding landscape is vital to sustain the species pool. On the contrary, we hypothesized that in unmanaged grasslands, the spider assemblages are stable and the importance of recolonization is limited, the local factors become much more important drivers in shaping spider assemblages than landscape-level factors. We tested the importance of local and landscape-level factors on the abundance and species richness of spiders in unmanaged grasslands. At the landscape-level, we found that only the isolation had significant effect on the total abundance, on the abundance of hunting and habitat specialist species, and on the abundance of a frequent species (*Gnaphosa mongolica*). At the local scale, however, four out of five studied factors influenced significantly the species richness and abundance of spider assemblages and the abundance of two frequent species (*Alopecosa psammophila*,*Berlandia cinerea*). Species richness and abundance increased by plant cover, litter cover, and patch size, while decreased by bare ground cover. We found that in unmanaged grasslands, the local factors had vital role in maintaining the spider species richness; this is just the opposite conclusion that was earlier reported for agricultural ecosystems, where landscape-level effects had crucial role providing the species for continuous recolonization.

1. Introduction

Prior to agricultural intensification, natural and semi-natural grasslands were one of the most diverse habitat types in Europe (Batáry et al., 2008). Since the second half of the last century, the increasing agricultural activity has been an important driver of biodiversity loss in these grasslands (Tscharntke et al., 2005; Krauss et al., 2010; Hooftman and Bullock, 2012; Dengler et al., 2014). Low-intensity grassland systems in Central and Eastern Europe maintain a diverse and unique fauna and flora (Varga, 1997; Török et al., 2000). During the last decades due to the increase of large-scale farming and abandonment of the traditional management practices, the Central and Eastern European grasslands also become highly fragmented and endangered (Horváth et al., 2009; Buchholz, 2010).

Grasslands play an important role in the maintenance of biodiversity in cultivated landscapes by providing habitats and/or refuges for many species (Jeanneret et al., 2003; Woodcock et al., 2005; Horváth et al., 2013). Survival of the majority of grassland arthropod species in cultivated landscapes primarily depends on the quality of habitats, but also depends on the surrounding landscape (Jeanneret et al., 2003). To understand the relationship between agricultural activity and grassland biodiversity, it is essential to investigate the effects at different spatial scales (e.g., the local scale and the landscape-level scale) in these habitats (Tscharntke et al., 2005, 2012; Batáry et al., 2008).

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Spiders are one of the most abundant and species rich generalist predators. They contribute to the biodiversity in natural and agricultural ecosystems (Wise, 1993). The occurrence of spiders mostly depends on local factors such as vegetation structure, vegetation composition, microclimate conditions, and prey availability (Heikkinen and MacMahon, 2004; Horváth et al., 2005; Batáry et al., 2008; Schirmel et al., 2011). Landscape-level factors such as percentage of grasslands, percentage of non-crop habitats, and landscape diversity also influence spider assemblages (Clough et al., 2005; Schmidt et al., 2008; Horváth et al., 2013). Moreover, the human disturbance (urbanization and fragmentation), natural disturbance (e.g., fire, flood, and drought), and management regime (mowing, grazing, and burning) are also important factors (Cattin et al., 2003; Horváth et al., 2009, 2012; Malumbres-Olarte et al., 2014). To understand the changes in structure and composition of spider assemblages in natural and semi-natural habitats, it is important to investigate the effects of environmental factors at both local and landscape-level scales (Batáry et al., 2008).

In the previous studies, the effects of local and landscape-level factors on spiders were mainly investigated in strongly modified habitats such as arable lands (Clough et al., 2005; Schmidt et al., 2005, 2008; Öberg et al., 2007; Concepción et al., 2008; Drapela et al., 2008; Pluess et al., 2010) and in managed (grazed or mowed) semi-natural grasslands (Hendrickx et al., 2007; Batáry et al., 2008, 2012; Miyashita et al., 2012; Zulka et al., 2014). Surprisingly, the assessment of the importance of local and landscape-level factors on the assemblages of unmanaged grasslands is still missing. We would like to stress that there is an essential difference between the spider assemblages living in strongly modified, disturbed habitats, and those inhabiting unmanaged habitats. Assemblages in modified, disturbed habitats are regularly disrupted, therefore, recolonization from the surrounding landscape may be permanent, while assemblages in unmanaged habitats are more stable, and therefore, the role of the recolonization may be less important. Therefore, it is important to test the influence of the local and landscape-level factors in these unmanaged habitats.

In this study, our aim was to test the effects of local and landscape-level factors on the spider species richness and abundance. We also tested the effects of local and landscape-level factors on the abundance of the most frequent hunting spider species. We hypothesized that spider species richness and abundance increase with increasing cover of plants and litter, average height of grass and patch size but decrease with increasing bare ground. We supposed that in unmanaged grasslands, the spider assemblages are stable; therefore, the effects of landscape-level factors (isolation and landscape diversity) are less important in shaping spider assemblages than local factors. Moreover, we also hypothesized that most frequent hunting species respond heterogeneously to both local and landscape-level factors due to their variability in habitat affinity and ecological demands.

2. Methods

2.1. Study area

We selected nine unmanaged dry sandy grassland fragments in the Kiskunság region (size: 30,628 ha) of the Hungarian Great Plain which is located between the Danube and the Tisza rivers (Central Hungary) (Table 1). All selected sampling sites have the same vegetation type; these fragments are embedded in the same matrix. The typical grassland vegetation of the unmanaged dry sandy grassland fragments was *Festucetum vaginatae danubiale* (Szinetár et al., 2005). The relative abundance of protected plant species can exceed 26% in these grasslands (Török et al., 2000). Wetlands, forests (native and planted), and arable fields surrounded all the investigated grassland fragments. Thus, the habitat matrix was similar for all the studied grassland fragments. The Kiskunság region lies in the warm temperate zone with an annual mean temperature between 10.2 and 10.8 °C. The annual mean precipitation is 550–600 mm with two maxima in May and November and summer drought (Török et al., 2000). The most typical soil types are sand with more or less humus content and saline soils. The Kiskunság region is an important biodiversity hotspot in Hungary, because of its unique native plant and animal communities on sandy areas (Török et al., 2000; Szinetár et al., 2005; Batáry et al., 2007). The region is characterized by a mosaic of natural grasslands (sandy grasslands and salt meadows), wetlands (marshes, fen meadows, and mires), and forests (sandy oak woods, poplar-juniper steppe woodlands, and floodplain forests), as well as arable fields (maize and corn) and non-native tree plantations (black locust (*Robinia pseudoacacia*), ennobled poplar species (*Populus* spp.) and pine species (*Pinus* spp.)). After introducing arable farming in the 18th century, the area of the natural habitats decreased significantly by the end of the last century. Nowadays, only remnants of these habitats are to be found within the fragmented landscape of the Kiskunság region. The minimum distance between the studied grassland fragments was 1 km; the maximum distance was 44 km, while the average distance between the fragments was 22 km.

2.2. Sampling design

During the 9-year study period (2001–2009), we sampled spider species using pitfall traps. We placed 10 traps randomly in each investigated fragment. All traps were at least 50 m apart from the grassland edges to avoid edge effects (Horváth et al., 2002). Traps consisted of plastic cups with 100 mm diameter and contained about 150 ml 70% ethylene glycol as a killing-preserving

Table 1
Environmental factors at local and landscape-level scale of the nine studied grassland fragments in Kiskunság region.

Fragments/ variables	Cover of plants (%)	Cover of bare ground (%)	Cover of litter (%)	Average height of grass (cm)	Patch size (ha)	Inverse isolation index (ha)	Landscape diversity
1. Bugac-borókás	36.7	49.0	4.3	29.4	408.0	556.0	0.261
2. Bugac-legelő	72.8	5.5	16.0	34.6	1022.4	688.1	0.372
3. Fischerbócsa	46.9	36.9	7.1	27.7	43.8	80.6	0.170
4. Fülöpháza	54.9	32.3	4.1	32.0	300.8	526.9	0.524
5. Kunadacs	54.5	22.0	17.7	32.0	3.0	28.5	0.113
6. Kunbaracs east	63.0	13.5	9.1	28.0	14.6	63.2	0.263
7. Kunbaracs west	59.6	14.6	14.8	33.2	8.6	57.0	0.148
8. Orgovány	67.8	15.7	8.5	30.6	108.0	185.7	0.365
9. Soltszentimre	42.3	42.7	7.9	34.3	175.5	270.7	0.539