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Recent artificial vineyard terraces as a refuge for rare and endangered spiders in a modern agricultural landscape

Ondřej Košulič[a,c,*], Radek Michalko[b], Vladimír Hula[c]

[a] Department of Forest Protection and Wildlife Management, Faculty of Forestry and Wood Technology, Mendel University in Brno, Zemědělská 3, 613 00 Brno, Czech Republic
[b] Department of Botany and Zoology, Faculty of Sciences, Masaryk University, Kotlařská 2, 611 37 Brno, Czech Republic
[c] Department of Zoology, Fisheries, Hydrobiology and Apiculture, Faculty of Agronomy, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

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ABSTRACT

Many xerothermophilic invertebrate species have become rare and endangered due to intensified agriculture and forestation during the last decades. An important question is whether human-made habitats may serve as refuges for rare xerophilous species inhabiting disappearing seminatural and natural locations. We studied spider assemblages of several vineyard terraces in the traditional wine region of the Czech Republic and investigated factors from microhabitat to landscape scale that could influence conservation usefulness of terraces. Species density, abundance, conservation value and degree of rareness were analyzed for conservation-important spider species on terraces with two succession-stage habitat types (sparse versus dense grass) in landscapes with varying proportions of surrounding potential source areas and different surrounding habitats. A total 171 species of spiders were recorded, with high proportions of rare xeric specialist (40%) and red-listed threatened species (15%) that supports the conservation potential of vineyard terraces. The conservation significance of terraces is affected by factors operating at (micro) habitat and landscape scales. Overall species density and spider abundance did not differ significantly between terraces with sparse versus dense vegetation cover. Rare and endangered epigeic species were associated with terraces having sparse vegetation while rare epiphytic species were associated with terraces having dense vegetation. Species density, conservation value, degree of rareness and abundances of red list and rare species increased with presence of adjacent steppe grasslands. Our results indicate such artificial habitats can be important refuges for a wide spectrum of xerothermophilic spiders. To prevent losses of rare and endangered xeric species, we suggest agricultural interventions and management methods that retain important diversification of microhabitats.

1. Introduction

The development of agricultural landscapes during recent decades has been characterized by increasing intensity of farm management and a consequent decrease in the number and size of natural and seminatural habitats. A result is that originally heterogeneous, highly structured landscapes have been converted into much more uniform areas consisting of intensively used agroecosystems (Robinson and Sutherland, 2002). Collectively, these negative factors have resulted in drastic reduction of the landscape's overall biodiversity (Kruess and Tscharntke, 1994; Duelli, 1997; Thomas, 2005; Henle et al., 2008). In particular, the populations and local species richness of arthropods favoring open, non-forest habitats have diminished greatly (Cowley et al., 2000; Thomas, 2000; Bengtsson et al., 2005).

Vineyard terraces were created in the Czech Republic's South Moravian Region during a period of agricultural intensification in the 1950–1980s, when xeric slopes and grasslands were transformed for the production of grapes. At that time, this constituted a very negative intervention in the local ecosystem due to the destruction of xeric, seminatural grasslands barely usable for conventional agricultural production. Today, however, the rate of natural succession on this habitat is relatively slow due to its steep slope, hot and dry conditions, calcareous loess geological

* Corresponding author at: Department of Forest Protection and Wildlife Management, Faculty of Forestry and Wood Technology, Mendel University in Brno, Zemědělská 3, 613 00 Brno, Czech Republic. Tel.: +420 545 133 247.
E-mail address: ondra.kosulic@seznam.cz (O. Košulič).

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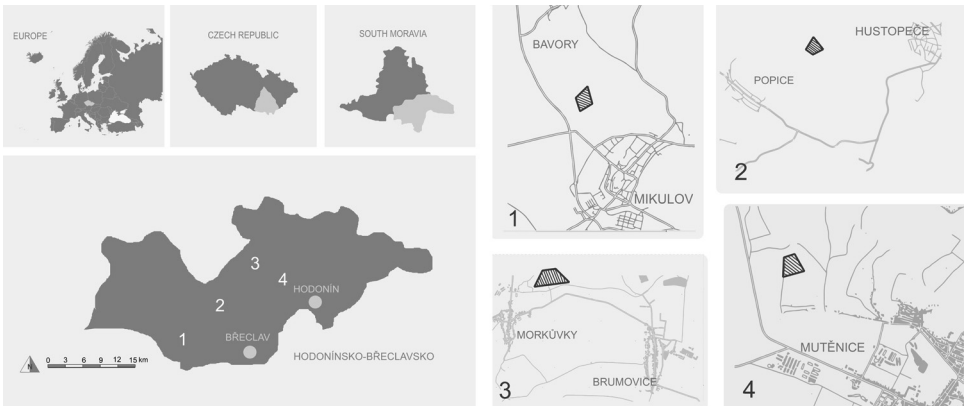

Fig. 1. Map of the research area in the south-eastern Czech Republic with localization of study sites.

substrate, and formation of mosaic-like structures with early and late succession stages. These features are unique for human-made habitats and probably could create suitable conditions to host unique species and promote overall species richness and abundance. Moreover, due to loss of natural and seminatural xeric arthropod habitats (Cremene et al., 2005; Schuch et al., 2012), it is desirable to explore and promote appropriate management of artificial, human-made biotopes that can replace the natural and seminatural habitats of rare xerothermophilic species (Beneš et al., 2003; Tropek et al., 2010; Tropek et al., 2012).

Spiders were used as model organisms to determine the potential importance of vineyard terraces for biodiversity conservation and ecosystem restoration in agricultural landscapes. Spiders are the most abundant terrestrial predators, and therefore they constitute an essential proportion of the predatory arthropods that play an important role as generalist pest control agents in agroecosystems (Nyffeler and Benz, 1987; Marc et al., 1999; Chatterjee et al., 2009). In addition, due to their close relationship to their habitats, effective sampling, and relatively easy determination, spiders constitute a good indicator group among invertebrates that may be surveyed to help in assessing the natural conditions and changes occurring in given locations (Clausen, 1986; Wheater et al., 2000; Pearce and Venier, 2006).

The occurrence of spiders in agricultural landscapes is affected foremost by microhabitat conditions (Luczak, 1979; Samu et al., 1999). The environmental conditions on the microhabitat scale are determined especially by the vegetation structure, bare soil patches, and succession stage of the microhabitat (Gibson et al., 1992; Seyfulina, 2005). Nevertheless, phenomena at the habitat and landscape scales also influence the occurrence of spiders (Clough et al., 2005; Isaia et al., 2006; Benítez and Méndez, 2011). The presence of suitable habitats (both natural and seminatural) is important, as these may serve as refuges for endangered species and/or as a source areas for sink habitats (Schmidt and Tscharntke, 2005; Hendrickx et al., 2007; Tropek and Konvička, 2008). The degree of landscape heterogeneity, as well as the configuration and position of suitable habitats influence spider species richness and abundance and are important for sustaining an effective dynamic in spider metapopulations (Hanski et al., 1995; Öberg et al., 2007; Miyashita et al., 2012).

A few studies have evaluated the ecological role of spiders in vineyards (Costello and Daane, 1995; Nobre and Meierrose, 2000; Venturino et al., 2008), and spiders have been noted as abundant predators in vineyards (Cate, 1975; Nyffeler and Sunderland, 2003). Nevertheless, there remains a lack of knowledge concerning spider assemblages from vineyard habitats in comparison with other agricultural habitats. Most studies of spiders in vineyards focus on the relationship between diversity and agricultural practices or landscape heterogeneity (Costello and Daane, 1998; Isaia et al., 2006; Bruggisser et al., 2010). Some faunistic studies do, however, mention the presence of threatened spider species from vineyards in Central Europe, and that may indicate vineyards' conservation significance for spiders (Beck, 1991; Jäger et al., 2000; Bryja et al., 2005; Gajdoš and Dankaninová, 2010; Košulič and Hula, 2013). Recently built vineyard terraces on loess substrate and in the intensive agricultural landscape of Central Europe had never been investigated as a refuge for invertebrates. Almost all known such publications focus on historical terraces maintained by rock walls and stony slopes, not by powdery loess soils as in the case of the terraces in this study (Ebert and Rennwald, 1991).

The objectives of the present study were to evaluate the conservation significance of vineyard terraces, to study key factors affecting diversity of spiders on the terraces, and thereby to help in finding practical habitat restoration and conservation management measures to support overall biodiversity. Toward these ends, the composition of spider assemblages was studied and several diversity and conservation indicators were compared among vineyard terraces located in landscapes with varying proportions of surrounding open steppe habitats as potential source areas and different habitats surrounding the terraces. Specifically, we compared two habitat types with different succession stage occurring in each terrace. We hypothesized that, despite the fact that vineyard terraces are newly formed habitats (1980s), they create important refuges and replacement biotopes through their heterogeneous mosaic of microhabitats, thereby increasing the overall landscape biodiversity in the Czech Republic's otherwise rather homogeneous landscape.

2. Materials and methods

2.1. Research area and study sites

The research area is situated within the South Moravian Region in the districts of Břeclav and Hodonín, which occupy the southernmost part of the region (Fig. 1). This area belongs to the Pannonian biogeographic region, which hosts the Czech Republic's best examples of thermophilic fauna and flora (Mackovčin et al., 2007). This is a lowland landscape (75–210 m a.s.l.) that is covered by a mosaic of arable fields, settlements, deciduous forests, vineyards and small isolated grasslands. The climate is warm and relatively dry, with an average annual temperature around 9.2 °C and average annual precipitation around 550 mm. The conditions are ideal for growing grapes, and the expanse of vineyards in South Moravia make up 95% of the total production area of vineyards in the Czech Republic. Vineyard terraces were created locally on areas having suitable habitat conditions (especially desirable slope exposures). Overall,