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Effects of habitat and landscape characteristics on the arthropod assemblages (Araneae, Orthoptera, Heteroptera) of sand grassland remnants in Southern Hungary

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ABSTRACT

For adequate conservation planning, ecologists need to understand the driving factors of the species richness and composition patterns of arthropod assemblages. The present study scrutinizes how the vegetation, the surrounding matrix and the process of fragmentation affects the diversity and the composition of arthropod assemblages in dune slack meadow remnants of an agricultural landscape in southern Hungary. Spiders, orthopterans and true bugs were sampled with sweep netting in a total of 25 sand steppe, mesotrophic wet meadow and alkaline meadow patches. Our general findings showed that the structure and species composition of arthropod assemblages depended primarily on the vegetation type. From among the size and shape of the patches, their extent of isolation and the types of the surrounding landscapes only the latter one could be shown to have a significant effect, though this was also restricted to the group of spiders. Therefore, the structure and composition of spider assemblages may be used as indicators for the adjacent agricultural activities. Unlike its effect on species composition, the effect of vegetation type was not consistent on the species richness of the arthropod assemblages and functional groups. The influence of vegetation type was greater on the species richness of herbivores (specialist and generalist true bugs and grasshoppers) than on that of the carnivores (spiders, bush crickets and carnivorous true bugs). Based on the fact that neither patch size nor the extent of isolation, i.e. the measures of fragmentation, influenced the species richness of the majority of the arthropod groups significantly, we conclude that fragmentation was not the main threat for the studied arthropod fauna. Furthermore, the present study calls attention to the limited efficiency of Island Biogeography Theory in the case of relatively large, traditionally managed grasslands embedded in extensive agricultural landscapes, like the general landscape pattern of the Great Hungarian Plain.

1. Introduction

The destruction and fragmentation of natural habitats are among the major threats to biodiversity worldwide (reviewed by Ewers and Didham, 2006). Temperate grassland communities are highly threatened, since large areas of their original range have been transformed into agricultural lands (Bourn and Thomas, 2002). Although agricultural landscapes are predominant in most European countries, in Central and Eastern Europe notable areas of natural and semi-natural grassy habitats, such as the sand grasslands of the Pannonian Basin, still exist and host diverse fauna and flora (Batáry et al., 2010; Báldi et al., 2013). Hungarian sand grasslands have a special position among sand habitats in Europe due to their geographical location and continental character. The flora and fauna of the region are isolated from other Eurasian sand dune areas and harbour numerous endemic plant and animal species and subspecies (Kröel-Dulay and Kovács-Láng, 2008). There are several species that are common here, but are extremely rare in the rest of Europe. The largest and presumably the most unique sandy area in Hungary is located in the Kiskunság. Although considerable grassland areas of the region – 99% of the steppe grasslands, 56% of the alkali vegetation and 55% of the fen vegetation – have been destroyed by human activity in the last two centuries (Biró et al., 2008), the natural, species rich vegetation of the dune slack meadows (DSM) could survive in the southern part of the Kiskunság as they were

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inadequate for cultivation owing to the high groundwater level, while the areas between them have been ploughed and used for agriculture since the 19th century (Margóczi et al., 2007).

Regarding the conservation of the rich arthropod fauna in Central and Eastern Europe, the factors influencing the species composition and diversity patterns of the arthropod communities in the remaining natural and semi-natural grasslands need more attention in order to establish proper conservation measures. The present study focuses on the effects of fragmentation, vegetation type and the surrounding matrix on the diversity and composition of arthropod assemblages of DSM remnants encircled by agricultural areas in Southern Hungary. The spatial characteristics, such as patch size, shape and the extent of isolation of the grassy habitats embedded in the agricultural matrix are known to have a great influence on the abundance and diversity of their arthropod communities (reviewed by Tscharntke et al., 2002). Several vegetation properties are known to influence the species richness and composition of arthropods (e.g. Morris, 2000), thus the type of vegetation can be considered as a substantial factor for invertebrates. In spatially heterogenic meadows, such as the DSM, various vegetation patches can provide habitat and shelter for different species, which thereby can form different assemblages (Torma et al., 2010).

Although grassland management is also known to play a significant role in shaping the arthropod assemblages (e.g. Morris, 2000), we did not include the evaluation of management in the present study as the studied DSM fragments were managed uniformly with mechanical mowing. In a landscape with high biodiversity the effect of management intensity is usually low (Tscharntke et al., 2005), as it was shown by numerous authors (Batáry et al., 2007; Sárospataki et al., 2009; Báldi et al., 2013). Although grassland management has direct effects on invertebrates (e.g. direct mortality due to mechanical mowing), the dominant effects are indirect or long-term in nature, acting via the vegetation (Nickel and Hildebrandt, 2003; Batáry et al., 2008; Torma and Császár, 2013).

Three arthropod taxa were chosen in the study: Araneae, Orthoptera and Heteroptera. Spiders are one of the most abundant polyphagous predators in all terrestrial ecosystems and the species composition of their assemblages is a sensitive indicator of the changes in habitat structure (Ysnel and Canard, 2000; Heikkinen and MacMahon, 2004). True bugs are highly diverse according to their trophic behaviour, ranging from herbivores to predators and bloodsucking parasites. However, the majority of true bugs are phytophagous and the vegetation has a profound influence on them (Zurbrügg and Frank, 2006). The diversity of heteropteran bugs has also been shown to be a good indicator of the total insect diversity (Duelli and Obrist, 1998). Orthopterans are in the focus of conservation biology as their diversity decline in many temperate regions (Steck et al., 2007). In Europe more than half of them are considered endangered species (e.g. Ingrisch and Köhler, 1998; Steck et al., 2007). Orthopterans are important primary and secondary consumers in grassland ecosystems, and they provide an abundant source of prey for many predators (Ingrisch and Köhler, 1998).

In order to reveal the main influential factors for arthropod assemblages in DSM remnants, we tested (1) the effects of spatial habitat characteristics (i.e. patch size, shape and the extent of isolation), (2) the effects of landscape features (i.e. the amount of the surrounding agricultural areas) and (3) the effects of vegetation type on the species diversity of arthropod assemblages in 25 DSM patches.

The island biogeography theory (IBT) of MacArthur and Wilson (1967) predicted higher species richness in larger and less isolated patches. In contrast, e.g. Lövei et al. (2006) emphasized the difference between the real islands and terrestrial habitat islands considering e.g. edge and matrix effects which can mask the predicted patterns of IBT. The perimeter to area ratio of patches determines the amount of core and edge areas (Laurence and Yensen, 1991). However, the implications of changes in diversity near edges are unclear due to various mechanisms affecting diversity patterns across edges – such as ecological flows, access to spatially separated resources, resource mapping and species interactions – and to the differential response of the biota to these mechanisms (reviewed by Ries et al., 2004).

2. Materials and methods

2.1. Study region and sampling

The present study was carried out in the South-Hungarian part of the Danube-Tisza Interfluve, commonly referred to as the Kiskunság. The area lies in the warm temperate zone with an annual mean temperature of 10.5 °C. The annual precipitation ranges from 550 to 600 mm (Kröel-Dulay and Kovács-Láng, 2008). The soil of the area is composed of mainly sand. In the southern part of the Kiskunság, where the sampling sites were selected in an approximately 400 km^2 area (Fig. 1), the DSM remnants form mosaics of sand steppe, fen and marsh meadow, reed and various alkaline vegetation patches in accordance with the microrelief and the water and salt content (Aradi et al., 2007). The DSMs were traditionally used as pastures and/or hay meadows (Margóczi et al., 2007). As we did not intend to study the effects of management on the arthropod assemblages, sampling sites with similar management, i.e. mechanical mowing once a year after July, were selected. Five alkaline meadows, ten sand steppe and ten wet meadow patches were selected for sampling. True bug, orthopteran and spider assemblages were sampled with sweep netting three times in total (13–14 May, 24–26 June and 14–16 September 2006). Due to the high water table only sweep-netting could be applied as the sampling method. Sweep-netting is a generally used method to collect true bugs and orthopterans (Zurbrügg and Frank, 2006; Báldi and Kisbenedek, 1997), however it is rarely applied to sample spiders (but see Horváth et al., 2009). We carried out 5 × 50 sweeps along constant paths at each site in each period. At each site, five ca. 25 m long paths ran parallel to each other with a minimal distance of 25 m between them in the patch interior. Data from different sweeps and different periods were pooled according to site, making one statistical sample for each site.

2.2. Assessment of the habitat and landscape variables

Vegetation type, size, shape and inverse isolation of grassland patches and the area of surrounding arable fields were used as habitat and landscape variables (Table 1).

We used the vegetation to characterize the habitat properties. Based on the Hungarian General National Habitat Classification System (Fekete et al., 1997) three vegetation types could be distinguished: sand steppe (SS), mesotrophic wet meadow (WM) and alkaline meadow (AM). We measured the area of the sampled patches on digital vegetation maps (Aradi et al., 2007) using the Arcview 3.11 GIS software. The perimeter to area ratio of the patches was calculated with the shape index (Patton, 1975). Isolation is usually defined as the distance from the source area (e.g. MacArthur and Wilson, 1967), even though the isolation of a habitat patch depends not only on the distance from the nearest patch but also on its size; therefore, we used the inverse isolation measure (Vos and Stumpel, 1995), calculated as the total area of patches with the same vegetation type as the sampled patch in a 500 m radius around each site. The total area of the surrounding arable fields in the landscape was also calculated in a 500 m radius around each site. We chose the 500 m radius because it has been