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Metacommunities of spiders in grassland habitat fragments of an agricultural landscape

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Abstract

Arthropod communities in fragmented agricultural landscapes depend on local processes and the interactions between communities in the habitat islands. We aimed to study metacommunity structure of spiders, a group that is known for high dispersal power, local niche partitioning and for engaging in species interactions. While living in fragmented habitats could lead to nestedness, other ecological traits of spiders might equally lead to patterns dominated either by species interactions or habitat filtering. We asked, which community pattern will prevail in a typical agricultural landscape with isolated patches of semi-natural habitats. Such a situation was studied by sampling spiders in 28 grassland locations in a Hungarian agricultural landscape. We used the elements of metacommunity structure (EMS) framework to distinguish between alternative patterns that reveal community organization. The EMS analysis indicated coherent species ranges, high turnover and boundary clumping, suggesting Clementsian community organization. The greatest variation in species composition was explained by local habitat characteristics, indicating habitat filtering. The influence of dispersal could be detected by the significant effect of landscape composition, which was strongest at 500 m. We conclude that dispersal allows spiders to respond coherently to the environment, creating similar communities in similar habitats. Consistent habitat differences, such as species rich versus species poor vegetation, lead to recognisably different, recurrent communities. These characteristics make spiders a predictable and diverse source of natural enemies in agricultural landscapes. Sensitivity to habitat composition at medium distances warns us that landscape homogenization may alter these metacommunity processes.

Keywords: Community ecology; Fragmentation; Habitat filtering; Dispersal; Natural enemies; Agricultural landscape; Grassland; Spider

Introduction

Natural, semi-natural grasslands are largely reduced to habitat islands in the agricultural matrix virtually everywhere on Earth where agricultural production is feasible (Kormann et al. 2015). Even though these grassland patches might represent overall a small area, they have an important role in maintaining regional biodiversity and providing ecosystem services for the agricultural land (Batary, Holzschuh, Orci, Samu, & Tscharntke 2012; Bommarco, Kleijn, & Potts 2013). Arthropod communities in fragmented agricultural

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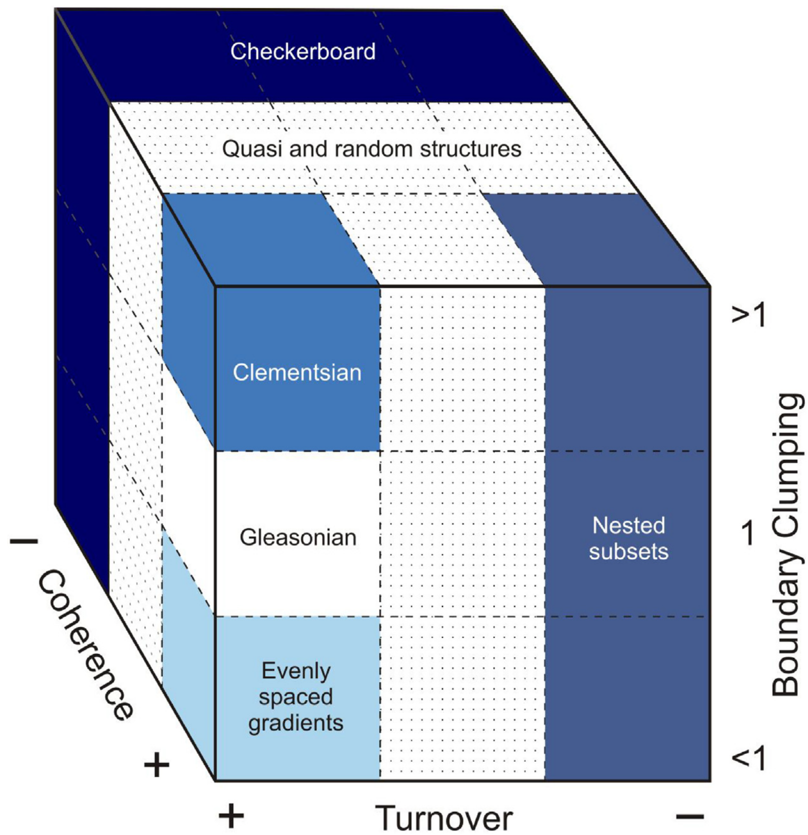

Fig. 1. A graphic representation of the classification of metacommunity structures in the EMS framework (Leibold & Mikkelson 2002). Structures are depicted in the three dimensional space defined by the three main attributes of the ordinated occurrence matrix: coherence, turnover and boundary clumping. Quasi and random structures (Presley et al. 2010) that are not treated in the present analysis are shown as dotted areas. Modified after Dallas (2014).

landscapes depend on local processes and on interactions between communities in the habitat islands. If local communities are isolated, then local processes will prevail. Local processes might be dominated by habitat filtering, interspecific interactions, or by random population events leading to local species losses. Habitat filtering may arise through tolerances to abiotic environmental conditions, habitat-specific interspecific interactions or the interplay of both (Cadotte & Tucker 2017). Conversely, if there are significant interactions between the local communities – because of the strong dispersal power of the species or the vicinity and/or connectedness of the habitat patches – then mass effects resulting from source-sink population dynamics can be expected. In any such situation, where species coexistence is determined by the interaction of local and regional processes, communities are best understood if they are treated and investigated as metacommunities (Mihaljevic, Joseph, & Johnson 2015). The understanding of metacommunity processes is needed to predict the level of biodiversity and ecosystem services that semi-natural habitat fragments provide, and also to assess how further fragmentation of such habitats and the impoverishment of regional species pools will change ecosystem services.

The elements of metacommunity structure (EMS) framework (Leibold & Mikkelson 2002) uses species occurrence data (species-by-site binary occurrence matrix) to classify metacommunity structure and provide hypotheses about underlying mechanisms. The EMS framework operates with three key notions: coherence, turnover and boundary clumping. If these are regarded as axes, then position along the axes (Fig. 1) provides the bases for the EMS classification of metacommunity structures into five categories: (1) If strong interspecific interactions lead to species pairs that have locally mutually exclusive distributions (negative coherence), this results in checkerboard patterns. Such a distribution is often regarded as a sign of local competitive exclusion. All other classified patterns assume positive coherence, which signifies that the majority of species in the metacommunity respond to the same environmental variation, not masked by strong interspecific processes and/or helped by sufficient dispersal that allows the occupancy of suitable habitat patches. (2) Nested subsets typically arise when local communities, for instance as a result of fragmentation and ensuing local extinctions, form subsets of a once more speciose community. Anti-nested patterns (for criticism of the concept see Almeida, Guimaraes, & Lewinsohn 2007; here used in the

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