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Spatial scale affects seed predation and dispersal in contrasting anthropogenic landscapes

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Abstract

Seed predation and dispersal can have strong, albeit opposing effects on plant communities and their extent depends on interactions between seeds and their vectors (abiotic factors or different animal taxa). We assume that vectors, due to their specific requirements, act at different spatial scales and seed-vector interactions might differ greatly between landscapes. So far, it remains largely unclear, how the interaction between seeds and their vectors affects the degree of seed predation and dispersal in novel anthropogenic landscapes. We expect changes in patterns either at the landscape scale (urban vs. rural areas), habitat scale (habitat heterogeneity) or microhabitat scale (vegetation variability).

We assessed seed predation and dispersal of two seed species by rodents, earthworms, other invertebrates and rain in cafeteria experiments in urban gardens and rural field margins and implemented generalized mixed effect models to test the effect of spatial scales and other environmental variables.

Seed predation and dispersal were generally low and similar patterns emerged when the same vector facilitated the function. Overall, predation and dispersal were similar in urban and rural areas but when differentiating between vectors, scale effects were evident. Seed predation by rodents and earthworms was affected at the landscape scale, seed predation by other invertebrates increased with higher habitat heterogeneity and seed dispersal by rain was negatively affected at the microhabitat scale through increased plant cover.

We show that one vector can facilitate the contrasting two functions, seed predation and dispersal, simultaneously, resulting in similar patterns at a specific spatial scale. However, different vectors might lead to contrasting patterns for the same function, depending on the spatial scale. This needs to be considered especially in anthropogenic areas, where ecosystem management decisions are also made at different spatial scales from private garden owners to landscape planning committees.

Zusammenfassung

Samenprädation und –ausbreitung können starke, wenn auch gegensätzliche Effekte auf Pflanzenlebensgemeinschaften ausüben und ihre Ausprägung hängt von Interaktionen zwischen Samen und ihren Vektoren (abiotische Faktoren oder verschiedene Tiere) ab. Wir nehmen an, dass Vektoren aufgrund ihrer unterschiedlichen Ansprüche auf verschiedenen Raumskalen unterschiedlich agieren und Samen-Vektor Interaktionen sich stark zwischen Landschaften unterscheiden. Bis jetzt wissen wir

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kaum, wie die Interaktionen zwischen Samen und Vektoren das Ausmaß von Samenprädation und–ausbreitung in neuen anthropogenen Landschaften beeinflussen. Wir erwarten Veränderungen der Interaktionen entweder auf der Landschaftsraumskala (urbane vs. rurale Gebiete), auf der Habitatraumskala (Habitatheterogenität) oder der Mikrohabitatsraumskala (Vegetationsvariabilität).

Wir nahmen Samenprädation und –ausbreitung von zwei Samenarten durch Nager, Regenwürmer, andere Invertebraten und Regen in Cafeteria Experimenten in urbanen Gärten und ruralen Feldrändern auf und nutzten generalisierte mixed-effects Modelle um den Einfluss von Raumskalen und anderen Umweltvariablen zu testen.

Samenprädation und –ausbreitung waren generell niedrig und ähnliche Muster traten zu Tage, wenn der gleiche Vektor die Funktion ausübte. Insgesamt waren Prädation und Ausbreitung gleich in urbanen und ruralen Gebieten, aber wenn zwischen Vektoren unterschieden wurde, wurden Raumskaleneffekte deutlich. Samenprädation durch Nager und Regenwürmer wurde auf der Landschaftsraumskala beeinflusst, Samenprädation durch andere Invertebraten nahm mit höherer Habitatheterogenität zu und Samenausbreitung durch Regen wurde auf der Mikrohabitatraumskala durch zunehmende Pflanzendeckung negativ beeinflusst.

Wir konnten zeigen, dass der gleiche Vektor die beiden gegensätzlichen Funktionen (Samenprädation und –ausbreitung) gleichzeitig ausführen kann, was zu ähnlichen Mustern in der gleichen Raumskala führt. Jedoch können unterschiedliche Vektoren kontrastierende Muster in Abhängigkeit von der Raumskala in der gleichen Funktion hervorrufen. Das muss besonders in anthropogenen Landschaften berücksichtigt werden, wo Ökosystem-Management-Entscheidungen auch auf verschiedenen Raumskalen getroffen werden – vom privaten Gartenbesitzer bis hin zu Landschaftsplanungskommittees.

Keywords: Earthworms; Granivory; Habitat heterogeneity; Invertebrates; Landscape scale; Microhabitat; Plant species richness; Rain dispersal; Small mammals; Vegetation structure

Introduction

Seed predation and dispersal (seed fate) can have severe, albeit opposing effects on plant reproduction and community composition (Hulme 1998; Levine & Murrell 2003), with seed predation removing potential new plant individuals and seed dispersal influencing the location of new individuals. Both functions depend on interactions of seeds with biotic or abiotic vectors. Abiotic vectors such as rain and wind can facilitate seed dispersal, whereas biotic vectors (animals of most taxa) can perform either seed predation or dispersal (Vander Wall, Kuhn & Beck 2005). Some animals can even act as seed predators and dispersers for the same seed species simultaneously (Retana, Pico & Rodrigo 2004; Pufal & Klein 2013). The type and extent of interaction between seeds and biotic vectors is influenced by various conditions. Whether an animal disperses or destroys seeds through consumption depends on the animals' preferences or size as well as on seed species and size (Eisenhauer et al. 2009; Koprdova, Saska, Honek & Martinkova 2010; Honek & Martinkova 2013). Therefore, distinguishing between seed predation and dispersal when seeds were consumed is difficult.

It has also been shown that plant diversity can excert a positive bottom-up control on some plant-animal interactions, either directly (i.e. increasing flower visits or decomposition rates with increasing plant species richness) (Scherber et al. 2010) or indirectly, i.e. increasing seed predation with increasing vegetation cover, which is positively correlated with plant species richness (Pufal & Klein 2013).

Seed fate is also affected at different scales depending on the life history, trophic level and foraging range of the animal (Kollmann 2000; Steffan-Dewenter, Münzenberg & Tscharntke 2001; Farwig et al. 2009). Even though we have some information on seed predation and dispersal at different spatial scales, patterns cannot be generalized (Steffan-Dewenter et al. 2001; Farwig et al. 2009), because observations can differ even for the same animal taxa (Kollmann 2000; Garcia & Chacoff 2007).

Even fewer information is available on the extent and impact of these functions in anthropogenic landscapes that emerged after the drastic transformation of natural landscapes in response to human population growth. Anthropogenic landscapes are severely depleted of natural habitats but differ vastly in their structure (Grimm et al. 2008), such as rural or urban areas (Ellis, Klein Goldewijk, Siebert, Lightman & Ramankutty 2010). Rural areas with intensified agricultural productivity are characterized by a strong simplification of the landscape with yearly changing monocultures and heavily fragmented semi-natural or natural habitats (Robinson & Sutherland 2002), which might still provide habitat for a range of native species (Menalled, Marino, Renner & Landis 2000). Urban areas are heterogeneous, dynamic landscapes (Grimm et al. 2008), characterized by high human population density, mostly sealed surfaces (roads, industrial properties, residential buildings) and few green spaces (gardens, parks or other open areas) (Ikin et al. 2013). In urban areas, habitats suitable for plant and animal species are heavily reduced and fragmented and plant diversity is often severely altered due to human taste and fashion (Reichard & White 2001). We