



Predator body sizes and habitat preferences predict predation rates in an agroecosystem

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Abstract

Top-down control of pest populations by their natural enemies is a crucial ecosystem service supporting agricultural production. The relationship between predator community composition and predation rates of pests remains poorly investigated. A deeper understanding of the processes shaping interaction strength in agroecosystems is needed if we are to accurately predict natural pest control services. Functional traits in a community can provide insights into processes shaping community assembly and ecosystem functioning. Functional diversity indices can be constructed from a single trait, such as body length, or from the integration of multiple traits, such as body length, hunting mode and habitat preference. However, their performance in predicting ecosystem functioning and services remains largely unexplored. We used empirical data replicated at landscape scales to examine which component of ground-dwelling predator community structure (activity-density, species richness, evenness, taxonomic distinctness and functional diversity) of spiders, carabids and staphylinids best predicted predation rates of aphids in spring cereals. Functional diversity explained a greater part of variation in predation rates than any other taxonomic or activity-density component. Among the indices for functional diversity, single-trait indices better predicted variation in aphid predation rates compared with multiple-trait indices. In particular, we found that the community-average value of body-size of ground-dwelling predators was negatively related to predation rates of aphids, whereas the proportion of spiders with a preference for arable land was positively related to predation rates. Additional analyses of body-size distributions of ground-dwelling predators suggested that intraguild predation was a key process shaping the relationship between predator community composition and the level of aphid pest control. Considering the functional trait composition of communities provides a more mechanistic understanding of the processes shaping the strength of trophic interactions in terrestrial ecosystems, thus improving predictive power. Body-size distribution and habitat preference appear to be particularly valuable in predicting the level of natural pest control by ground-dwelling predators in an agroecosystem.

Zusammenfassung

Die Schädlingsbekämpfung durch natürliche Feinde ist eine wichtige ökosystemare Dienstleistung und trägt positiv zur landwirtschaftlichen Produktion bei. Der Zusammenhang zwischen der Zusammensetzung von Räubergemeinschaften und der

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Frassleistung an Schädlingspopulationen ist jedoch wenig untersucht. Ein besseres Verständnis der Prozesse welche Interaktionen zwischen natürlichen Feinden und Schädlingen bestimmen, ist für Vorhersagen von Schädlingskontroll-Leistungen wichtig. Die funktionellen Eigenschaften in Tiergemeinschaften können dabei Einblicke in Prozesse liefern und verschiedene Indizes, welche auf einzelnen oder mehreren Eigenschaften basieren, wurden für die Analyse von Gemeinschaften entwickelt. Beziehungen zwischen diesen Indizes und ökosystemaren Funktionen und Dienstleistungen wurden bisher jedoch nicht ausreichend untersucht. In dieser Studie wurden auf der Landschaftsebene replizierte, empirische Daten verwendet um Beziehungen zwischen der Gemeinschaftsstruktur (Aktivitätsdichte, Artenzahl, Äquität, taxonomische Verschiedenheit und funktionelle Diversität) von Spinnen, Lauf- und Kurzflügelkäfern und Frassleistungen an Blattlauspopulationen zu untersuchen. Die funktionelle Diversität erklärte den höchsten Anteil der Variation der Frassleistung und Indizes welche auf einzelnen Eigenschaften basierten waren dafür besser geeignet als multivariate Indizes. Der für Abundanzen von Räuber-Arten gewichtete Körpergrößenindex stand in einer negativen Beziehung zur Frassleistung an Blattläusen. Gemeinschaften mit einem hohen Anteil von Spinnen, die Agrarhabitate präferieren, zeigten eine hohe Frassleistung an Blattläusen. Zusätzliche Analysen der Körpergrößenverteilung in Räubergemeinschaften deuten außerdem darauf hin, dass Intragilde-Prädation ein wichtiger Prozesse, für die Bestimmung der natürlichen Kontrolle von Blattlauspopulationen ist. Eine Berücksichtigung der funktionellen Eigenschaften in Räubergemeinschaften ermöglicht ein verbessertes, mechanistisches Verständnis der Prozesse welche trophische Interaktionen in terrestrischen Ökosystemen beeinflussen. Sowohl die Berücksichtigung von Körpergrößenverteilungen als auch von Habitat-Präferenzen sind von besonderer Bedeutung für die Vorhersage der Schädlingskontroll-Leistung durch laufaktive generalistische Prädatoren im Agrarland.

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Introduction

Global biodiversity is increasingly threatened by environmental changes such as climate change or land use intensification (Tylianakis, Laliberté, Nielsen, & Bascompte, 2010; Tschamtko, Klein, Krüss, Steffan-Dewenter, & Thies, 2005). Rapid rates of biodiversity loss have been observed for several taxa around the globe (Pereira, Navarro, & Martins, 2012). Agricultural production depends on ecosystem services such as pollination, biological control, nutrient retention, and regulation of water flows (Bommarco, Kleijn, & Potts, 2013). Although these services are mediated by communities of beneficial organisms, it is not well understood how changes in communities will affect ecosystem functioning and services. Understanding the consequences of altered communities for ecosystem functioning and delivery of ecosystem services is an unresolved challenge for ecologists.

A number of studies have demonstrated a positive relationship between species richness and the rate, or the stability, of ecosystem functioning (Cardinale et al., 2012). However, not all species contribute equally to ecosystem functions and an increasing amount of evidence indicates that taking community composition in terms of relative abundance and functional traits into account can provide major insights on processes shaping emergent functions of assemblages (Cadotte, Carscadden, & Mirotnick, 2011; Hillebrand, Bennett, & Cadotte, 2008). The increased interest for functional approaches has led to the development of several metrics to quantify the multidimensionality of functional

diversity (Ricotta & Moretti 2011; Villéger, Mason, & Mouillot, 2008). Functional composition of a community is often analysed using either indices related to individual traits, or by composite indices combining information about multiple traits (Ricotta & Moretti 2011; Villéger et al., 2008). The latter are increasingly used in studies of community assembly (Villéger, Miranda, Hernández, & Mouillot, 2010; Flynn et al., 2009), whereas single-trait indices are largely used in studies that examine the effect of functional composition on a particular ecosystem function or service (Lavelle et al., 2011; Díaz et al., 2007). Moreover, the hypothesis that the evolutionary history of species within a community captures main differences in trait composition, such that phylogenies can be used as a proxy for functional diversity, has recently received attention (Cadotte et al., 2011; Flynn, Mirotnick, Jain, Palmer, & Naeem, 2011). The potential for these indices to predict a particular ecosystem function or service remains, however, poorly studied (but see Flynn et al., 2011).

Top-down control of pest populations by their natural enemies is an important ecosystem service that supports agricultural production (Losey & Vaughan, 2006). A recent meta-analysis showed that positive relationships between predator species richness and prey suppression are likely to occur in agricultural ecosystems (Letourneau, Jedlicka, Bothwell, & Moreno, 2009). These positive relationships emerge from niche complementarity among predator species, such as predation occurring at different times in the season, or facilitation between species. However, negative or neutral relationships due to antagonistic interactions such as intraguild predation also appear in a non-negligible proportion of cases

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