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Linking species assemblages to environmental change: Moving beyond the specialist-generalist dichotomy

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Abstract

Environmental changes due to land use developments, climate change and nitrogen deposition have profound influences on species assemblages. Investigating the dynamics in species composition as a function of underlying traits may increase our understanding of ecosystem functioning and provide a basis for effective conservation strategies. Here, I use a broad array of species traits for butterflies to identify four main components of associated traits. These reflect the spatial use of the landscape, abiotic vulnerability, developmental rate and phenology, and food specialisation, respectively. The first three trait components each contribute to determine Red List status, but only the developmental rate and phenology component is related to recent population trends. I argue that the latter component reflects the environmental impact of nutrient availability and microclimate, as affected by nitrogen deposition. This perspective sheds a new light on ongoing changes in community composition. Thus, a multidimensional view of trait associations allows us to move beyond the simplistic specialist–generalist dichotomy, renew our view on species-specific studies and help in setting new priorities for conservation.

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Zusammenfassung

Änderungen der Umweltbedingungen durch Entwicklungen bei der Landnutzung, durch Klimawandel und Stickstoffeintrag haben grundlegende Auswirkungen auf Artengemeinschaften. Die Untersuchung der Dynamik der Artenzusammensetzung als eine Funktion der zugrundeliegenden Eigenschaften der Arten können helfen, Ökosystemfunktionen besser zu verstehen und bieten eine Basis für effektive Naturschutzstrategien.

Hier nutze ich ein weites Spektrum von Arteigenschaften von Schmetterlingen um vier Hauptkomponenten von verbundenen Merkmalen zu identifizieren. Diese repräsentieren die (1) räumliche Nutzung der Landschaft, (2) die Gefährdung durch abiotische Faktoren, (3) Entwicklungsgeschwindigkeit und Phänologie sowie (4) die Nahrungsspezialisierung.

Die ersten drei Merkmalskomponenten tragen jeweils dazu bei, den Rote-Liste-Status einer Art zu bestimmen, aber nur die Komponente Entwicklungsgeschwindigkeit und Phänologie ist mit rezenten Populationstrends verknüpft.

Ich vertrete die Auffassung, dass die letzte Komponente den Umwelteinfluss von Nahrungsverfügbarkeit und Mikroklima widerspiegelt, wie er von Stickstoffeinträgen beeinflusst wird.

Dieser Perspektivaufsatz wirft ein neues Licht auf gegenwärtige Änderungen der Gemeinschaftszusammensetzung. Somit erlaubt uns eine multidimensionale Betrachtung von Merkmalsverbünden, über die vereinfachende Spezialist-Generalist-Dichotomie hinauszugehen, unseren Blick auf artspezifische Untersuchungen zu erneuern und neue Prioritäten für den Naturschutz zu setzen.

Keywords: Community ecology; Species traits; Land use; Climate change; Nitrogen deposition; Conservation; Butterflies

Introduction

Loss of biodiversity has been identified as one of the key processes ultimately threatening planet Earth as a safe operating space for humanity (Rockström et al. 2009). Biodiversity changes are driven by a range of anthropogenic environmental changes, amongst which changes in land use, climate and nitrogen deposition have been identified as the three most important (Sala et al. 2000).

The process of declining biodiversity is not only a matter of a loss of individual species. It is also accompanied by changes in species assemblages (Brose 2010). These changes can be understood as the result of declines and extinctions of species with narrow ecological niches that are vulnerable to environmental change and colonisations and increases of species with broad ecological niches that are tolerant to the changing conditions. The first group is commonly termed as specialists and the second group as generalists (Townsend, Begon, & Harper 2003). The result of increasing generalists and decreasing specialists has been included as one of the drivers – besides the spread of invasive exotic species – of 'biotic homogenisation' (Mccune & Vellend 2013), i.e. the increasing similarity of regional species pools (McKinney & Lockwood 1999; Olden & Rooney 2006).

The use of the specialist–generalist dichotomy has become increasingly popular, with over 50% of 839 relevant articles published in the last four years (www.scopus.com; search on specialist species or generalist species in December 2013). However, it may also give rise to confusion, because it remains unclear which characteristics govern the inferred specialisation or lack thereof. The specialisation is typically seen as one involving habitat type (e.g., Warren et al. 2001), rather than food resource, but this only begs the question which habitat conditions and associated species traits then should be considered. Although there is also a clear tendency to view changes in species communities as a function of species traits (Garnier et al. 2007; Koh, Sodhi, & Brook 2004; Mayfield et al. 2010; Tilman 1999), this still is often limited to a narrow set of traits, such as dispersal capacity (see Travis et al. 2013), that fail to capture the multidimensional life history of a species (Hillebrand & Matthiessen 2009). A practical reason for this narrow approach often lies in the lack of data on a broad spectrum of species characteristics. Another is the challenge to deal with the complexity of multiple trait analyses.

Here, I develop a new perspective on linking species assemblages to environmental change using butterflies as a focal group. Butterflies are well-suited for several reasons (Thomas 2005). First, they constitute a sufficiently species-rich group to examine trait variation across a variety of environmental conditions. Second, their biology, ecology but also their distribution and population trends are comparatively well-known (at least in northwestern Europe). And third, their short life cycle implies a short response time to influential environmental changes. In this paper, I will first use a broad selection of species traits to identify main associations of species traits through principal component analysis. Next, these trait components are linked to species occurrence and population trends. This approach has been followed before (see Pavlikova & Konvicka 2012; Shreeve, Dennis, Roy, & Moss 2001; Summerville, Conoan, & Steichen 2006), but we are only beginning to explore the final step: putting these trait-based trends in a broad context of environmental change. The resulting insights