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Biogeography and ecology of endemic invertebrate species in Austria: A cross-taxon analysis

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Abstract

Austria supports a considerable number of endemic invertebrate species, but a cross-taxon analysis is currently lacking. Based on a recent national inventory, we analysed distribution patterns, ecology and conservation biogeography of 361 endemic species and subspecies (beetles: 174 taxa; butterflies and moths: 34 taxa; caddisflies: 16 taxa; snails: 80 taxa; spiders and harvestmen: 57 taxa) within Austria. Endemic species were very unevenly distributed with highest numbers of endemic species found in the North-eastern Calcareous Alps followed by the Southern Alps and the easternmost Central Alps. The location of hot spots (=grid cells of c. 35 km^2 size with highest endemic species numbers) varied substantially between taxonomic groups. The range size of endemic invertebrate taxa was skewed towards very narrow distributions – 222 taxa are restricted to <10 grid cells (total area c. 350 km^2), of which 71 taxa were known from a single grid cell only. Between taxonomic groups we found substantial differences in elevation distribution. Whereas beetles and butterflies and moths were most species-rich at high elevations (1900–2000 m a.s.l.), caddisflies (1000–1200 m) and snails (400–500 m) were most species-rich at mid to low elevations. Endemics associated with different broad habitat types differed markedly in average range size, endemics of habitats with limited and patchy distribution (caves, springs) had the smallest ranges. The endemic taxa of the five groups showed substantial differences in their habitat association. We found a strong positive correlation of range size with elevation range, whereas the number of habitats colonized was only weakly associated with range size. Thus, different features of niche breadth differed in their correlation with endemic species range sizes. Finally, we found that the conservation status of Austrian endemics is poor since 54% of the

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endemic species are nationally red-listed. Thus, a dedicated conservation strategy is urgently needed to conserve the endemic fauna of Austria.

Zusammenfassung

In Österreich kommen zahlreiche endemische Wirbellosenarten vor, eine vergleichende Analyse fehlte allerdings bislang. Auf Grundlage eines aktuellen nationalen Inventars werden die Verbreitungsmuster, Ökologie und Naturschutz-Biogeographie von 361 endemischen Arten und Unterarten (Käfer: 174 Taxa; Schmetterlinge: 34 Taxa; Köcherfliegen: 16 Taxa; Schnecken: 80 Taxa; Spinnen und Weberknechte: 57 Taxa) in Österreich analysiert. Die höchsten Endemiten-Zahlen wurden in den Nordöstlichen Kalkalpen festgestellt, gefolgt von den Südalpen und östlichsten Zentralalpen. Die Lage der Hotspots variiert deutlich zwischen den taxonomischen Gruppen. Sehr kleine Areale überwiegen bei den endemischen Tierarten–222 Taxa sind auf unter 10 Rasterfelder (Fläche unter 350 km^2) beschränkt, von denen 71 Taxa nur aus einer Rasterzelle (unter 35 km^2) bekannt sind. Die Höhenverbreitung unterscheidet sich zwischen den Gruppen, wobei Käfer und Schmetterlinge einen Vorkommensschwerpunkt in hohen Lagen haben (1900–2000 m NN), Köcherfliegen (1000–1200 m) und Schnecken (400–500 m) hingegen in tieferen Lagen. Endemiten mit unterschiedlich breiter Habitatbindung haben unterschiedliche Arealgrößen, wobei Endemiten von räumlich begrenzten und zerstreut vorkommenden Habitaten (Höhlen, Quellen) die kleinsten Arealgrößen aufweisen. Die Endemiten der fünf taxonomischen Gruppen zeigen deutliche Unterschiede in ihrer Habitatbindung. Die Arealgröße korreliert stark positiv mit der Höhenverbreitung, während sie nur schwach mit der Zahl der besiedelten Habitate korreliert ist. Unterschiedliche Eigenschaften der Nischenbreite korrelieren demnach unterschiedlich eng mit der Arealgröße. Der Gefährdungsgrad der Endemiten Österreichs ist alarmierend hoch, rund 54% der Taxa befinden sich auf der nationalen Roten Liste. Wegen dieser hohen Gefährdung ist eine gezielte Schutzstrategie dringend erforderlich, um die einzigartige Fauna Österreichs zu erhalten.

Keywords: Cross-taxon comparison; Endemism; European Alps; Hot spot; Niche breadth; Range size

Introduction

Endemics, taxa restricted to a given area (Gaston 1994), are a region's unique contribution to global biodiversity. The geographical distribution of endemic species is strongly shaped by the interaction of historic and current environmental conditions. These factors include climate and edaphic variables, topography, size and spatial arrangement of resulting habitats (Gaston 1994; Rosenzweig 1995). In temperate regions, climate history (*e.g.* Ice Ages) has strongly shaped the current distribution of endemics (Hewitt 2000; Jansson 2003; Essl, Dullinger, Plutzar, Willner, & Rabitsch 2011). In the European Alps, Pleistocene climatic fluctuations with recurrent glaciations of large areas (Van Husen 1987) resulted either in survival of taxa in disjunct refugia or extinction (Holdhaus 1954; de Lattin 1967; Hewitt 1996; Taberlet, Fumagalli, Wust-Saucy, & Cosson 1998; Tribsch & Schönswetter 2003; Schönswetter, Stehlik, Holderegger, & Tribsch 2005). In addition to environmental factors, biotic interactions, species traits and ecology are also important in determining taxon distributions. As life cycle, dispersal limitation, and ecological requirements differ strongly among species and different taxonomic groups, it is to be expected that their resulting biogeographic patterns will also differ (Dullinger et al. 2012).

Analyses of endemism patterns are mostly based on few well-studied taxonomic groups (vascular plants, vertebrates) (*e.g.* Kier et al. 2009). However, patterns found to be valid for these taxonomic groups will not necessarily hold for invertebrates, which contribute most to animal species diversity and include the majority of endemic species (Essl, Rabitsch, Dullinger, Moser, & Milasowszky 2012; Essl et al. 2013). A comprehensive understanding of the distribution of all endemic species can identify hotspots where 'multiple' endemic species from various taxonomic groups can be found and so inform conservationists on where to prioritize conservation efforts (Mittermeier, Turner, Larsen, Brooks, & Gascon 2011; Schmitt 2011). This is also a prerequisite for further analyses of the extinction risks from climate and land-use changes. Endemic species are especially vulnerable to these pressures because they often have small range and population sizes, and sometimes low genetic diversity and specific habitat requirements (Dirnböck, Dullinger, & Grabherr 2003; Thomas et al. 2004; Malcolm, Liu, Neilson, Hansen, & Hannah 2006; Dirnböck, Essl, & Rabitsch 2011; Ochoa-Ochoa, Bezaury-Creel, Vázquez, & Flores-Villela 2011).

Endemic range sizes in Austria vary from very narrowly distributed steno-endemics to relatively widespread species (*e.g.* species of several mountain chains within the European Alps). It has been argued that ecological plasticity is positively correlated with species range size (*e.g.* Gaston, Blackburn, & Lawton 1997). However, it remains unclear if such a relationship plays an important role for range restricted species in highly heterogeneous mountainous environments, which offer a broad spectrum of habitats and elevation belts within a small area. In addition, if endemic species are strongly dispersal limited – as may be the case for many