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Genera as surrogates of bryophyte species richness and composition

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ABSTRACT

Surrogates offer quick and cost-efficient solutions to assess and monitor biodiversity. In this study we have tested higher taxa surrogates, particularly genera richness and composition as surrogates for bryophyte species richness and composition, in two different habitats (exposed rock outcrops and watercourses), across two spatial scales (local and micro scale), in central and northern Portugal. Furthermore, we have also tested the influence of environmental variables on the richness and composition of species and genera. Our results showed significant and positive relationships between species and genera richness and composition for the habitats and scales studied. Also, concerning the analyzed scales analyzed, correlations between species and genera richness, as well as species and genera composition, were found to be positive and significant. Moreover, the environmental variables tested influenced species and genera richness and composition in the same way. In conclusion, the higher taxa approach could be an effective method for a rapid assessment and monitoring of bryophytes in the studied area, for the habitats and scales considered.

1. Introduction

Nowadays, assessing and monitoring biodiversity is an important task in conservation biology, but species' surveys are expensive and, time-consuming and experts are needed (Mandelik et al., 2007). Recently, surrogates have become increasingly explored as a prompt solution to monitor habitats or ecosystems and as a cost-efficient means of detection of changes in biodiversity (Mazaris et al., 2008).

According to Grantham et al. (2010) surrogates include known taxonomic groups, umbrella species, focal species, species assemblages, and other ecological classifications so as to represent patterns of biodiversity such as richness, and composition. Biodiversity surrogates can be coarsely divided into environmental variables and taxonomic surrogates (Grantham et al., 2010). Taxonomic surrogates include: (1) cross taxa – one group of taxa is used as surrogate of another group (Chiarucci et al., 2007); (2) morphospecies – taxa separated based on their morphological characters are used as surrogates (Derraik et al., 2010); (3) higher taxa – information on higher taxonomic levels (e.g. genera, families or orders) is used rather than species (Gaston and Williams, 1993). For taxonomic surrogates, stronger associations might be provided when surrogates are from phylogenetically related groups, as they will more likely share climatic requirements (Bergamini et al., 2005) – which, in the higher taxa approach, is easily achieved. In fact, niche conservatism, i.e. the share of ecological niches between closely related species, can be measured as the percentage of variance among extant species that can be explained at higher taxonomic levels – however, in the case of no conservatism, the variance would only be explained at the species-level (Prinzing et al., 2001).

Surrogacy is an important condition in the context of biodiversity monitoring, conservation and management. Although higher taxa are not natural units, they tend to comprise species that are closely related and, therefore, they can be used as parcels of species' richness that are easier to analyse (Gaston, 2000). Some premises of the higher taxa approach are particularly relevant: (1) in the same location there are fewer genera than species; (2) sampling effort and identification of genera is less time-consuming than the species'; (3) distribution of species within genera is relatively homogenous (i.e., most genera include few species and only a few contain numerous species); (4) using higher taxa leads to less misidentifications, because higher taxa are usually easier to distinguish than species;(5) the use of higher taxa facilitates the achievement of a quicker and a more complete inventory in the field, and (6) identifying higher taxa is less dependent of some phenophases than the identification of species (e.g. some species of bryophytes of the studied habitats are extremely difficult if not impossible to identify when sterile – e.g.: *Schistidium* spp.,

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Andreaea spp., *Brachythecium* spp., *Riccia* spp.) (Mandelik et al., 2007; Prinzing et al., 2003; Vieira et al., 2012d).

Since species richness is often taken as an important measure in nature conservation (Bergamini et al., 2005), the higher taxa approach has been tested as a surrogate for species richness for a number of taxa such as ants, beetles, flies, arachnids, angiosperms, birds, mammals, and mussels (Andersen, 1995; Báldi, 2003; Balmford et al., 1996; Doerries and Van Dover, 2003).

Because species richness describes only a part of biodiversity, it is important to take into account species composition in order to describe patterns and changes in biodiversity. Moreover, species richness cannot be used to design reserve networks or to detect changes in community composition (Bergamini et al., 2005). Besides, at local scale, biological variation may lie in the composition instead of in species richness, thus encouraging the protection of areas with complementarity sets instead of solely species-rich sites (Mandelik et al., 2007). So far, few studies have tested the usefulness of the higher taxa approach to describe patterns in the compositional turnover of species (Prinzing et al., 2003; Smale et al., 2010; Terlizzi et al., 2009).

Heino (2014) argued that genus-level data should have a similar degree of community composition heterogeneity and a similar environmental variation to species-level data. However, that study found that that is not always the case. Indeed, in this study the environmental variables that determined the higher taxonomic ranks were slightly different. A number of studies on the higher taxa approach analysed the influence of environmental variables on both species and genera richness. In these studies, the aim was to test if environmental variables influence both genera and species in the same way (Cardoso et al., 2004; Heino and Soininen, 2007; Hill et al., 2001; Vieira et al., 2012d). Some testing has been done for environmental variables like chemical variables (i.e. pH), hydraulic variables (i.e. current velocity) (Heino and Soininen, 2007), geographical location (Cardoso et al., 2004), vegetation cover (Vieira et al., 2012d). However, the higher taxa approach analysing the influence of environmental variables on both species and genera richness was only applied to organisms such as macroinvertebrates, spiders, and wasps, but, to the best of our knowledge, it has never been applied for bryophytes.

According to previous studies (Gaspar et al., 2010; Mac Nally et al., 2004), spatial scale is an important factor to be considered when establishing the higher taxa approach since species richness and composition are scale dependent and the surrogacy could be affected by this variable. Measures of co-occurrence of species are strongly scale-dependent because of the spatial distribution in natural areas, and the spatial grain in which the species are collected and reported. Furthermore, the scale at which species occurrence or higher taxa data are collected and reported can bias co-occurrence estimates (Favreau et al., 2006; Gaspar et al., 2010). Many studies have shown that, from regional to continental scales, higher taxa can be used as surrogates for species richness patterns (Ferla et al., 2002; Larsen and Rahbek., 2005; Mac Nally et al., 2004). At local-scale, this approach has rarely been studied for terrestrial ecosystems and more studies, for different taxonomic groups, are still needed, since general conclusions cannot be extrapolated from regional to local or micro scales (Mandelik et al., 2007).

In this study we have considered the following questions: (1) can bryophyte species richness be predicted by genera richness?; (2) can the higher taxa surrogacy approach reflect the difference between species composition in different geographical locations?; (3) how is the effectiveness of higher taxa surrogacy approach affected by different habitat types and scales?; and (4) how are species' and genera' richness and composition influenced by environmental variables?

In order to tackle these questions, we have tested if genera richness and composition could act as an effective surrogate of bryophyte species richness and composition patterns with two datasets collected from different habitats – exposed rock outcrops and watercourses – in northern and central Portugal. In both habitats, there are no genera with large numbers of species and most of the taxa correspond to species whose identification relies on microscopic features, many impossible to verify in the field. This combination of factors makes these two habitats ideal for testing the higher taxa surrogacy approach. Furthermore, we have tested the influence of several environmental variables at the local and micro scales in both species and genera richness and composition.

2. Methods

2.1. Datasets

Taxonomic data at the species level was collected from exposed rock outcrops between March 2005 and April 2007 in northern and central Portugal (Hespanhol et al., 2010). A total of 98 localities were sampled in 11 Natura 2000 Network Sites (Fig. 1A). Localities were selected according to the extent and altitudinal variation of each Natura 2000 Network Site. On each selected rock outcrop, an area of 100 m^2 was selected arbitrarily and ten sample plots were recorded in the three different microhabitat types (rock surfaces, cavities and fissures) identified at each sample site, in order to represent the whole ecological and floristic variation within each sample site as well as possible. The plots had an area of 625 cm^2 and their shape was adapted for each microhabitat (25 cm × 25 cm for rock surfaces and 50 cm × 12.5 cm for fissures and cavities). All bryophyte species

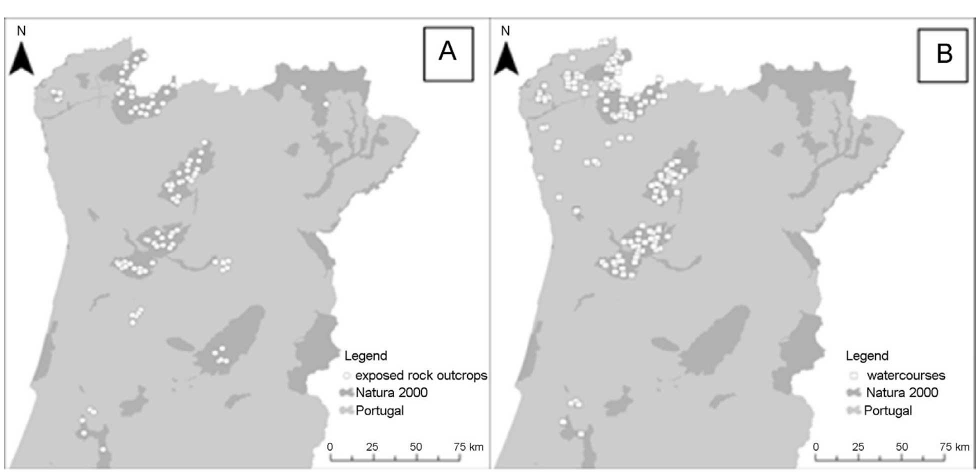

Fig. 1. Distribution of bryophyte survey localities for two habitats. (A) Exposed rock outcrops; (B) watercourses.