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Cross-taxon congruence in wetlands: Assessing the value of waterbirds as surrogates of macroinvertebrate biodiversity in Mediterranean Ramsar sites

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ABSTRACT

Wetlands are among the most threatened habitats and the species they support among the most endangered taxa. Measuring and monitoring wetland biodiversity is vital for conservation, restoration and management, and often relies on the use of surrogate taxa. Waterbirds are commonly used as flagships of biodiversity and are the subject of major conservation initiatives. Therefore, it is important to assess the extent to which waterbirds indicate the general biodiversity of wetlands and serve as surrogates.

We explore the relationships between community composition and species richness of waterbirds and aquatic macroinvertebrates in 36 Ramsar wetlands in southern Spain to assess if waterbirds are good surrogates for other taxonomic groups. Specifically, we aimed to (i) test the congruence of patterns of species composition and richness among waterbirds and aquatic macroinvertebrates; and (ii) investigate which environmental variables are associated with the biodiversity patterns of waterbirds and macroinvertebrates, with the purpose of identifying key factors explaining potential discordance in these patterns.

We found a limited concordance between assemblage patterns of both taxonomic groups that may be related to their contrasting responses to environmental gradients. Assemblages of waterbirds appear to be more affected by climate variables and water surface area, whereas conductivity was the most important factor influencing macroinvertebrate communities. Furthermore, we found a negligible or inverse relationship in their patterns of richness, with wetlands with higher waterbird species richness showing significantly lower richness of Hemiptera and macroinvertebrate families, and no significant relationship with Coleoptera. In addition, GLM models showed that, in general, different environmental variables are related with the richness patterns of the different taxonomic groups.

Given the importance of the Ramsar convention for the conservation of an international network of wetlands, our findings underline the limited potential of waterbirds as aquatic biodiversity indicators in Mediterranean wetlands, and the need for caution when using waterbirds as flagships. An integrative analysis of different biological communities, using datasets from different taxonomic groups, is a necessary precursor for successful conservation policies and monitoring. Our results illustrate the need to create a diversified and complete network of protected sites able to conserve multiple components of wetland biodiversity.

1. Introduction

Wetlands are among the most threatened habitats and the species they support among the most endangered taxa (Millennium Ecosystem Assessment, 2005). These aquatic ecosystems are

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considered one of the most important to protect, due to the ecosystem services they provide and the threats they face (Costanza et al., 1997; Junk et al., 2013). Wetlands located in Southern Europe are of special interest due to the biodiversity hotspot in the Mediterranean Basin (Myers et al., 2000) and the strong anthropogenic pressures they suffer (e.g., Ortega et al., 2004). Furthermore, they are expected to suffer acutely from reduced water supply due to global change (Cížková et al., 2013).

Despite the threats affecting freshwater ecosystems, conservation efforts for freshwater biodiversity are constrained by the lack of complete and reliable information for a number of geographic areas, habitat types and taxonomic groups (Dudgeon et al., 2006). Hence, measuring and monitoring biodiversity is a crucial task for conservation or restoration of inland waters in general, and wetlands in particular. Surveying biodiversity presents difficulties associated with limited time and financial resources and often requires a large degree of expertise. Broad-scale assessments of biodiversity often rely on the use of surrogate taxa which show strong relationships with the biodiversity of other target groups, are taxonomically and ecologically well- understood, easily monitored and occur in a range of habitat types (see Rodrigues and Brooks, 2007 for a review). Therefore, the extent to which a particular taxonomic group represents the biodiversity content of a particular ecosystem needs to be assessed as a prerequisite for its use as a surrogate. While the reliability of surrogate or indicator taxa in freshwater systems has been tested in several previous studies for some taxonomic groups (e.g., Bilton et al., 2006; Sánchez- Fernández et al., 2006; see Heino, 2010 for a review), cross-taxon congruence in biodiversity patterns among aquatic invertebrates and vertebrates other than fishes has seldom been assessed.

As taxon richness is probably the main variable used to describe community diversity (Gaston, 1996) most assessments of surrogates basically focus on this aspect (e.g., Velghe and Gregory-Eaves, 2013), while cross-taxon congruence of community structure has received less attention, despite the fact that it can be a useful indicator of how broad conservation strategies can conserve species diversity (Bilton et al., 2006; Su et al., 2004). Hence, further research is necessary to better understand whether patterns of species richness and composition are congruent between taxonomic groups in aquatic ecosystems.

Birds are commonly used as surrogates of biodiversity owing to the wide availability of relevant data on their distribution and status and their broad popular appeal (e.g., Gregory et al., 2003; Gregory, 2006; Eglington et al., 2012). They are the object of many international nature conservation initiatives, such as the worldwide network of Important Bird Areas, and the Special Protected Areas (EU Birds Directive) in Europe. In the case of inland waters, waterbirds usually drive the designation of wetlands of international importance under the Ramsar convention, a global intergovernmental treaty for the conservation and sustainable use of wetlands and their resources (Ramsar Bureau, 2000). This Convention was adopted in 1971 and was initially focussed exclusively on waterbirds (particularly wildfowl, F. Anatidae) as a manner of promoting conservation of migratory bird species and identifying key sites for them (e.g., Kleijn et al., 2014). Although the parties to the convention have since listed many criteria for identifying and designating wetlands of international importance which depend on other aquatic organisms and biodiversity in general (http://www.ramsar.org/cda/en/ramsar-about-faqs-what-are-criteria/main/ramsar/1-36-37%5E7726_4000_ 0_last accessed 7 March 2014) the historical emphasis on waterbirds has been very influential, notably in Europe.

Even though waterbirds play a key functional role in many aquatic ecosystems, with a structuring influence on the communities of invertebrates and macrophytes in wetlands (Green and Elmberg, 2014), their reliability as surrogate taxa in these habitats remains to be tested. Some previous studies have focused on the relationship between communities of waterbirds and plants (Green et al., 2002), zooplankton (Green et al., 2005) or fishes (Paszkowski and Tonn, 2000). Nevertheless, very few studies are available on the congruence in the diversity patterns of waterbirds and macroinvertebrates (but see Rooney and Bayley, 2012).

As important components of wetland biodiversity, aquatic macroinvertebrates and waterbirds are related to each other through trophic webs (e.g., Tománková et al., 2014) and dispersal interactions (Green and Figuerola, 2005), and both of them are widely subjected to various ecological, biomonitoring and conservation studies. Waterbirds have been tested as indicators of aquatic ecosystem conditions (e.g., Kingsford, 1999), while aquatic macroinvertebrates have been used extensively as indicators for wetland conservation (e.g., Boix et al., 2005) and increasingly as tools for the assessment of freshwater biodiversity and conservation priorities (Bilton et al., 2006; Ormerod et al., 2010).

In the present study we examine the concordance in the patterns of community composition and species richness across waterbirds and aquatic macroinvertebrates in Ramsar wetlands of southern Spain, in order to assess if waterbirds can be a potential surrogate for predicting diversity of other taxonomic groups in wetlands. Ramsar wetlands are good candidates to investigate the cross-taxa congruence in biodiversity patterns because of their relatively good conservation status. Furthermore, they include all the most important wetlands for waterbirds in southern Spain. In this framework we aimed to: (i) test the congruence of patterns of species composition and richness among waterbirds and aquatic macroinvertebrates; and (ii) investigate the environmental variables associated with the biodiversity patterns of waterbirds and macroinvertebrates, with the purpose of identifying key factors explaining potential discordance in these patterns.

2. Methods

2.1. Study area

In Spain, 74 wetlands are designated as Ramsar sites, covering a total of 303,090 ha (as of June 2014). Andalusia represents the region of Spain with the largest Ramsar protected area and the highest number of Ramsar sites (25), including a mosaic of different wetland types ranging from coastal lagoons to riverine and floodplain systems, and permanent or temporal inland lakes and marshes.

The present study was conducted in 36 wetlands included within the 25 Ramsar sites of Andalusia (SW Spain) (Fig. 1, Appendix A). All the studied Ramsar wetlands are also protected areas under regional, national and/or other European legislation (Directive 92/43/ECC and Directive 79/409/EEC) and three of these wetlands (Doñana, Odiel marsh and Cabo de Gata) are also MAB protected areas (UNESCO Biosphere Reserves).

The size of studied Ramsar site ranges from 35 to 15,246 ha while the mean altitude of wetlands ranges from the sea level to 798 m.a.s.l. According to the freshwater ecoregions of the world proposed by Abell et al. (2008), all the Andalusian wetlands belong to the Southern Iberia region. Climate is conditioned by westerly winds from the Atlantic Ocean and the Mediterranean influence, while rain distribution throughout the year is determined by the Azores High behavior (Rodrigo et al., 1999). Due to its strategic geographical position, this region represents an important bridge between Europe and Africa and a large number of migratory waterbirds move through SW Spain and Morocco (Rendón et al., 2008). One of the sites, Doñana, is one of the two most important wintering sites in Europe for waterbirds (Rendón et al., 2008). The importance of this region is also reflected by how the conservation of waterbirds in Spain can have positive consequences for the