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Cuckoo and biodiversity: Testing the correlation between species occurrence and bird species richness in Europe

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ABSTRACT

The use of biodiversity surrogates is an increasingly popular tool, because it provides strong results while reducing the costs of conservation studies. Here, we hypothesize that cuckoo (*Cuculus canorus*) occurrence may correlate with high bird species richness based on the assumption that their presence should mirror the richness of their potential avian hosts and the overall bird community. Specifically, we assessed the association between species occurrence and taxonomic diversity patterns on a multi-spatial scale using datasets from seven European countries. Our results show that high bird species richness is a good proxy for cuckoo occurrence, and the best results were based on data from point counts. The species was almost absent at sites with low species richness, suggesting that the presence of cuckoo is an appropriate surrogate of bird biodiversity. The accuracy of the models ranged from 0.68–0.71 (for large spatial scale) to 0.86 (for local spatial scale) and provided valuable indications of bird taxonomic diversity distribution on all different types of environments monitored in each country. These associations are possibly related to co-evolutionary relationships with host species (correlated with overall species richness) and the cuckoo's preference for sites that are attractive to many other bird species, due to high habitat diversity or abundant food resources. Our findings highlight how conservation planners can use cuckoo occurrence as a surrogate to maximize efficiency when studying bird species richness patterns. These results also demonstrate the advantages of using the cuckoo rather than top predators as a potential surrogacy tool for citizen scientist programs.

1. Introduction

Conservation planning and management strategies are fundamentally based on spatial information of biodiversity distribution (Margules and Pressey, 2000; Rodrigues and Brooks, 2007; Wiens et al., 2008). Biodiversity has a critically important role in the conservation of ecosystem function, and biologists and managers now recognize that species conservation involves more than simply observing the presence of threatened species (Clark et al., 2014; Geiger et al., 2010; Schwartz et al., 2000; Sol et al., 2014). While different facets of biodiversity are recognized (i.e. phylogenetic, taxonomic, and functional diversity) (Devictor et al., 2010; Zupan et al., 2014) in space and time (Baselga, 2010), species richness remains one of the most important and widely used measures for quantifying biological diversity on Earth. Species richness is also considered a basic surrogate for more complex concepts of ecological diversity and has been successfully applied to assess

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the habitats of different taxa (Boch et al., 2013; Freemark et al., 2006; Maes et al., 2005; Magurran, 2004; Thomas and Mallorie, 1985; Young et al., 2013). Furthermore, many criteria used to study sustainable agriculture practices are based on species richness, alone or in combination with the occurrence of specialist species (Andersson and Lindborg, 2014).

Nevertheless, the study of species richness requires a particularly complex methodology and significant investments of time, effort, and funds. Therefore, an effective indirect method that would suitably account for species richness would be useful (Yoccoz et al., 2001). The use of surrogates to identify hotspots of species richness is a common practice in conservation biology (Carrascal et al., 2012; Roth and Weber, 2008; Sattler et al., 2014; Sergio et al., 2005). Priority areas for conservation are often designed based on the distribution of biodiversity surrogates or bioindicators (Larsen et al., 2012). There are several advantages associated with surrogate use in ecological studies, including the ability to simplify, represent, and assist in complex system management (Lindenmayer et al., 2014); the ease of use, which reduces monitoring costs (Rodrigues and Brooks, 2007); and the predictive capacity for modelling (Mellin et al., 2011). In brief, surrogates can be divided into two main categories (Grantham et al., 2010): (1) taxonomic or biotic surrogates and (2) environmental surrogates. Taxonomic surrogates are based on biological data, for example, as a species or groups of species. Environmental surrogates are typically abiotic parameters such as climate (temperature, precipitation, solar radiation), elevation, soil type (Garnier-Géré and Ades, 2001; Sarkar et al., 2005), and various landscape metrics including measures of spatial heterogeneity (Batáry et al., 2010; Morelli et al., 2013; Schindler et al., 2015).

Cross-taxon surrogates are substantially more effective than surrogates based on environmental data (Rodrigues and Brooks, 2007). Among the recent candidates considered as taxonomic surrogates of species diversity, birds are among the most used. They are widely distributed and can be readily identified with numerous monitoring schemes (Kissling et al., 2012; Larsen et al., 2012). Top predators are a good example of bird species that can be used as surrogate bioindicators of species richness. They are one of the best documented avian indicators in terms of both potential and limitations (Cabeza et al., 2007; Kéry et al., 2007; Roth and Weber, 2008; Sergio et al., 2008). The effectiveness of biodiversity surrogates continues to be debated (Grantham et al., 2010; Marfil-Daza et al., 2013), but it is widely acknowledged that there is a need for more effective and reliable surrogates in conservation biology. Species richness patterns could be non-concordant on different spatial scales (e.g. local or regional), thus creating conflicts when establishing goals for conservation plans (Ricketts, 2001) and necessitating a multi-scale approach. Alternatively, other bird species or groups of species may be employed as suitable surrogates for species richness, potentially due to co-evolutionary factors. Because biotic interactions affect species' spatial distributions via several mechanisms such as predation, competition, resource–consumer interactions, host–parasite interactions, mutualism, and facilitation (Bascompte, 2009; van Dam, 2009; Wisz et al., 2013), co-evolutionary considerations may provide insight into the causes of biodiversity distribution (Poulin and Morand, 2005; Thompson, 2005).

The cuckoo *Cuculus canorus* is a brood parasite that exploits the reproductive behaviors of numerous host species to incubate its eggs and raise its chicks (Davies, 2011; Soler et al., 1999; Welbergen and Davies, 2012). As such, these birds have a specific relationship with potential host populations (Stokke et al., 2007; Wesołowski and Mokwa, 2013). Most insectivorous passerines in Europe have an history of interacting with the common cuckoo, and these pairwise interactions possibly indicate tight co-evolution (Krüger et al., 2009). Cuckoos are also characterized by particularly high detectability due to their distinctive and loud vocalisation, which greatly enhances survey effectiveness. The distinctiveness and popularity of its song also make the cuckoo an effective species to encourage people who are not experienced birdwatchers to participate in a wide-scale volunteer survey under the umbrella of citizen science initiatives.

In the present study, we tested the hypothesis that *C. canorus* may serve as an effective taxonomic surrogate for bird species richness based on the assumption that the presence of this avian parasite breeder would mirror the richness of its potential avian host community and the local bird community as a whole. We evaluated this hypothesis by measuring whether cuckoo occurrence is related to sites with greater bird biodiversity in different European countries at both small and large spatial scales. Our primary goal was to demonstrate this as an effective approach for assessing taxonomic biodiversity distribution.

2. Methods

2.1. Study area, spatial scales, and environments

The study was carried out using different datasets on bird species' presence–absence collected in seven European countries (Fig. 1). The data on bird species distribution cover two different spatial scales: (1) local scale, mainly small or medium-size areas (approximately 61.2–3500 km^2) in central Greece, central Italy, western Poland, San Marino Republic, and southern Switzerland (1216 sites in total, Table 1) and (2) large scale (from 78,870 to 671,308 km^2) in France and the Czech Republic (Table 1).

The sampled sites in western Poland (51.73 N, 17.49E) were mainly distributed on farmlands. The sampled sites in central Italy (43.36 N, 12.50E) were largely grassland with shrublands and scattered woodland patches. In San Marino Republic (43.92 N, 12.43E), the sampled sites were distributed on a mosaic of different land-use typologies, with a greater prevalence of agricultural and small- or medium-size woods mixed with urban and peri-urban patches. The sampled sites in the Prefecture of Trikala, Greece (39.82 N, 21.72E) were distributed on intensified agriculture fields with scattered shrubs and few patches of forestal vegetation. The sampled sites in southern Switzerland (46.04 N, 8.92E) were distributed on managed (open) and unmanaged (closed) chestnut forests.

The sampled sites in France were randomly distributed throughout the country and included agricultural landscapes with gradients of management intensity ranging from intensively managed to high nature value (HNV) farmlands. These areas included mosaics of meadows and pastures, arable fields, midfield woodlots of different ages, scattered trees, and discontinuous linear habitats (mainly mixed rows of trees and shrubs).

The transects surveyed in the Czech Republic covered all the main typologies of environments present in the country.

2.2. Bird data collection

Point counts were carried out each month during the 2010 breeding season (April–June) in all countries, except for Switzerland (samples were collected in different survey campaigns during 2006 and 2013) and Greece (surveyed in two campaigns in 2008 and 2010). All points were visited once between 06:00 and 10:00 for 5 min, only during favorable weather conditions without rain or strong wind. Point counts provide highly reliable estimates of relative population density and are a standardized practical method to compare bird communities among habitats and temporal scales (Bibby et al., 1992). All diurnal bird species detected visually and acoustically were recorded. In France, counts were