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Presence of Cuckoo reliably indicates high bird diversity: A case study in a farmland area

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ABSTRACT

Here we studied the occurrence of Cuckoo *Cuculus canorus* and top predators as indicators of biodiversity in agro ecosystems of Western Poland, to identify local hotspots. Bird species richness and land-use diversity were used as measures of biodiversity. The relationship between the presence of Cuckoos and four avian top predators with biodiversity measures were examined using Generalized Linear Mixed Models.

Cuckoos were mainly distributed on sites with greater species richness, but were absent from the low species richness sites, while the top predators were distributed uniformly. The performance of the best models using the presence of Cuckoo was 27% higher than the best models using top predators. Our results highlight the predictive capacity of Cuckoos as an indicator of bird species richness than top predators and the usefulness of this species in biodiversity studies. The cookoo is charismatic, widespread across the main types of landscapes, and is easy to detect from its song. Importantly, our findings propose that cookoo can be used as effective and cheap tool to monitor the high bird diversity in different European countries.

1. Introduction

One of the central themes in ecology is to understand the distribution and the abundance of species, including those that are coevolving (Thompson, 2005). Coevolution is the process by which species specialise in their interactions with one another, and the way in which these specialised relationships results in reciprocal evolutionary changes. For this reason, studies of coevolution can be useful for understanding the causes of biodiversity distribution in the landscape (Poulin and Morand, 2005; Thompson, 2005). The role of biodiversity is crucial for conservation and the functioning of ecosystems (see for example Schwartz et al., 2000). Biodiversity can be studied by focusing on species richness and taxonomic, phylogenetic and functional diversity (Devictor et al., 2010). However, the study of biodiversity is difficult; data can be hard to collect and studies time consuming, and hence costly. Consequently, the use of tools to indirectly estimate an ecosystem may prove helpful. One way of improving the knowledge of biodiversity is to identify its measurable attributes or surrogates (Magurran, 2004; Noss, 1990).

The complexity of ecosystems has led to the development and use of surrogates to simplify, represent, and help manage complex systems. Some have evn described the use of surrogates of biodiversity as a 'holy grail of conservation' (Lindenmayer et al., 2014). However, the effectiveness of surrogates is hard to determine, and despite the considerable importance these ecological tools have for conservation planning, they continue to produce varied and conflicting results (Grantham et al., 2010). For instance, avian top predators have characteristics that could make them suitable as indicators of biodiversity hotspots (Cabeza et al., 2007). The debate about the usefulness of birds other than raptors has reignited in the past ten years (Cabeza et al., 2007; Sergio et al., 2008, 2005). Studies on the association between the occurrence of top predators and biodiversity have been particularly criticized. The criticisms on the use of raptors as charismatic birds as surrogates of biodiversity included methodological biases introduced in the sampling design and low effectiveness of the approach when applied to different environments (i.e., lack of transferability) (Kéry et al., 2007; Roth and Weber, 2008).

The chief characteristics of a reliable surrogate as bioindicator are that it must be: (1) sufficiently sensitive to provide an early warning of change; (2) widely applicable in nature; (3) capable of providing a continuous assessment over a wide range of perturbed

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environmental conditions; (4) independent of sample size; and (5) easy and cost-effective to measure, collect, assay, and calculate. For these reasons, we believe that the Cuckoo *Cuculus canorus* is potentially a good candidate as an indicator in biodiversity studies because is it widespread and common in European agroecosystems (Morelli et al., 2014; Tryjanowski et al., 2011). This species is characterized by the highest rate of detectability (characteristic, with loud vocalizations or songs, which favors surveys), it arrives late in the breeding season and hence has the ability to be distributed relative to the distribution and the abundance of other species that have already started to reproduce (Tryjanowski et al., 2005), and it has a specific relationship with many potential host populations (Stokke et al., 2007; Wesołowski and Mokwa, 2013), which are parasited. Avian brood parasitism is a reproductive strategy by which parasites lay their eggs in the nest of other species, the hosts, which incubate and rear the parasitic offspring (Davies, 2011; Soler et al., 1999).

Hence, we hypothesize that Cuckoos function as better indicators than top predators to study and predict the patterns of bird diversity in an area. The aim of this study was to assess the predictive power of the occurrence of Cuckoos as indicators of bird species richness, and secondly to compare the goodness of fit of predictive models using Cuckoos and the presence of avian top predators on biodiversity estimated as total bird species richness and land use diversity.

2. Methods

2.1. Study area

The study was conducted in the agricultural landscape of Western Poland, near Odolanów (51°34′N, 17°40′E). The study area (141 km^2) is an extensively used agricultural landscape that comprises a mosaic of meadows and pastures (44%), arable fields (42%), midfield woodlots of different ages (6%), and scattered trees and discontinuous linear habitats, mainly mixed rows of trees and shrubs (see details in Hromada et al., 2002).

2.2. Bird data collection

We obtained data on bird species richness and abundance by using five-minutes point counts carried out at 59 sites each month during the breeding season April–June 2009–2012. Every site comprised three points (each as a vertex of a triangle) at a distance of at least 300 m from each other at which observers counted birds from three independent directions (15-min bird count). All counts were performed between half an hour and four hours after sunrise, but only during favorable weather conditions (i.e., no rain or strong wind). Point counts provide highly reliable estimates of relative population density using this recognised, standardized method to compare bird communities among habitats and temporal scales (Bibby et al., 1992). The survey of breeding raptors in the sample sites was performed during the same period, using point counts and, additionally, searching for nests to confirm the presence as breeding species. The raptor species considered in this study as top predators were Buzzard *Buteo buteo*, Goshawk *Accipiter gentilis*, Sparrowhawk *Accipiter nisus* and Kestrel *Falco tinnunculus*. These species were selected because they have already been used in other studies (Sergio et al., 2006, 2005) and because they are well distributed in the study area.

2.3. Biodiversity measures

We used two measures of biodiversity. The first measure was related to the biological diversity of bird species and the second to land use diversity or landscape heterogeneity.

Table 1
List of bird species most used as host by cuckoo *Cuculus canorus* following Wesołowski and Mokwa (2013), relative frequency of parasitation used to rank in this study the sampled sites on the presence of potential hosts.

Specie	Frequency of host (%)
Acrocephalus scirpaceus	32.4
Lanius collurio	16.9
Acrocephalus palustrisa	8.5
Phylloscopus sibilatrix	6.3
Motacilla alba	5.6
Phoenicurus ochruros	4.9
Erithacus rubecula	4.2
Prunella modularis	3.5
Sylvia communis	2.4
Hirundo rustica	2.1
Saxicola rubetra	2.1
Acrocephalus arundinaceus	2.1
Anthus trivialis	1.4
Phoenicurus phoenicurus	1.4
Sylvia curruca	1.4
Troglodytes troglodytes	1.4
Alauda arvensis	1.2
Muscicapa striata	1.2
Turdus merula	1.2
Hippolais icterina	0.7
Phylloscopus collybita	0.7
Motacilla flava	0.7
Sylvia atricapilla	0.7
Sylvia borin	0.7
Sylvia nisoria	0.7

Bird species richness (BSR) was used as a biodiversity measure, because it is a basic surrogate for the more complex concept of ecological diversity (Magurran, 2004; Morelli, 2013). Species richness is the most popular diversity index in ecology and, according to some studies, is a better surrogate of biodiversity or habitat condition than other biodiversity indices (Young et al., 2013). At each site sampled, species richness was calculated as the sum of all recorded bird species.

Land-uses diversity (LUD) is a surrogate of available trophic niches and therefore of potential biodiversity (Kisel et al., 2011). The LUD was calculated using the Shannon-Weaver diversity index, with the formula $H = \Sigma p_i \ln(p_i)$, where the different p_i are the proportions of the different land use types in the area surrounding the sample site within a radius of 100 m. The typologies of land-uses considered in this study were: cultivated, grassland, forest, reforestation, riparian, hedgerows, isolated trees, shrubs, building, roads, railways, rivers and water.

In order to study the birds that the are potential hosts of Cuckoos, host species were counted and then birds were ranked according to the most frequently parasitized species recorded in Poland (Wesołowski and Mokwa, 2013). The rank for the site was calculated as the summatory of values per bird species host (Table 1), after the application of a standardization method to these values from the ‘vegan’ package in R (Oksanen, 2014).

2.4. Statistical analyses

The sampled sites were treated as statistically independent observations because the values of spatial autocorrelation between geographic distance and land use dissimilarity of sites was low (Mantel test $r < 0.12$, $n = 59$ sampled sites, $p > 0.05$) (Manly, 2006). Dissimilarity indices among land use composition at sampled sites were calculated using the “vegdist” function of the ‘vegan’ package for R (Oksanen, 2014), applying the Sørensen index of dissimilarity between pairwise sites for land use composition.

The relationship between the two biodiversity measures (BSR and LUD) measured in this study was quantified by means of a Pearson correlation test.