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Bird diversity in urban green space: A large-scale analysis of differences between parks and cemeteries in Central Europe

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ABSTRACT

Urbanization is a permanent and still continuing expansion of human settlements and is responsible for dramatic changes of natural areas to urban areas. In traditional view, urbanization is often blamed for the loss of biodiversity and biotic homogenization of natural communities. However, for some species, urban areas, can represent suitable environment for life and even enable them to maintain stable and abundant populations. Urban ecosystems are not homogenous; within human settlements we can find several different habitats which can be occupied by species with different tolerance to certain aspects of urban life. This diversity can be exhibited by interhabitat changes in species richness, diversity and abundances of local communities. Here, we investigated biodiversity patterns in bird communities of two urban habitats, parks and cemeteries, in three Central European countries. Data on species richness, diversity and abundances of birds were collected from published papers as well as unpublished sources. Our analyses revealed that bird species richness was positively correlated with area and age of trees in both habitat types. There was however no significant relationship between species diversity and area in both habitat types. Moreover, species composition of bird communities significantly varied between cemeteries and parks with strong preference for one of habitat types in several species. Predominant occupancy of habitat type by certain species could be linked to interhabitat differences in vegetation structure, human behaviour and management. Interestingly, several bird species often recognised as urban avoiders were detected in surveyed cemeteries and parks.

1. Introduction

Urbanization involves a permanent and ongoing expansion of human settlements and is responsible for dramatic changes of natural areas in cities (Grimm et al., 2008; McDonald, 2008). Because of continuing and rapid increase of human population which entails growth of material consumption demand, urbanized areas represent hotspots driving local as well as global environmental changes and influences biodiversity on multiple scales (Kareiva et al., 2007; Grimm et al., 2008). The most noted local effects of urbanization are related to the loss of biodiversity and biotic homogenization (Chace and Walsh, 2006; Clavero and Brotons, 2010; Clavero et al., 2011; Morelli et al., 2016).

Bird communities are important components of biodiversity in urban ecosystems. Birds also represent a suitable and frequent model for the evaluation of environmental changes in urban areas (Marzluff, 2005) due to their relatively easy detectability and identification in the field and complexity of responses to environmental alterations (Croci et al., 2008). Although some species known as "urban avoiders" seems to be intolerant to urban areas, such environment offers suitable habitats for species which are able to cope with novel conditions (Croci et al., 2008; Maklakov et al., 2011). Urban heat island effect, as well as humans providing food to birds might cause even the expansion of some

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species (Croci et al., 2008; Møller et al., 2014; Fisher et al., 2015). On the other hand, avian survivorship in urban areas can be influenced by risk of collision with human-made objects, mainly buildings and cars (Klem, 1990), predators, including these ones directly connected with human like cats and dogs (Sorace, 2002), and disease (Delgado-V and French, 2012).

Successful colonization of urban ecosystems is often linked to biological traits of each species (Croci et al., 2008; Maklakov et al., 2011). Unequal susceptibility of species to urban conditions indicates that urban areas may act as an environmental filter (Tscharntke et al., 2012; Aronson et al., 2014) that influences species composition, community richness and population sizes of birds. However, urban ecosystems are not homogenous; within human settlements we can find different habitat subtypes which can be occupied by species with different tolerance to certain aspects of urban life (Jokimäki and Kaisanlahti-Jokimäki, 2003; Møller et al., 2012; Aronson et al., 2014; Fischer et al., 2015).

Species richness is often used as an operational variable reflecting the state of biological diversity (Jiguet et al., 2005) and constituting one of the most useful measures of biodiversity, mainly in birds (Gotelli and Colwell, 2001; Ricklefs, 2012; Morelli, 2013; Young et al., 2013). The main factor implicated in variation of species richness is habitat size, followed by spatial heterogeneity of area, its isolation, productivity and age (MacArthur and Wilson, 1967; Fernández-Juricic and Jokimäki, 2001; Mittelbach et al., 2001; Pautasso et al., 2011). Furthermore, for birds, species richness and abundance are often correlated (Ferenc et al., 2014; Jokimäki et al., 2016). Urbanization is obviously linked to an increased accumulation of avian biomass but a reduction in species richness (Chace and Walsh, 2006). Additionally, bird abundance trends have been correlated with specific patterns of urban-related habitat changes (Germaine et al., 1998; Jokimäki et al., 2016). Urbanization process endangers species in many ways: a) by removal of native habitats because of development on the urban–rural fringe, and b) by indirect effects, due to the fact that urbanization can deplete the resources in surrounding areas (Czech et al., 2000). Moreover, human presence can reduce breeding abundance, affecting also the foraging strategies of urban birds (Fernández-Juricic et al., 2001).

Parks and cemeteries are known as biodiversity islands in urban ecosystems (Jokimäki, 1999; Fernández-Juricic and Jokimäki, 2001). They can stabilize species richness and population structures of several animal groups, and their value as refuges for birds has been underlined (Lussenhop, 1977). Parks and cemeteries belong to the best recognized and studied types of urban green space, along with urban woodlands (forests) and gardens (Luniak and Pisarski, 1982; Jokimäki 1999; Low et al., 2009). They differ significantly in terms of how they are managed and perceived by their users and are associated with different sets of values revealed by urban inhabitants. Proximity to parks tends to be perceived as an amenity, while proximity to cemeteries as a disamenity, by apartment buyers (Tudor et al., 2013; Czembrowski and Kronenberg, 2016). Although cemeteries are used for recreational purposes in Central and Eastern Europe (Jakóbczyk-Gryszkiewicz et al., 2008), they are far less visited than parks. Indeed, similar reluctance to use cemeteries for recreational purposes (compared to positive attitudes towards visiting parks) can also be observed in other regions and continents (Huang, 2007; Kjøller, 2012). One more important aspect of urban parks and cemeteries is that they are usually managed in a top-down manner by local managers (in general these are local authorities in the case of parks and church authorities in the case of cemeteries). This changed their ecological features and usually support lower biodiversity than in the case of green spaces where a bottom-up management practice is followed, such as allotment gardens (Andersson et al., 2007).

The main aim of this study was to compare the biodiversity of bird communities in two urbanized habitats: parks and cemeteries in Central Europe. First, bird species richness and diversity composition were analysed. Then, we focused on the differences between bird species most characteristic of both types of urban green space.

2. Methods

2.1. Data collection

In this study, we focused on bird communities of parks and cemeteries in three Central European countries: Poland, Slovakia and Czech Republic. The data were collected by literature review based on a search (key words: park* OR cemeter* AND cit* OR town*) of scientific databases (Scopus; Web of Science and JSTOR); an internet search (Google/Google Scholar); as well as published and unpublished ornithological bibliographies and other sources (see Fig. A; ESM for data sources distribution). When papers with relevant information on our topic were selected; their references (backward search) and citation records (forward search) were searched for other articles that could provide relevant data.

Data for parks and cemeteries were used only if breeding bird community was established by territory mapping method (Tomiałojć, 1980). Such collected data were then treated as paired couples meaning that we included only sources where both habitats types were studied simultaneously in the same city/town. This approach eliminated many studies on parks from our sampling, but we obtained a more balanced geographic record. We extracted from these publications basic data on geographic location (latitude and altitude), habitat type (park or cemetery), number of breeding pairs, as well as total number of breeding species (for full index of sites see Supplementary Table 1). Furthermore, each sampling site (park or cemetery) was described by set of environmental variables. We used remote sensing and field information, available from the authors. The environment was described using the following variables: area (ha), age of trees (in years, an estimation of maximum age of the oldest trees within the area), canopy coverage (%), building coverage (%), level of fragmentation (ranked from 1 (minimum), to 4 (maximum)), distance to nearest urban area (meters), distance to nearest natural area (meters), presence or absence of artificial lights, amount of shrubs (ranked from 1 (minimum) to 4 (maximum)).

2.2. Statistical analyses

In this study, species richness was used as a main descriptor of breeding avifauna because provides one of the simplest and univariate measures of community diversity (Magurran, 2004). The number of species present in a given area is often used as an operational variable reflecting the state of biological diversity (Jiguet et al., 2005). We intentionally decide not to work with number of breeding pairs and density because in the relatively small cemeteries and parks, many bird species foraged outside breeding place, and many nested colonially and semicolonially (e.g. *Corvus frugilegus, Columba palumbus*, *Turdus pilaris*, Carduelidae) which makes studies on density irrelevant (Luniak, 1981; Tomialojc, 1970, 1980; Jokimäki and Kaisanlahti-Jokimäki, 2003). Bird richness was calculated as the number of bird species recorded in each site (park or cemetery). The bird species diversity was calculated for each site using the Shannon–Weaver diversity index. We used linear regression to calculate the correlation between biodiversity measures (bird species richness and diversity), and biodiversity measures with the size of cemeteries or parks. A comparison of the area size of cemeteries and parks was performed using Welch two sampling *t*-test.

We used non-metric multidimensional scaling (NMDS) to perform a preliminary comparison between cemeteries and parks, based on environmental characteristics used to describe the sampling sites (area, canopy, shrub and building coverage, distance to nearest urban area, distance to nearest natural area, presence of artificial lights) and bird species composition (number of individuals per species in each sampling site). The NMDS is an indirect gradient analysis approach which produces an ordination based on a distance or dissimilarity matrix, that collapse information from multiple dimensions (e.g, from multiple communities, sites, etc.) into two dimensions (Kenkel and Orloci, 1993;