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The role of phylogeny and life history of migratory waterbirds in designing fishpond management plans

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ABSTRACT

The acceleration of wetland loss on a global scale has frequently been reported in the past decades which is in correspondence with serious declines of migratory waterbirds. Indeed, the spatial distribution of waterbirds during migration has been shown to be associated with various predictors, ranging from feeding behaviours and migratory strategies to physical attributes of wetlands and spatial effects related to human disturbance. These results demonstrate that different constraints of ecology and life history may shape the effects of human disturbance on migratory water bird populations. In this work we analyse the role of ecological predictors and life history traits in shaping avian responsiveness to spatial attributes of artificial constructions in a phylogenetic context, using an extensive dataset of migratory water birds in Hortobágy, one of the most important stop-over sites in a major Afro-Eurasian flyway. Our study revealed that response to human disturbance factors such as the density and distance of public roads on larger spatial scales is predominantly related to life-history predictors such as the age of maturity, migration strategy and constrained by phylogenetic relatedness. Therefore we recommend that phylogenetic relatedness and life-history traits are considered when designing management plans for larger water bodies used by staging waterbirds.

1. Introduction

The expansion of human activities and global climatic change have accelerated wetland loss worldwide in the past few decades (Gibbs, 2000; Luck, 2007). Accordingly, there is a growing need for the recreation of natural wet habitats and establishment of artificial wetlands to provide habitats for endangered wetland species and to maintain ecosystems services (Woodward and Wui, 2001; Zedler and Kercher, 2005). Human activities may have strong negative effects on waterbird populations in wetland areas, with a special respect to the spatial metrics of human infrastructure such as distance and density of roads and settlements (Beale and Monaghan, 2004; Burton, 2007; Houston et al., 2012). Thus, it is highly important to manage a variety of artificial wetlands to mitigate the effects of disturbance at water bird habitats, especially at migratory hotspots (Zedler, 2000; Pringle, 2001; Taft et al., 2002; Dudgeon et al., 2006). Fishponds are considered one of the most important types of wetlands sustaining rich biodiversity at global scales, which harbour a wide range of wet habitats and cover significant areas in compared to those of seminatural sites (Broyer and Curtet, 2012). As a result, extensive fishpond areas have been designated as Ramsar and Natura 2000 sites or included in networks of nature reserves to maintain threatened wetland diversity (Rajchard et al., 2013). Indeed, fishponds play a significant role as migratory hotspots or stopover sites for migratory waterbirds along a number of flyways, in contrast to the increased levels of human disturbance in these wetland patches (Kameníková and Rajchard, 2013; Zhang et al., 2013).

Different species respond differently to the same levels and types of artificial landscape properties which are often related to human disturbance in wetlands (Middleton, 1999; Blumstein, 2006). Exploring the primary drivers of this variability may not only expand our insight into the effects of human disturbance but also contributes to predict the sensitivity of each species to these effects and thereby improve the effectiveness of conservation planning (Margules and Pressey, 2000).

A number of investigations have identified several potential life history traits and environmental conditions that might at least partially explain the interspecific variance in responses to

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human disturbance (Middleton, 1999; Saunders et al., 2002). For instance, the spatial distribution of waterbirds during migration has been shown to be associated with various predictors, ranging from feeding behaviours and migratory strategies to physical attributes of wetlands and spatial factors related to human disturbance (Blumstein et al., 2005). These results demonstrate that different constraints of ecology and life history may shape the effects of human disturbance on migratory water bird populations. However, only a few multispecies studies on waterbird habitat selection during migration have controlled for the phylogenetic relationships among species, which can be a significant source of variation among species in disturbance responsiveness (Møller, 2008).

To provide guidelines for designing management plans of artificial wetlands, here we identify potential drivers of avian responsiveness to spatial characteristics of fishponds related to human disturbance. To do so, we employed the phylogenetic comparative approach to investigate the habitat use of waterbirds during migration in Hortobágy, a national park considered as one of the most important stop-over site of the East-European flyway connecting Finland, Baltic States, Hungary and North-Africa, and is one of the most prominent migratory flyways for other birds as well (Ecsedi, 2004).

We investigated relationships between the responsiveness to disturbance and a number of species-characteristics in a phylogenetic context by testing a number of predictions outlined by recent studies. Body size has been proposed to be a primary driver of sensitivity to human disturbance in a recent study, with larger species showing decreased flush distances to approaching humans (Blumstein et al., 2005). Life span might also drive disturbance responsiveness in water birds, as longevity should be associated with risk taking and thus overall wariness in avian taxa (Blumstein, 2006). Theory predicts that migration strategy might influence habitat selection during migration in waterbirds. Indeed, some long-distance migrants exhibit more intensive responses to wetland type and disturbance as refuelling rates are primarily influenced by these variables: in many species ecologically suitable feeding sites are localized and scarce on geographical scales, which increases the costs of disturbance sensitivity (Piersma, 2007). Indeed, species differ in their sensitivity to human disturbance in contrasting ecological conditions: in a recent investigation Madsen et al. (1998) demonstrated that species which stay close to the cost or inland and are concentrated in relatively large flocks are highly sensitive to anthropogenic disturbance. Additionally, diet composition might affect the spatial distribution of waterbirds during migration. Recent investigations have demonstrated the effects of the number of broods and clutches per year on the sensitivity to the spatial and temporal distribution of food (Nagy and Holmes, 2005; Jiguet et al., 2007), making brood number and clutch size possible drivers of habitat selection during migration. To test the above predictions, we investigated the spatial distribution of water birds during migration, a measure successfully used in a number of studies as a proxy of responsiveness to human disturbance (Taft et al., 2002; Yasué, 2005).

2. Methods

2.1. Study area

Hortobágy National Park (N47.5° E21.1°; henceforth HNP) is the largest contiguous alkaline grassland in Europe, consisting of steppe areas interspersed with alkali marshes. An area of 27,000 ha of the HNP is protected by the Ramsar Convention because of its importance as a breeding and stopover site for waterbirds (Ecsedi, 2004). As part of a large-scale water management project, fish-pond systems were built in the central part of the Hortobágy during the first two decades of the 20th century. Fish-ponds cover 6000 ha in total, with seven fish-pond systems located inside the study area covering 3000 ha. The studied fishpond systems consist of 44 ponds with sizes ranging from 8 to 470 ha. During the past century, the importance of these artificial ponds have been increasing for sustaining wetland flora and fauna including endangered species such as Pygmy Cormorant *Phalacrocorax pygmeus*, Ferrugineous Duck *Aythya nyroca* and Eurasian Otter *Lutra lutra*. Pond shorelines are covered predominantly by reed beds.

Fishponds are managed extensively: fish-farming technology is adjusted to conservation priorities resulting in slower fish production. Ponds are harvested once within a 1–2 years period, depending on fish species and age group. During harvest, fishponds are drained revealing mudflats rich in invertebrates, important food items for tens of thousands of migratory water birds. The spatial and temporal availability of nutrient supply for these taxa is influenced by input of organic manure and fish food (Ecsedi, 2004).

2.2. Waterbird data

Waterbird data were collected in 44 fishponds in the central, eastern and western part of the HNP, forming seven spatial blocks between 2002 and 2010 from the break-up of ice to the end of May. Surveys were carried out once a week during the morning hours following a standard transect of randomised direction. Data were collected on 51 observation days (10.2 days per year on average) by spending 132 h on field and covering 1820 km. Waterbirds were categorised at the ordinal level, comprising Gaviiformes, Pelecaniformes, Ciconiiformes, Anseriformes and Charadriiformes (Stralberg et al., 2003).

During each survey we recorded the number of individuals of each species feeding in the ponds. Therefore we conducted the survey in the early morning hours, starting at sunrise and finishing in 2 h. If the number of individuals was not constant in a pond during the survey, we recorded the maximum number of birds.

Predictor variables were categorised as proxies related to (i) wetland characteristics and (ii) human disturbance, as described in Appendix 1. To obtain robust metrics of model performance, we scaled the wetland predictors to the same metric scales.

We derived the following proxies of responsiveness to artificial landscape composition from the raw data for each bird record: minimum distance to the next tarmac road and human settlement as well as the density of tarmac roads, settlement sizes and human population in a range of 10 km of the observation site (Appendix 1). As these metrics are often related to measurements of human disturbance (Végvári et al., 2011a,b), we refer to these variables as disturbance proxies. As the spatial distribution of major habitat types and land-use classes show a high degree of homogeneity in the study area, we omitted these predictors from further analyses.

2.3. Predictors of disturbance responsiveness

Life history data for each species were obtained from Snow and Perrins (1998). Waterbirds were categorised as long or short distance migrants, i.e. species wintering south or north of the Sahara; residents were not classified as a separate group, as separating residents from short-distance migrants is seldom straightforward (Snow and Perrins, 1998). We employed body mass as a robust proxy for a number of life history traits (Blumstein, 2006). We used the average number of broods and clutch size subsequently raised per season (henceforth brood number and clutch size) as characteristic proxies of annual fecundity. Data were also collected on the typical age at maturity as a robust measure of life span (in years).