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Increased landscape heterogeneity supports the conservation of European rollers (*Coracias garrulus*) in southern Hungary

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ABSTRACT

European rollers (*Coracias garrulus)* were almost extinct from large parts of Hungary in the 1970–1980s. However up till now their population size increased considerably, mainly due to a nature conservation campaign, supplying artificial nest-boxes for breeding. We studied which factors affected rollers' occurrences at the landscape scale in southern Hungary, under natural circumstances and when artificial nest-boxes were supplied. We analyzed the composition and the configuration of the landscape at two spatial scales. We found that beside the presence of natural grasslands, heterogeneous landscape provided high quality breeding and hunting sites favorable for rollers. Even though habitat characteristics of roller territories with natural holes or nest-boxes were similar, breeding sites without artificial nest-boxes harbored higher coverage of forests and heterogeneous agricultural areas. Sites with occupied and unoccupied nest-boxes considerably overlapped, suggesting that the available habitats were not saturated. Nest-box supplementation proved to be an effective tool for rollers' conservation in areas where natural nesting sites were limited, but prey resources were available. Consequently, the preservation of landscape heterogeneity is a key factor which should be taken into consideration in the conservation management of roller populations.

1. Introduction

Understanding bird-habitat relationships is important for developing an effective management plan for avian conservation. Territory selection of birds is a hierarchical process, proceeding from assessment of landscape heterogeneity characteristics through the local scale selection of suitable habitat patches to the fine-scale selection of nest-sites (Wiens, 1989). Birds are selective to the vegetation types in which they breed, but may use patches of several different habitat types within their home-ranges (Virkkala, Luoto, & Rainio, 2004). Consequently, the distribution pattern of a bird population can be explained both by the local characteristics of the nesting sites and the whole landscape structure. Habitat selection is often studied at the local scale, using measures such as food availability and abundance (Hart et al., 2006) or nest site characteristics (Golawski & Golawska, 2008; Golawski & Meissner, 2008; Pasinelli, 2007). Large scale landscape data may also be used effectively to predict the distribution and abundance of species (Jansson & Angelstam, 1999; Bennett, James, Radford, & Haslem, 2006).

Habitat characteristics may affect survival rate of the populations, their breeding success, population growth rate, and predation risk (Cody, 1985; Martin, 1995; Wiens, 1989). At larger scales, landscape composition influences movement patterns and reproductive performance of birds (Bionda & Brambilla, 2012; Bruun & Smith, 2003; Hakkarainen et al., 2003). Habitat fragmentation may increase predation rate and results in a variety of edge effects

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(Bayne & Hobson, 1997; Chalfoun, Thompson, & Ratnaswamy, 2002).

Habitat mapping projects such as national land-use databases (Sanchez-Zapata & Calvo, 1999) and the Pan-European Corine Land Cover (CLC) project have already been used to understand bird distribution patterns and their responses to landscape change (e,g., Radovic & Tepic, 2009). For example, analyzing the effects of landscape composition proved to be useful for detecting changes in the size of farmland bird populations (Batáry, Báldi, & Erdős, 2007; Fuller, Trevelyan, & Hudson, 2006). In order to develop and implement appropriate measures for conserving bird populations we need the knowledge on habitat requirements of the endangered bird species and the landscape factors affecting the occurrence of these species (López-Iborra, Limiñana, Pavón, & Martínez-Pérez, 2011; Morales, Garcıa, & Arroyo, 2005; Moreira et al., 2012; Virkkala et al., 2004; Warren, Betts, Diamond, & Forbes, 2005).

The European roller (*Coracias garrulus*) is a threatened bird species in Europe (its IUCN status is "near threatened, NT", see birdlife database at http://www.birdlife.org/datazone/species/factsheet/22682860). European population of rollers declined considerably in the 1970s, disappearing as a breeding species from Finland, Denmark, Germany and the Czech Republic (Cramp, Perrins, & Brooks, 1993). The Hungarian population also suffered a serious decline from the 1980s: European rollers completely disappeared from western Hungary, and the stronger populations of the eastern and southern regions also declined (Magyar et al., 1998). The reasons for this decrease have not been completely revealed. The main causes could be the loss of suitable habitats due to changes in agricultural practices and the loss of proper nesting hollows (Kovács, Barov, Orhun, & Gallo-Orsi, 2008). In Hungary the lack of nesting hollows seems to be the main limiting factor, since nest-box programmes successfully increased the breeding population in different habitats (Kiss, Elek, & Moskát, 2014; Molnár, 1998). Whilst in 1994 the estimated population size of rollers was about 600 pairs in Hungary, nowadays it is about 1100 pairs (Kiss et al., 2014) and the majority of rollers breed in artificial nest-boxes. As European rollers are migratory birds, unfavorable changes on their migration routes and wintering areas could probably contribute to this process, including the use of pesticides and illegal hunting (Kovács et al., 2008). Unfortunately, exact data about the migration routes and the location of their wintering areas are only available for the Western European population (Emmenegger, Mayet, Duriez, & Hahn, 2014; Rodríguez-Ruiz et al., 2014).

The European roller is a secondary cavity-nesting species, consequently, rollers in Hungary naturally nest in the abandoned nest cavities of larger-sized woodpeckers such as the green woodpecker (*Picus viridis*) and the black woodpecker (*Dryocopus martius*) (Szijj, 1958). Occasionally rollers also breed in sand cliffs and buildings (Cramp et al., 1993), however it was not detected in our study area (Southern-Hungary; Molnár, 1998). The most typical feeding habitats are pastures and meadows or agricultural fields where rollers consume large insects, although they occasionally eat small vertebrates (Kiss et al., 2014).

Although several studies have targeted the small-scale habitat characteristics that affect rollers' nest-site selection (Avilés, Sánchez, & Parejo, 2000a; 2000b; Rodriguez, Avilés, & Parejo, 2011) and their conservation (Avilés & Parejo, 2004), rollers' environmental requirements at large geographical scales are still poorly understood. Agricultural intensification affected roller populations negatively in Spain; it reduced roller abundance at their natural breeding sites (Avilés et al., 2000a), as well as their breeding success and clutch sizes (Avilés & Parejo, 2004). Just a few studies investigated characteristics of natural nesting sites such as hollows or human structures (Bouvier, Muller, Génard, Lescourret, & Lavigne, 2014; Catry et al., 2011; Václav, Valera, & Martinéz, 2011).

The objectives of the present study were:

(i) To compare the density and distribution of rollers in sites with artificial nest-boxes and in natural breeding sites in southern Hungary.
(ii) To determine factors affecting the occurrence of European rollers in landscapes without artificial nest-boxes at large spatial scales. We hypothesized that the effects of agricultural intensification on rollers would be detected at the landscape scale. Rollers' presence/absence data without artificial nest-box supply were used at different spatial scales for detecting what factors affect rollers' occurrences under natural circumstances. We predicted that landscapes with high frequencies of natural breeding sites are favorable for rollers, but the elevated level of intensive agricultural fields would cause an opposite effect.
(iii) To analyze the factors which affected rollers' presence at the individual-territory level. A successful nest-box program for roller conservation in this area (Kiss et al., 2014; Molnár, 1998) allowed us to also compare the effects of habitat characteristics at the individual (territory) level. We predicted that high quality feeding sites, such as natural or semi-natural grassland habitats over intensively farmed fields, are favorable for rollers when nest-boxes are offered to occupy.

2. Methods

2.1. Study species and census methods

The European roller is a medium-sized, colorful, insectivorous bird species. Rollers are typical sit-and-wait predators, utilizing perch sites as vantage points when they look for prey. Perch sites used by rollers include fences, pylons and power lines, solitary trees, dead tree branches, sticks or any other vantage point from which they can detect prey on the ground (e.g., we have observed rollers perched on haystacks). Our study took place in Csongrád (N46°25′35.25″; E20°14′05.75″) and Bács-Kiskun counties (N46°34′01.59″; E19°22′42.17″) in southern Hungary, a region characterised by a matrix of intensively and extensively managed agricultural fields, sandy and alkaline grasslands (Fig. 1). The distribution of rollers in this region was surveyed at the landscape-scale in 2010. Rollers' occurrence was surveyed by territory mapping based on two visits. The first was in the early breeding season (between May 10 and 20) and the second one in the middle of the breeding season (between June 10 and 20) before nestlings fledged. The observers used binoculars and scopes to survey the whole area. We also checked for the occupancy of the nest-boxes at least twice during the breeding season (between May 20 and June 10, and June 20 and July 20).

Rollers' breeding density varies by region in Europe. Václav et al. (2011) found mean density of 0.63 pairs/100 m in human buildings (e.g., bridges) in Spain; however, such a high breeding density has not been reported yet from Hungary. In the latter area rollers rarely use buildings and sand cliffs, which can provide relatively aggregated potential nest sites, but they rather prefer to use new and abundant feeding sites such as freshly mowed grasslands (our pers. obs.). Rollers typically defend a 50–100 m radius circular area around the nest (Cramp et al., 1993), but published studies reported a high variation in distances between foraging sites and nesting holes. Avilés and Parejo (2004) reported ca. 170 m as a mean value, but Cramp et al. (1993) mentioned longer distances (0.5–1 km, or exceptionally even more). An earlier study in our study site found the average territory size ca. 4.8 ha (cc. 125 m; Molnár, 1998). We determined the number of roller pairs in our study area based on the maps of observations and occupied nest boxes. Following the