Acta Oecologica 59 (2014) 91–96

Contents lists available at ScienceDirect

Acta Oecologica

journal homepage: www.elsevier.com/locate/actoec

Original article

Habitat edges affect patterns of artificial nest predation along a wetland-meadow boundary

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ARTICLE INFO

Article history:
Received 20 October 2013
Accepted 16 June 2014
Available online 6 July 2014

Keywords:
Artificial nest
Ecotonal effect
Habitat fragmentation
Nest predation
Wetland meadow

ABSTRACT

Wetland habitats are among the most endangered ecosystems in the world. However, little is known about factors affecting the nesting success of birds in pristine grass-dominated wetlands. During three breeding periods we conducted an experiment with artificial ground nests to test two basic mechanisms (the *matrix* and *ecotonal effects*) that may result in edge effects on nest predation in grass-dominated wetland habitats. Whereas the *matrix effect* model supposes that predator penetrate from habitat of higher predator density to habitat of lower predator density, thus causing an edge effect in the latter, according to the *ecotonal effect* model predators preferentially use edge habitats over habitat interiors. In addition, we tested the edge effect in a wetland habitat using artificial shrub nests that simulated the real nests of small open-cup nesting passerines. In our study area, the lowest predation rates on ground nests were found in wetland interiors and were substantially higher along the edges of both wetland and meadow habitat. However, predation was not significantly different between meadow and wetland interiors, indicating that both mechanisms can be responsible for the edge effect in wetland edges. An increased predation rate along wetland edges was also observed for shrub nests, and resembled the predation pattern of real shrub nests in the same study area. Though we are not able to distinguish between the two mechanisms of the edge effect found, our results demonstrate that species nesting in wetland edges bordering arable land may be exposed to higher predation. Therefore, an increase in the size of wetland patches that would lead to a reduced proportion of edge areas might be a suitable management practice to protect wetland bird species in cultural European landscapes.

1. Introduction

Nest predation is the main factor driving nesting failure in birds, and may significantly influence the dynamics of avian populations (Ricklefs, 1969). Temporal and spatial variations in nest predation rates are well documented (Andrén, 1992; Fisher and Wiebe, 2006; Lahti, 2001; Martin, 1993; Sieving and Willson, 1999), though they are not well understood or explained (Donovan et al., 1997; Gustafson, 2005; Koubová et al., 2011). For example, nest predation can be higher in habitat edges compared to habitat interiors (the edge effect; Gates and Gysel, 1978). Since the proportion of edges increases with habitat fragmentation, the edge effect can be responsible for low nesting success and consequently for population declines of birds over large regions (Murcia, 1995).

The existence of the edge effect has been very well documented in North American and Scandinavian studies (along arable land-forest borders), but is less apparent in mosaic European landscapes (see Batáry and Báldi, 2004). Nevertheless, increased nest predation rates in interior habitats compared to edge zones (an *opposite edge effect*) have also been demonstrated in some experiments (Marini et al., 1995; Storch, 1991). Such inconsistent results often depend on the predator community (Johnson et al., 1989; Lahti, 2001) and landscape context (Bayne and Hobson, 1997; Clurk and Nudds, 1991; Driscoll and Donovan, 2004). Moreover, it is evident that the edge effect is a dynamic process with temporal variation (Chalfoun et al., 2002; Pasitschniak-Arts and Messier, 1995; Stephens et al., 2003; Svobodová et al., 2011, 2012), and therefore research conducted over just 1–2 years may not be able to detect it.

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http://dx.doi.org/10.1016/j.actao.2014.06.003
1146-609X/

Many studies have investigated the edge effect, but mainly in agricultural landscapes with hard edges (Andrén, 1992, Batáry and Báldi, 2004; Bayne et al., 1997; Conner and Perkins, 2003; Donovan et al., 1997; Huhta et al., 1996; Lahti, 2001; Major and Kendal, 1996; Wilcove et al., 1986). Data from lower-contrast edges such as the transition zone between wetlands and meadows are less available (e.g. Pasinelli and Schiegg, 2006; Wallander et al., 2006), despite the fact that wetland habitats are among the most endangered ecosystems in the world (Zedler and Kercher, 2005). In Central Europe, research on nesting success in wetlands has been mostly restricted to reed habitats (e.g. Báldi and Batáry, 2005; Batáry et al., 2004; Batáry and Báldi, 2004, 2005; Schiegg et al., 2007; Trnka et al., 2009). Although open bogs and inundated meadows of Central Europe provide important breeding sites for particular threatened species such as waders (e.g. Common Snipe, *G. gallinago*; Common Redshank, *Tringa totanus*), Corn Crake (*Crex crex*), Hen Harrier (*Circus cyaneus*) or Black Grouse (*Tetrao tetrix*) (Hagemeijer and Blair, 1997), studies from grass-dominated wetlands are rare (Albrecht, 2004).

Although there is no doubt that the edge effect occurs in many habitats (Batáry and Báldi, 2004), mechanisms leading to the occurrence of habitat edges on avian nest predation have rarely been evaluated (Andrén and Angelstam, 1988; Svobodová et al., 2011, 2012). Edge effects on nest predation can be predicted based on the distribution of habitat-specific resources along the borders of two adjacent habitats and consequent patterns in predator occurrence and movements (Ries and Sisk, 2004, more in Koubová et al., 2011). Basically, there are two models linking predator movements with elevated nest predation rates in habitat edges: (1) the *matrix effect* model supposes that predators penetrate from habitats of higher quality (for the potential nest predators) to habitats of lower quality, and cause an edge effect in the lower quality habitats (also termed the *spillover model*, *sensu* Lidicker, 1999) and/or (2) edges may contain complementary resources from both adjacent habitats (of the same or different quality) and/or can contain specific resources which can be specifically used by nest predators. In addition, some predator species may also focus their activity specifically around edge structures and use them as travel lines (Bider, 1968; Larivière and Messier, 2000; Šálek et al., 2009). This leads to a higher predator density at the border between adjacent habitats (the *ecotonal effect* model; Lidicker, 1999).

The aim of our study was to analyse patterns of nest predation in a grass-dominated wetland surrounded by forests, pastures and harvested meadows. In our study area, Albrecht (2004) has already demonstrated higher predation on nests of a small shrub- and open-cup nesting passerine, the Scarlet Rosefinch (*Carpodacus erythrinus*), along wetland edges bordering arable land than in the interior of wetland habitat. However, the mechanism responsible for this edge effect was not evaluated because Rosefinch nests occurred only in the wetland habitat, i.e. not in whole transition zone between the wetland and meadow. Using artificial ground nests distributed along whole habitat gradient (i.e. the edge and interior of the wetland and harvested meadow respectively), we were able to test the basic mechanisms of the edge effect, i.e. the *matrix* versus the *ecotonal effect* models. We assumed that higher nest predation in habitat edges (i.e. in meadow edge and/or wetland edge) than in habitat interiors would support the *ecotonal effect* model, and lower nest predation in the wetland interior than in edge habitats and the meadow interior would correspond with the *matrix* model (also see Lidicker, 1999). We expected to find the matrix effect along the habitat gradient between wetland and meadow because a higher density of generalist nest predators usually occurs in the surrounding arable land (hay meadows and pastures in our study area; also Andrén and Angelstam, 1988, also see the discussion in Albrecht, 2004). In addition, we used artificial shrub nests to test whether the spatial distribution of their predation resembles the predation patterns of ground nests, and corroborate patterns of natural nest predation on shrub-nesting Rosefinches.

2. Materials and methods

2.1. Study site

The study locality was situated in the Vltava River Valley of the Šumava Mts. (Bohemian Forest) National Park (48°47′–48°53′N, 13°57′–13°51′E, 800 a. s. l., 24 km^2), Czech Republic, which is one of very few areas of primary non-forested habitats in Central Europe (Sádlo and Bufková, 2002). The area was mainly composed by periodically inundated wetlands (25%) surrounded by coniferous or mixed forest (15%) and extensively used meadows (mainly harvested for hay) (60%). For the purpose of this study, we distinguished two main habitat types: (1) wetland; mostly created by a mosaic of shrub and humid herbal vegetation that is regularly flooded during the April–May period. The dominant species of this oligotrophic wetland ecosystem were *Sphagnum*, *Spiraea salicifolia*, *Phalaroides* sp., *Glyceria* sp., *Carex* sp., *Eriophorum* sp., and *Filipendula ulmaria*. (2) Surrounding hay meadows and pastures; composed mainly of meadow grasses (*Poa* sp., *Festuca* sp.) and other herbs (*Taraxacum*, *Trifolium*). Shrubs were completely absent in this habitat. Since the edge zone between wetland and meadow was relatively sharp (within 15 m of the habitat border), the vegetation structure does not significantly differ from the surrounding habitat. Hence, there were four types of nest locations (see below), i.e., wetland and meadow interiors, wetland edges (towards the meadows), and meadow edges (towards the wetland) (more details in Albrecht (2004).

2.2. Experimental design

To test if nest predation is influenced by the distance of the nest from a habitat edge we used two types of artificial nests, i.e. ground nests and shrub nests. A ground nest was constructed as a small depression in the ground lined with a small amount of dry grass. The cup of a shrub nest was created from half of a tennis ball covered by soil and plant material, fixed by wire to a shrub branch. Since the rubber scent of tennis balls can discourage potential predators, the shrub nests were aired for 14 days (Davison and Bollinger, 2000). Whereas the ground nests may have resembled the nests of ground nesting bird species such as Corn Crake, Black Grouse, Common Quail (*Coturnix coturnix*), or Whinchat (*Saxicola rubetra*), the shrub nests represented nests of open-cup shrub nesting species such as the Scarlet Rosenfinch and Whitethroat (*Sylvia communis*). All these species regularly occur in our study area (Hora et al., 1997). The experiment was conducted from mid-May till mid-June (i.e. 2005 May 20th, 2006 June 10th, 2007 June 1st), which is the average period of clutch laying for these species in the CR (Albrecht, 2004, 2011). Further, experiments were usually initiated at least four weeks after the spring floods because the presence of floodwater in the wetland could have had a major impact on predator activity (Lecomte et al., 2008). Each nest was baited with two quail eggs, and one of them was filled with wax for predator identification (hereafter wax eggs; Storch et al., 2005; Thompson and Burhans, 2004). In both nest types, wax eggs were anchored in the nest pits with a string and nail in order to prevent predators from carrying them away (Suvorov et al., 2012).

In total, 360 ground nests were installed during the three breeding periods (2005–2007), i.e. 120 every year in different localities. Nests were randomly located (see below) along a