



Predation risk of artificial ground nests in managed floodplain meadows

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ABSTRACT

Nest predation highly determines the reproductive success in birds. In agricultural grasslands, vegetation characteristics and management practices influences the predation risk of ground breeders. Little is known so far on the predation pressure on non-passerine nests in tall swards. Investigations on the interaction of land use with nesting site conditions and the habitat selection of nest predators are crucial to develop effective conservation measures for grassland birds.

In this study, we used artificial nests baited with quail and plasticine eggs to identify potential predators of ground nests in floodplain meadows and related predation risk to vegetation structure and grassland management.

Mean daily predation rate was 0.01 (± 0.012) after an exposure duration of 21 days. 70% of all observed nest predations were caused by mammals (Red Fox and mustelids) and 17.5% by avian predators (corvids). Nest sites close to the meadow edge and those providing low forb cover were faced with a higher daily predation risk. Predation risk also increased later in the season. Land use in the preceding year had a significant effect on predation risk, showing higher predation rates on unmanaged sites than on mown sites. Unused meadows probably attract mammalian predators, because they provide a high abundance of small rodents and a more favourable vegetation structure for foraging, increasing also the risk of incidental nest predations. Although mowing operation is a major threat to ground-nesting birds, our results suggest that an annual removal of vegetation may reduce predation risk in the subsequent year.

1. Introduction

Nest predation is an important determinant of breeding success in birds, with direct effects on annual reproduction and thus population dynamics (Martin, 1993; Cresswell, 2011). Besides breeding site characteristics and food availability, nest survival depends on the abundance and habitat utilization of potential predators (Angelstam, 1986; Klug et al., 2009). Therefore, the identification of nest predators and their habitat selection is crucial for understanding the ecological context of nest predation (Ribic et al., 2012; Lyons et al., 2015). Ground-nesting birds are especially vulnerable to predation, because their nests are easily accessible to both mammalian and avian predators (Martin, 1993). For grassland birds, sward structure highly influences predation risk, because vegetation provides nest concealment and reduces the mobility of predators (Dion et al., 2000; Lyons et al., 2015). Vegetation structure, in turn, is strongly affected by management regimes (Isselstein et al., 2005).

Population declines in many grassland birds are associated with an intensification of land use (Vickery et al., 2001; Newton, 2004; Bota et al., 2005). More frequent mowing conducted at earlier dates highly

increased nest losses in ground-breeders (Grüebler et al., 2008). Additionally, modern agricultural practices alter habitat conditions, resulting in a loss of suitable nesting sites, a reduction of food availability and may also increase predation pressure (Vickery et al., 2001; Evans, 2004). Only few studies, however, addressed management effects on nest predation risk so far (Pescador and Peris, 2001; Ejsmond, 2008). Further knowledge on the interaction of land use with habitat conditions and nest predation is important for developing effective conservation measures for birds breeding in agricultural grasslands (Evans, 2004).

In this study, we conducted an artificial nest experiment resembling Corncrake *Crex* nests. These medium-sized, ground-breeding rails inhabit tall grass vegetation that is mostly agriculturally managed. Land use intensification resulted in severe population declines in the last decades (Green et al., 1997; BirdLife International., 2016). Corncrakes behave very cryptic making it almost impossible to find and monitor real nests.

It has been controversially debated if artificial nest experiments can reliably measure predation risk of natural nests. Studies revealed both underestimations and overestimations of predation rates, mainly

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because artificial nests lack parental activity, begging calls of nestlings, were placed at suboptimal or unnatural sites or may attract different predators (e.g. Weidinger, 2001; Pärt and Wretenberg, 2002; Moore and Robinson, 2004). Some studies, however, revealed comparable patterns of predation of artificial and real nests under consideration that egg size and nest appearance resembles as close as possible natural nests (e.g. Wilson et al., 1998; Davison and Bollinger, 2000; Pehlak and Lõhmus, 2008). Although artificial nests allow no conclusion of actual nest predation, they often give the opportunity to sample a greater number of nests and to control for some environmental factors in order to receive insights of the predation risk at certain habitat gradients (Dion et al., 2000; Malzer and Helm, 2015). Additionally, observing artificial nests is less intrusive than searching for real nests, which is especially a concern when dealing with rare or endangered species (Vögeli et al., 2011).

In most studies, artificial nest experiments are used to assess predation risk of songbird nests, but only few studies focussed on non-passerine ground-breeders (Pehlak and Lõhmus, 2008; Seibold et al., 2013). Breeding success and nest predation is widely investigated for grassland birds nesting on short swards, like waders (Seymour et al., 2003; MacDonald and Bolton, 2008a), but nests of species breeding in tall and dense vegetation are difficult to find and to observe. Therefore, little is known about the predation pressure for non-passerine species breeding in eutrophic grasslands.

The aim of this study was to identify potential predators of ground nests in floodplain meadows. We expect that in tall and dense grasslands predator activity and hence predation risk of artificial nests depends on the distance to the meadow edge and vegetation structure. Because the latter is highly affected by management practice of the preceding year we also tested for land use effects on artificial nest survival.

2. Material and methods

2.1. Study area

This study was conducted on about 2.5 km² in a grassland polder within the Lower Oder Valley National Park, which is situated in northeastern Germany at the border to Poland (53° 03' N, 14° 18' E). Vegetation is dominated by Reed Canary Grass *Phalaris arundinacea* and sedges *Carex* spp. Floodplains along the Oder River are inundated during winter and artificially drained for agricultural purposes from early April onwards. Most meadows are annually managed by low-intensity grazing with cattle or mowing for hay-harvest in summer. The study area is an important breeding site for Corncrakes (up to 250 calling males) and other ground-breeders nesting in tall grass, such as Common Snipe *Gallinago gallinago*, Redshank *Tringa totanus*, Yellow Wagtail *Motacilla flava* and the threatened Aquatic Warbler *Acrocephalus paludicola*. Potential predators to ground nests in the study area are mainly Red Fox *Vulpes vulpes*, Weasel *Mustela nivalis*, Stoat *Mustela erminea*, European Polecat *Mustela putorius*, American Mink *Neovison vison*, Hooded Crow *Corvus cornix* and Common Raven *Corax corax*.

2.2. Artificial nest experiment

Artificial nests were set up on 12 meadows (sites) during two sampling periods starting on 5 May and 5 June, respectively in 2014 and 2015. In 2014, additional nests were placed on six sites starting on 15 May, resulting in total 131 sample nests in 2014 and 103 nests in 2015. Experiment duration was 21 days to simulate the egg-laying and incubation period of Corncrakes. Each nest was formed as a shallow depression into the soil or given plant material and contained two Japanese Quail *Coturnix japonica* eggs and one naturally coloured plasticine egg (Purger et al., 2008) of similar size than Corncrake eggs. To minimize human scent on the eggs we wore latex gloves during

setup (Malzer and Helm, 2015). Nests were placed along a linear transect at 30 m intervals starting from the field edge with three to six nests located at one site. During the second sampling period in June transects lines were moved by at least 50 m from transects used in May to avoid an influence from the first sampling. Nest locations were marked with bamboo poles and nest fate was checked every three days. We considered nests to be depredated if one of the quail eggs had been damaged or removed. Tooth and bill imprints in plasticine eggs and remains of eggshells were used to identify mammalian or avian predators. We measured the space between canine imprints and attributed distances > 17 mm to Red Fox and distances < 17 mm to mustelid carnivores (Bellebaum and Boschert, 2003). Because of overlapping jaw sizes we were not able to identify species among mustelids. Some plasticine eggs showed bitemarks by mice, whereas quail eggs remained intact. Small rodents may be attracted to plasticine (Purger et al., 2008; Pärt and Wretenberg, 2002), but since we were interested in potential predators of non-passerine quail-sized eggs, these cases were not treated as predation.

2.3. Habitat data

For each nest location, we determined the nearest distance to the meadow edge. Vegetation data were sampled at each nest during setup in early May and early June. Vegetation cover was estimated in % of the total projected ground cover within 1 m² and was divided into the cover of forbs, sedges and grasses. Vegetation height and litter height were measured in cm with a folding rule. Management in the preceding year was recorded for each site being either mowing (n = 12) or no land use (n = 6).

2.4. Statistical analyses

All statistical analyses were performed using the programme R version 3.3.1 (R Core Team, 2016). First, all habitat variables were compared between depredated and intact nests and between mown and unused sites using non-parametric Mann-Whitney-U-tests. Daily nest predation rates were estimated by Mayfield logistic regression (Hazler, 2004) using a generalized linear mixed effects model (GLMM) with binomial error distribution fitted with the R package 'lme4' (Bates et al., 2014). This procedure uses an events/trials syntax without entering proportions, where events are coded according to nest fate (0 = intact, 1 = depredated) and number of trials are expressed by the number of exposure days until either predation event or the end of the experiment (Hazler, 2004). Because nests were checked every three days we used the midpoint between two controls to calculate exposure days if predation occurred (Ludwig et al., 2012; Seibold et al., 2013).

Correlations between habitat variables were assessed using Spearman rank correlations; collinearity was tested using variance-inflation factors (VIF) calculated with the function *corvif* of the R package 'AED' (Zuur et al., 2009) and parameters with $r_S > 0.50$ and $VIF > 2$ were excluded from modelling. Litter height ($r_S = -0.59$, $P < 0.001$; $VIF = 2.3$) and cover of grasses ($r_S = -0.57$, $P < 0.001$; $VIF = 2.8$) were negatively correlated to forb cover. Therefore, we used only forb cover as a representative variable in the model. Habitat variables considered in the model were distance to meadow edge, total vegetation cover, forb cover, sedge cover, setup date and management in the preceding year being either mowing or no land use. Because vegetation parameters were affected by land use (Table 1) we also tested for interactions. As random effect we included site to account for placement of several artificial nests at the same meadow.

The most parsimonious model was obtained by ranking candidate models according to the differences in AIC_c (Akaike's Information Criterion adjusted for small sample size) scores (ΔAIC_c) and the model with $\Delta AIC_c < 2$ was considered as the best explanatory model (Burnham and Anderson, 2002, Table 2). For each parameter we generated Bayesian 95% credible intervals using the function *sim* of the R

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