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Negative effect of roosting Starlings (*Sturnus vulgaris*) on clutch survival in the Great Reed Warbler (*Acrocephalus arundinaceus*)

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Running title: Roosting Starlings influence clutch survival of the Great Reed Warbler

Abstract This study provides preliminary findings related to whether and how the roosting of Starlings (*Sturnus vulgaris*) in reedbeds influences the survival of clutches of the Great Reed Warbler (*Acrocephalus arundinaceus*). During the nesting seasons of 2014 and 2015, we surveyed the complete area of a mining pond in Serbia (south-eastern Europe) for Great Reed Warbler nests, and the presence of roosting Starlings was also recorded. Using the Mayfield method, we estimated the daily survival rate of Great Reed Warbler eggs and nestlings, and compared these rates between Starling roosting and non-roosting areas. Although both egg and nestling survival rates were lower in the Starling roosting than in the non-roosting areas, the differences were not significant, which was also reflected in overall nesting success. However, when only data from the time period when Starling roosting occurred, the overall Great Reed Warbler egg survival was significantly lower in roosting areas than in non-roosting areas. Our results suggest that Starling roosting did not influence the clutch survival of the Great Reed Warbler significantly, but that there can be a negative short-term or local effect. Our study implies that a larger number of Starlings and a longer roosting period could affect clutch survival more negatively.

Key words: roosting; nesting success; daily survival rate; *Acrocephalus arundinaceus*; *Sturnus vulgaris*; south-eastern Europe

Introduction

The roosting, or communal resting, of birds on migration and/or during the night has been the subject of many studies, which usually focused on the effects of roosting on the anthropogenic environment (e.g. Clergeau & Quenot 2007), the effects of excrement rich in phosphorus on water bodies (e.g. Klimaszyk et al. 2014), the dissemination of diseases (e.g. Janousek et al. 2014), the social structure and behaviour of the roosting birds (e.g. Lambertucci 2013), or the methods of counting roosting flocks (e.g. Cantos et al. 1999). Some species that roost en masse, such as Starlings (*Sturnus vulgaris*), Red-winged Blackbirds (*Agelaius phoeniceus*) or Cowbirds (*Molothrus ater*), tend to select various vegetation structures for roosting, e.g. tree avenues, parks, shrubbery and reed beds (Meanley 1965). Starlings prefer reed beds for roosting in the post-breeding period or during their autumn migration (Mérő & Žuljević 2013/2014). In Central Europe, the nesting of Starlings begins at the end of March and the fledglings leave the nests at the beginning of May, when they form large flocks during foraging (Molnár 1998). Similarly to other bird species that roost en masse, Starlings can cause considerable damage to the vegetation at their roosting sites (Meanley 1965).

The breeding ecology of the reed specialist Great Reed Warbler (*Acrocephalus arundinaceus*), has been thoroughly discussed in several papers (e.g. Dyrcz 1981; Petro et al. 1998; Uzun et al. 2014). Clutch survival and nesting success are influenced by reed bed structure (Graveland 1998; Mérő & Žuljević 2014), the level of precipitation and flooding of the nests (Mérő et al. 2014), stormy winds followed by cold temperatures (Fischer 1994), Cuckoo (*Cuculus canorus*) parasitism (Moskát et al. 2009), and/or various sources of predation (Trnka & Grim 2014).

However, there is no information on the effects of roosting Starlings on nesting success of Great Reed Warblers or other reed passerines.

The aim of this study was to evaluate whether and how Starling roosting influences clutch survival or nesting success in the Great Reed Warbler. At our study area, a mining pond in northern Serbia (south-eastern Europe), the roosting of Starlings had previously been observed during the autumn migration, in September and October (Mérő & Žuljević 2013/2014). In 2014 and 2015, however, many Starlings roosted on the pond in the spring, during the early nesting period of Great Reed Warblers (late May and early June). This situation provided an opportunity to study the potential effects of Starling roosting on the clutch survival of the Great Reed Warbler. We explored these effects by comparing the survival of eggs and nestlings between nests found in roosting and non-roosting areas of the reed bed.

METHODS

The study was conducted in 2014 and 2015 at Bager Pond (N 45.788˚, E 19.098˚) near the town of Sombor (northern Serbia). The pond covers 1.3 ha, and its water level fluctuates seasonally and also depends on the precipitation. Nearly 90% of the pond is covered with reed (*Phragmites australis*). For a more detailed description of the study area, see Mérő et al. (2014, 2015). In both nesting seasons, weather conditions and the amount of precipitation were average (Serbian Republic Hydro-meteorological Service). In 2014, 85% of the reed was burned in March, whereas in 2015 the reed bed remained intact.

Fieldwork was conducted in May, June and July. We thoroughly searched the entire area of the pond for Great Reed Warbler nests. We systematically surveyed the pond for nests by walking in the reedbed for c. 3 hours per visit (Mérő et al. 2014, 2015). We checked nests regularly at 5-day intervals, and recorded the number of eggs, nestlings, the number of lost eggs, nestlings and fledglings, and the number of roosting Starlings. During each visit, we also recorded the number and location of Starlings observed on the pond.

We classified nests by whether they were in roosting or non-roosting areas. The number of nests in roosting and non-roosting areas were not normally distributed (Shapiro-Wilk test, $P < 0.001$), therefore, we compared them by the non-parametric Mann-Whitney U-test. Because data from the two years were pooled, there can be non-independence if some pairs nested in both years. However, this non-independence was likely to be small because our extensive colour-ringing programme, conducted as part of other longer studies, showed that there were no cases when Great Reed Warbler females chose the same male in both years.

We defined nesting success as the probability that an egg produces a fledgling (Mayfield 1975). We then tested the difference in nesting success between the two nest categories by using the Mann-Whitney U-test. We also estimated the daily survival rates of eggs and nestlings by using data on egg-days and nestling-days (Mayfield 1975), and tested the difference in clutch survival between roosting and non-roosting areas by J-tests (Johnson 1979; Hensler & Nichols 1981). In a further analysis, we calculated daily egg and nestling survival using data only from the exact roosting period, i.e., when Starling roosting and Great Reed Warbler incubation coincided. The difference in daily survival of eggs between nests in roosting and non-roosting areas was also tested with J-test. J-tests were calculated in the program available from Konrad Halupka (www.biol.uni.wroc.pl/halupka), while other statistical analyses were performed with SPSS statistical software.

RESULTS

During both nesting seasons, the roosting of Starlings began exactly when the first Great Reed Warbler broods were raised, and lasted until June 10 in 2014, and until June 15 in 2015. The size of the roosting area was 0.15 ha in 2014 and 0.35 ha in 2015. In both years, the number of roosting Starlings varied between 100 and 400 individuals; the mean number in 2014 was 197 ± 99.5 (SD) (1313 individuals/ha) and in 2015 it was 223 ± 142.0 (SD) (637 individuals/ha). The roosting area in 2014 was located only in the non-burnt (mixed reed) patch.

We found a total of 37 Great Reed Warbler nests (14 in 2014, 23 in 2015). We found no difference in the number of Great Reed Warbler nests between the Starling roosting (n = 8.5 ± 2.12 (SD)) and non-roosting areas (n = 10.0 ± 4.24 (SD), Mann-Whitney U test, U = 1.50, P = 0.68). Nesting success was non-significantly lower in the Starling roosting area (mean Mayfield nesting success: 0.42 in 2014, 0.40 in 2015) than in the non-roosting area (0.55 in 2014, 0.54 in 2015, U = 152.50, P = 0.39). The overall daily survival of the eggs (J-test, z = 1.49, P = 0.13) and nestlings (z = 0.03, P = 0.97) also did not differ significantly between the roosting and non-roosting areas. However, during the exact roosting period (roosting and incubation coinciding), the daily survival rate of eggs was considerably higher in the non-roosting area (daily survival rate 0.98) than in the roosting area (daily survival rate 0.95, z = 3.10, P = 0.002). The daily survival of eggs was higher in the non-roosting area in 2014 (z = 3.04, P = 0.002), while there was no difference in daily egg survival between the two areas in 2015 ($z = 1.61$, $P = 0.11$), when the roosting area was larger.

DISCUSSION

This study provides preliminary results on the possible effects of roosting of Starlings on the clutch survival in a reed-nesting passerine. Although overall nesting success was non-significantly lower in roosting areas than in non-roosting areas, there was a significant difference when data from the period when roosting and incubation coincided were analysed. This result provides evidence for the negative effect of roosting on clutch survival and also suggests that a longer period with more roosting individuals during sensitive (incubation) periods may cause more damage to Great Reed Warbler clutches. This is supported by the findings that the daily survival of eggs was significantly lower in roosting areas during the exact roosting period in 2014, and that a similar mean number of individuals roosted on a smaller area in 2014 than in 2015. Previous studies conducted on this pond revealed considerably larger Mayfield nesting success (e.g. 0.69 in 2011) of the Great Reed Warbler when roosting of Starlings did not occur (Mérő et al. 2014, 2015). We suggest that the mechanism for the lower clutch survival in roosting areas was that predation increased as a result of the reed damages due to Starlings, which resulted in a better visibility and a higher exposure of the nests to predators such as the Little Bittern (*Ixobrychus minutus*) and Hooded Crow (*Corvus cornix*) (authors' personal observation). In a few cases, Great Reed Warblers also abandoned their nests with complete clutches in highly damaged patches of reed.

Our study is the first that draws attention to the possible negative effect of Starling roosting on clutch survival in reed-nesting birds, and thus, a comparison of our results with those of other studies is not possible. However, our suggestion that damage to reed by Starling roosting reduces reed quality, which is important for Great Reed Warbler nesting success, is supported by previous findings that show that weather-related and anthropogenic (e.g. reed management) factors can also influence clutch survival in this species. For example, the effects of reed burning in the non-breeding period considerably influence the availability of old reed (Mérő et al. 2014). However, Mérő et al. (2015) reported that mean reed density, i.e. vegetation structure, did not differ between the threatened and non-threatened areas during the nesting period. This suggests no differences in nesting success of the Great Reed Warbler between burnt and non-burnt areas, as reported earlier by Mérő et al. (2014). Stormy winds and large amounts of precipitation are able to flatten the reed similarly to roosting Starlings (personal observation), but these effects have never been investigated in detail from the aspect of clutch survival. The consequences of adverse weather have been explained in terms of increased predation, shortage of food sources or chick hypothermia due to nest abandonment (Fischer 1994; Mérő et al. 2014).

In conclusion, the significantly lower egg survival in the roosting area during roosting in 2014 supports the view that roosting can have negative effects on breeding success of reed-nesting passerines and suggests that an adequate density of roosting birds could further significantly decrease clutch survival. Although Starling roosting did not affect overall clutch survival and nesting success, it did so during the sensitive incubation period, and we thus suggest that longer-lasting roosting and/or roosting by more Starlings can have a more negative effect. For stronger conclusions, the effects of roosting should be further investigated not only on the Great Reed Warbler, but also on other reed-nesting birds.

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