Terrestrial Ecology and Behaviour
Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 68 (3), 2016: 363-366

Effects of Roosting Starlings, *Sturnus vulgaris* L., on the Nest Defence Behaviour of the Great Reed Warbler, *Acrocephalus arundinaceus* (L.) (Passeriformes)

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Abstract: We studied the effects of roosting starlings, *Sturnus vulgaris*, on the nest defence behaviour of great reed warbler, *Acrocephalus arundinaceus*, monogamous parents from 54 nests. A generalised linear mixed model was constructed to investigate the effects where the nest defence behaviour was the dependent variable and the independent variables were year (2011, 2014 and 2015), patch (roosting vs. non-roosting reed patches), sex and nest ID (as random effect). We found that the nest defence behaviour of great reed warblers was more intensive in years when starlings roosted. The significant interaction between year and patch indicated that the nest defence behaviour was more intensive in roosting reed patches. Similarly to previous studies, the females defended the nest more aggressively than the males. In conclusion, we suggest that nest defence behaviour of the great reed warbler in roosting areas might be influenced by various factors, e.g. the excessive noise of roosting starlings or the motion and density of birds in the vicinity of the nests.

Key words: roosting, *Sturnus vulgaris,* nest defence behaviour, *Acrocephalus arundinaceus,* reed density

Introduction

The nest defence behaviour of the great reed warbler, *Acrocephalus arundinaceus* (L.), has been extensively studied in terms of various nest predators and predation mechanisms (Kleindorfer *et al*. 2005, Trnka, Grim 2014a), cuckoo, *Cuculus canorus* (L.), parasitism (Honza, Moskát 2008, Moskát *et al*. 2008, 2009, Trnka, Grim 2014b), social mating system (Trnka, Prokop 2010), nest position and reed density (Mérő, Žuljević 2015). Whereas various tactics are used against predators (e.g. silent waiting or distraction, Mérő, Žuljević 2015), great reed warblers behave highly aggressively against cuckoos (Honza *et al*. 2010), even killing the parasite bird (Trnka, Grim 2013a, Mérő, Žuljević 2014). As regards the social mating system of the great reed warbler, the nest defence behaviour differs considerably between monogamous and polygynous pairs, and females have generally been found to be more aggressive than males (Trnka, Prokop 2010). However, the nest defence of males has been reported to be more aggressive than that of females when the intruder was a parasitising cuckoo (Požgayová *et al*. 2009). Furthermore, Trnka *et al*. (2013b) observed that great reed warbler females demonstrated high repeatability in nest defence behaviour across nesting seasons in contrast with males.

It is known that birds such as starlings, *Sturnus vulgaris* L., may roost in large flocks in reed beds (Mérő, Žuljević “2013/14) where, as a result of their weight and droppings, they can cause considerable damage to the reed beds (Meanley 1965), even flattening the reed stems (Haslam 2004). Mérő, Žuljević (2015) found that the nest defence behaviour of great reed warbler was more intensive in dense than in sparse reeds. The flattening of the stems may result in sparser reed, less concealed nests and a lower intensity of nest defence behaviour, which may lead in turn to lower nesting success because of the in-

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creased risk of predation (Trnka *et al*. 2009). To explore this issue, we studied the effects of roosting starlings on the nest defence behaviour of the great reed warbler.

The presence of roosting starlings was regularly recorded during the nesting seasons in May and June 2014 and 2015 at the Bager Pond (study area). We recorded the nest defence behaviour of the great reed warblers during regular nest checks involving a human intruder/nest predator (e.g. Hollander *et al*. 2008, Trnka, Prokop 2010). Previous findings led us to predict that the intensity of the nest defence behaviour of the great reed warbler parents would be lower in years when starlings roost and lower in the case of nests located in roosting reed patches.

Material and Methods

The study was conducted at the Bager Pond (N 45.788˚, E 19.098˚) in the region of Sombor (Serbia). For a detailed description of the study area, see Mérő *et al*. (2014, 2015). The present study compared the nesting seasons in 2014 and 2015, when the roosting of starlings was recorded, with the season 2011 as a control, when roosting was absent. During these three nesting seasons, the mean water depths and the amounts of precipitation varied similarly (Republic Hydro-meteorological Service of Serbia, Table 1). These conditions are important because the nesting density and breeding success of the great reed warbler have been shown to depend on these factors (Mérő *et al*. 2014). The main characteristics of the roosting of starlings are given in Table 1.

The fieldwork was conducted from May to July in 2011, 2014 and 2015, when the entire area of the pond was completely surveyed for nests. We identified altogether 54 monogamous great reed warbler nests (19 in 2011, 14 in 2014 and 21 in 2015), which were checked regularly at five-day intervals. We recorded the numbers of eggs and nestlings, the nest-losses due to the abandonment of nests, or egg or nestling predation, the nest defence behaviour of the great reed warbler parents and the numbers of roosting Starlings. In the present study we included nests of monogamous pairs, both with successfully raised broods and those which failed, while nests of polygynous males were excluded because monogamous males defend their nests more vigorously than polygynous males (Trnka, Prokop 2010). The presence of a cuckoo nestling was regarded as an average great reed warbler young, because the nest defence behaviour of the great reed warbler parents did not differ in the cases of cuckoo or great reed warbler nestlings (Honza *et al*. 2010). All nests were found in the egg-laying or incubation stage. To categorise the behaviour of the parents, we used scores ranging from 0 to 4 (Table 2) following Mérő, Žuljević (2015). Both sexes were marked using coloured rings. The birds were ringed at the beginning of the nesting season at the end of April and during May. Great reed warblers were attracted with male songs played from mobile devices, and captured with mist nets. During the regular nest checks, birds were identified via the codes on the colour rings with a camera. The boundaries between the roosting and the non-roosting areas were delineated with a handheld GPS receiver.

We constructed a generalised linear mixed model (GLMM), where the nest defence behaviour was the dependent variable (modelled as ordinal), and the year (2011, 2014 and 2015), patch (roosting vs. non-roosting patches), sex and nest ID were the independent variables. The nest ID was taken as a random effect in the GLMM in order to avoid pseudoreplication. Further, in the GLMM we tested the effects of interactions of the independent variables (e.g. year * patch) on the nest defence behaviour of the great reed warbler. Multi-collinearity was not observed among the independent variables; the variance inflation factors ranged from 1.01 to 1.39. The significance of the effects of the sexes in the nest defence behaviour was tested with t-test. Statistical analyses were implemented in SPSS 17.0 statistical software (SPSS Inc., Chicago, USA).

Results

In contrast with our predictions, we found that nest defence behaviour of the great reed warbler was influenced significantly by year and sex, and the interaction between year and patch (Table 3). Significant coefficient estimates showed that nest defence behaviour of the parents was more vigorous in years when starlings were roosting, and that the defence behaviour of the females was more aggressive than that of the males (t-test, $t_{125} = 3.65$, $p < 0.0001$). The interaction between year and patch indicated that the nest defence behaviour was more aggressive in years when Starlings were roosting in the roosting reed patches. However, other interactions did not influence nest defence behaviour (Table 3).

Discussion

Our results revealed that the nest defence behaviour of the great reed warbler was more intensive in the years when starlings were roosting than in the year

Table 1. Water depth at nest sites, precipitation amount during nesting season and main characteristics of the roosting patches of starlings

Year	Mean water depth (±SE)	Precipitation amount (mm)	Size of roosting area (ha)	Mean number (±SE) of roosting starlings	Estimated number of roosting starlings per hectare
2011	77 ± 26.9	146.4	-	-	-
2014	72 ± 6.7	212.2	0.15	197 ± 35.2	1 313
2015	80 ± 5.2	160.5	0.35	223 ± 53.7	637

Table 2. Nest defence behaviour scores and their description taken from Mérő, Žuljević (2015)

Score	Description of nest defence behaviour of great reed warblers
0	neither of parents was present
1	one or both of the parents were present, but silent at a distance of more than 3 m from the nest
2	parents gave alarm calls at a distance of more than 3 m from the nest
3	parents gave a loud alarm at a distance of between 1 and 3 m from the nest
4	parents gave a loud alarm at a distance of less than 1 m from the nest, or participated in a direct physical attack

Table 3. Results of generalised linear mixed-model (GLMM) testing main effects and interactions of the predictor variables on the nest defence behaviour of the great reed warblers.

Predictor variables		Coefficient ± SE	F value	df	*P* value
Main effects	Year	-0.29 ± 0.235	4.963	2	0.008
	Patch	-0.13 ± 0.213	0.200	1	0.655
	Sex	0.51 ± 0.262	19.157	1	< 0.0001
Interactions	Year * Patch	0.64 ± 0.340	4.161	1	0.042
	Year * Sex	0.07 ± 0.364	0.314	2	0.731
	Patch * Sex	-0.14 ± 0.347	0.998	1	0.319
	Year * Patch * Sex	-0.22 ± 0.514	0.187	1	0.665

when starling roosting was absent. The interaction between year and patch indicated that the great reed warblers defended their nests more strongly in the roosting patches. In previous studies, nest concealment and reed density proved to be positively related to nest defence behaviour, indicating that nests in dense reed were better protected than those in sparse reed (Mérő, Žuljević 2015). As a result of the flattening of the reed stems in the patches where starlings were roosting, the reed density became sparser and the nests of the great reed warbler in the roosting patches became more visible (authors' unpublished observation). In contrast with the results of Mérő, Žuljević (2015), in the present study the great reed warblers defended their nests more aggressively in the starling-caused sparse reed than in the intact denser reed. We therefore assume that the enhanced nest defence behaviour in roosting years and patches might be influenced, for example, by the excessive noise of roosting birds or the motion and density of birds in the vicinity of the great reed warbler nests. However, for proper conclusions in this respect, further specific studies are needed.

Similarly to Trnka, Prokop (2010), Trnka, Grim (2013b) and Mérő, Žuljević (2015), we found that females defended the nests more aggressively than males. A number of factors can influence the nest defence behaviour of the sexes of this species, resulting in differences in aggressiveness of males and females (e.g. Požgayová *et al*. 2009). For example, polygynous males which simultaneously have two or more active nests defend their nests less vigorously than monogamous males. The nest defence behaviour of females in both mating statuses is similar, indicating a greater difference in aggressiveness between a polygynous male and its females than within a monogamous pair (Trnka, Prokop 2010). Furthermore, the female nest defence behaviour is found to be independent of the presence or absence of the male partner, while monogamous males do not compensate for when the females are absent (Trnka, Grim 2013). These previous findings suggest that several factors can influence the nest defence behaviour of the great reed warbler, and therefore result in significant differences between the sexes in nesting seasons when the roosting of starlings was present.

This issue must be properly clarified in future studies. For example, starling dummies might be placed in or above great reed warbler nests in both roosting and non-roosting patches. If various numbers of dummies are placed per nest, the effects of the density of roosting birds on the nest defence behaviour could be studied.

In conclusion, the nest defence behaviour of the great reed warbler was found to be more intensive in years when starlings roosted and highest in the case of nests located in roosting patches. We assume that various factors may play a role in the nest defence behaviour of great reed warblers in roosting patches, e.g. the excessive noise of roosting starlings or their motion and density in the vicinity of the nests. As reported in previous studies females exhibit significantly more aggressive nest defence behaviour, but we suggest that this is not a constant pattern: the study by Požgayová *et al*. (2009) revealed that males displayed more intensive nest defence behaviour than females against the parasitising cuckoo.

Acknowledgements: This study was supported by the Nature Protection and Study Society – NATURA from Sombor (Serbia). T.O.M. was funded by a grant from the National Scientific Research Base Programs of Hungary (OTKA K106133).

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Received: 24.09.2015
Accepted: 16.12.2015