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## Experiments with artificial nests on predation in reed habitats

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**Abstract** We performed nest predation experiments with artificial nests in reedbeds investigating whether nest predation pressure is different at the water-reed edge and the grassland-reed edge compared with the reed interior. Furthermore, we tested the effects of vegetation structure (reed density, height and thickness) and the effect of other nest site characteristics (distance from edge, water depth) on the success of artificial nests. The experiments were completed 3 times during the breeding season in 2001 at Lake Neusiedl, Austria. Each artificial nest resembled Great Reed Warbler (*Acrocephalus arundinaceus*) nests and contained one plasticine and one Quail (*Coturnix coturnix*) egg and the predators were identified by marks left on the eggs. The potential predators were birds, probably the Marsh Harrier (*Circus aeruginosus*), gulls (*Larus* spp.) and reed warblers (*Acrocephalus* spp.). Nest survival data were analysed using the Mayfield method, and we performed a discriminant analysis for the data of vegetation and nest site characteristics. The nest predation was higher at the edges than in the reed interior, and was most pronounced in April, before the new reed sprouted. The reason for this finding was probably that after May the new reed contributed to greater concealment of the nests through the higher reed density and height.

**Keywords** Concealment · Edge effect · Mayfield method · Nest site · Vegetation structure

### Introduction

Fragmentation may be one of the most serious problems in nature conservation. Several studies have shown that there is a negative impact of fragmentation on breeding success of birds (Gates and Gysel 1978; Wilcove 1985; Andrén and Angelstam 1988; Murcia 1995; Robinson et al. 1995; Keyser et al. 1998). As well as reducing the total area of the original habitat, fragmentation also increases the extent of habitat edge (Gates and Gysel 1978; Murcia 1995). As a consequence, edge-related predation and brood parasitism may decrease nest success at habitat edges (Brittingham and Temple 1983; Wilcove 1985). These factors may be responsible for the population decline of many North American neotropical, migratory songbirds (e.g. Askins 1995). More recent reviews on nest predation also seem to support the hypothesis of increased predation along habitat edges (Paton 1994; Andrén 1995; Hartley and Hunter 1998; Manolis et al. 2000). However, most of the nest predation studies focused on field-forest edges (Andrén 1995), and little work has addressed nest predation in non-forested habitats, such as reedbeds (exceptions: Hoi and Winkler 1988, 1994; Honza et al. 1998; Kristiansen 1998; Báldi and Batáry 2000; Hansson et al. 2000).

The few previous studies showed contradictory results in the distribution of nest predation rate. Higher nest predation at the edges were reported by Hoi and Winkler (1988) and Kristiansen (1998), a non significant but lower predation at the edge by Honza et al. (1998), while the six experiments at three sites by Báldi and Batáry (2000) resulted in contradictory outcomes. Our hypothesis was that there is an edge effect in the nest survival rates of artificial nests on water-reed and on grassland-reed edges. We also tested the effects of vegetation characteristics and nest concealment on the

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success of artificial nests. We predicted that greater nest concealment results in higher nest survival.

## Methods

Our study was conducted during April, May and June 2001 in eastern Austria at Lake Neusiedl, in the area of Neusiedler See-Seewinkel National Park (47°56'N, 16°45'E). As mentioned above, we made our investigation on both edges of the reedbed, so the first study site was at the grassland-reedbed edge, which was a gradual edge between the meadow and the reed. On this site, there was low and sparse reed next to the grassland, growing higher and denser towards the interior. The other edge, which was between the water and reed, was a genuine sharp edge with the highest reed stems. The third site was situated in a 2-km wide reedbed with an edge along a canal with a high density of reed stems.

We used artificial nests, which give sufficient information for comparative purposes (Major and Kendal 1996). Artificial passerine nests were made of chicken wire and lined with grass, resembling in size and appearance the nest of Great Reed Warbler (*Acrocephalus arundinaceus*). The studies of Martin (1987) and Matessi and Bogliani (1999) showed that the predation rate of such artificial nests proved to be similar to real nests. The nests contained one fresh Quail (*Coturnix coturnix*) and one plasticine egg; the latter similar in size and shape to a Great Reed Warbler's egg. In the last week of April, 40 artificial nests were laid out at a height of 60 cm at each site. We repeated the experiments in May (2 weeks after the first experiment) and June (2 weeks after the experiment in May) at the same sites, but nests were placed in different locations. So, altogether 360 nests were exposed for 2 or 3 days, exceptionally for 4 days. We left at least 30 m between any two nests. A nest was considered predated if at least one of the eggs showed any sign of damage or had disappeared. Three nests were excluded from the analyses because it turned out that these nests had not been properly fixed, and one nest disappeared.

At each nest, we measured the distance from the edge (in the interior the distance from the canal) and the water depth (only at the water-reed edge). We also recorded some parameters

of the vegetation which were the followings: reed density, height and thickness (the latter only after April). Reed density was measured by introducing a 0.5-m-long stick into the reed next to the nest, then the number of reed stems touching the stick were counted. The mean reed height was assessed around the nest, and we measured the reed thickness of ten randomly chosen stems with a caliper. From May onwards, when the new reed stems began to appear, we separately measured the density and height of the old and new reed stems.

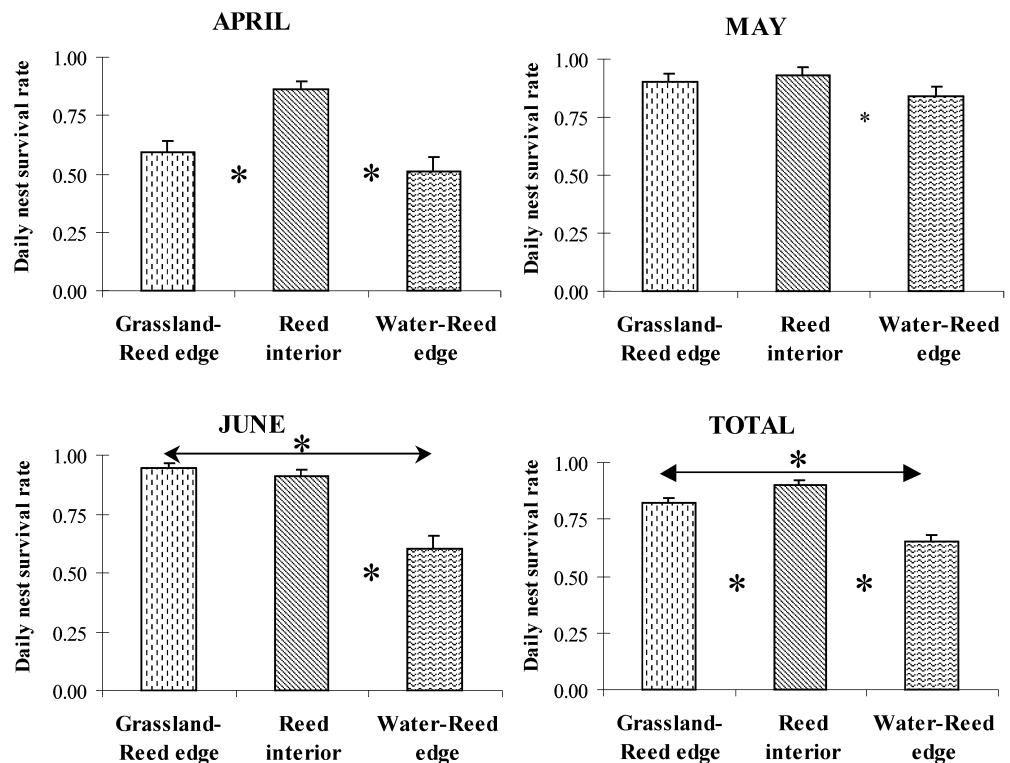
Using the Mayfield method we calculated the daily nest survival rates (Mayfield 1975). Then these rates were compared between sites and between months according to Hensler and Nichols (1981) using the *z*-test. The effect of vegetation characteristics (and distance from edge; water depth) on nest predation was examined by performing a standard discriminant analysis for all the nests, where the grouping variable was the condition of the nests after the experiments (predated or nonpredated). We also computed discriminant analyses for each site in each month. The calculations were made using Statistica software (StatSoft 1995).

We assumed that small-mouthed predators (small rodents) could be effective predators of small passerine birds' nests. For that reason, we prepared plasticine eggs (smaller than Quail eggs) to demonstrate the predation of small mammals (and other animals). We tried to identify the predators on the basis of the clues left on the plasticine and/or Quail eggs.

## Results

Overall, nearly half the nests (42%; 150 of 356) were considered as predated. We found that the survival rates at the edges were lower in April, when we compared the daily nest survival rates with the *z*-test (Fig. 1). At the grassland-reed edge the difference in survival between the edge and interior disappeared from May onwards, while at the water-reed edge it remained detectable through the whole season.

**Fig. 1** Daily survival rates of artificial nests at Lake Neusiedl, Austria, during April, May, and June, and for the pooled data. Asterisks indicate significant differences between edge and interior or differences between the edges. Large asterisks  $P < 0.05$ , small asterisks  $P < 0.1$



Interestingly, the two edges were significantly different in June. At the water-reed edge three-quarters of the artificial nests were predated, compared with only 15% of the nests at the grassland-reed edge. If we pooled all data, we found a significant difference between edges and interior, and also that the nests at the water-reed edge survived the least well (Fig. 1).

We also compared the seasonal changes of the daily nest survival rates at every site (Fig. 2). We did not find any differences at the reed interior, but there was a significant difference at the edges between April and May. The nest predation increased again after May at the grassland-reed edge. However, at the water-reed edge the predation decreased. After pooling the data, there was a marked increase in survival from April to May, and a slight decline from May to June.

We applied a standard discriminant analysis for the vegetation characteristics and water depth and distance from edge. When we performed this analysis for all nests, we found a significant difference between the predated and intact nests (Wilks' Lambda: 0.715;  $F_{8,347} = 17.261$ ;  $P \ll 0.0001$ ). Four parameters contributed significantly to this difference: water depth ( $P \ll 0.0001$ ), height of new reed ( $P < 0.01$ ), and density of new ( $P < 0.01$ ) and old reed ( $P < 0.1$ ). The non-predated nests were situated next to shallower water, and to denser and higher reed. When we repeated this discriminant analysis at the three sites for each month, we found significant differences between the predated and non-predated nests only in April at every site (Table 1). In the table those variables are also shown which significantly

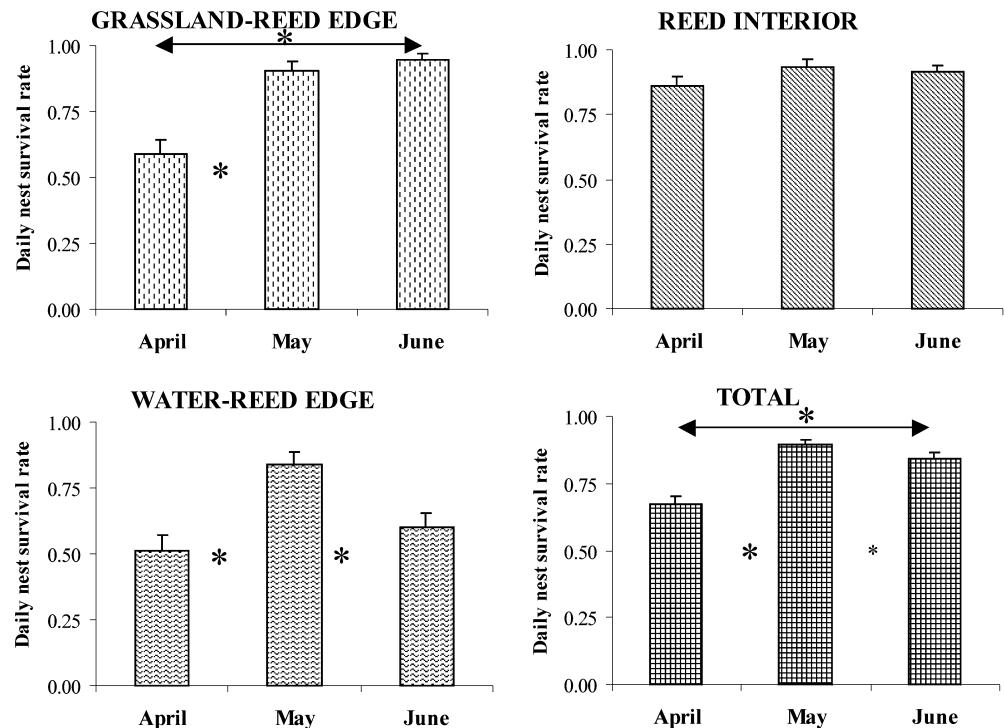
contributed to this difference, where with the exception of the water depth, the values were higher at the intact nests.

We recognised three categories of predator species based on the clues left on the eggs: (1) large bird predator; (2) small bird predator, and (3) mammalian predator. More than two-thirds of the identified nest predators (94/125) were large birds, the other predators were mainly small birds (26/125), and predation by mammals (5/125) was very incidental. The potential large bird predators are Black-headed Gull (*Larus ridibundus*), Caspian Gull (*Larus cachinnans*), Marsh Harrier (*Circus aeruginosus*) and corvids (*Corvus* spp.). The interestingly high small bird predation is probably caused by reed birds, such as Great Reed Warbler and Reed Warbler (*A. scirpaceus*). The potential mammalian predators are Wood Mice (*Apodemus* spp.), or Harvest Mouse (*Micromys minutus*). All of the potential predator species occurred in the experimental area.

## Discussion

The first reviews (Paton 1994; Andrén 1995) found a nest predation edge effect. However, more recently Lahti (2001) concluded in his review that there is no increase in nest predation rates near habitat edges. Báldi and Batáry (2000) did not find an edge effect in nest predation for reed habitat in four of their six experiments. In our study, we found a significant edge effect on nest predation of artificial nests at both edges in April. However, this phenomenon remained pronounced through the

**Fig. 2** Seasonality in nest success at Lake Neusiedl, Austria, at grassland-reed and water-reed edges, at reed interior and for the pooled nest data. Asterisks indicate differences between the months. Large asterisks  $P < 0.05$ , small asterisks  $P < 0.1$



**Table 1** Results of discriminant analyses for each site in each month. The grouping variable was the condition of the nests after the experiments (predated or non-predated). In the upper cells the value of Wilks' Lambda, the  $F$ -value and the level of significance is presented. In the lower cells only those variables are shown which

		April	May	June
Grassland-reed edge	Wilks' Lambda	0.431; $F_{3,36} = 15.801$ ; $P \ll 0.0001$	0.658; $F_{6,33} = 2.860$ ; n.s.	0.949; $F_{6,33} = 0.298$ ; n.s.
	Density of old reed	$F = 46.521$ ; $P \ll 0.0001$	-	-
Reed interior	Wilks' Lambda	0.609; $F_{3,34} = 7.287$ ; $P < 0.001$	0.972; $F_{6,33} = 0.157$ ; n.s.	0.751; $F_{6,32} = 1.772$ ; n.s.
	Density of old reed	$F = 6.337$ ; $P < 0.05$	-	-
	Height of old reed	$F = 4.509$ ; $P < 0.05$	-	-
Water-reed edge	Wilks' Lambda	0.568; $F_{4,34} = 6.475$ ; $P < 0.001$	0.897; $F_{7,32} = 0.527$ ; n.s.	0.629; $F_{7,32} = 2.701$ ; n.s.
	Water depth	$F = 16.748$ ; $P < 0.0001$	-	-
	Distance from edge	$F = 6.400$ ; $P < 0.05$	-	-

whole season only at the sharper water-reed edge. We agree with Angelstam's (1986) hypothesis, which suggests that nest predation is most likely to occur where there is a steepness of productivity gradient between the habitat patch and its matrix, and less likely to occur if this gradient is less pronounced.

Hoi and Winkler (1988, 1994) found in their experiments, performed in the reedbeds of Lake Neusiedl, that the rate of nest depredation on passerine nests show a seasonal trend, which is related to nest density. They showed the highest predation rate in early June, and this pattern was confirmed by Hoi et al. (2001). However, Honza et al. (1998) did not find a significant change in the proportion of unsuccessful nests during the breeding season. The reason of this stability could be the fewer disturbances from the matrixes, and the homogenous vegetation of the reed interior. At the grassland-reed edge, where the reed density and height was least, the new reed probably caused the highest change in the visibility of nests. However, on the water-reed edge the nest survival rate in June was again very low, which agrees with the findings of Hoi et al. (2001), who found that the nest predation of reedbed birds is highest in June. Ferguson (1994) also found the same pattern on Red Bishop's (*Euplectes orix*) nests in South African reedbeds.

The visibility and the availability of the nests influence nest success. Ferguson (1994) could not show a significant correlation between brood survival and characteristics of the reed; only the distance from edge of reeds correlated strongly with breeding success. Honza et al. (1998) found a statistically not significant, but positive, correlation between clutch survival and nest height of reed birds above ground or water surface, but there was no difference in the other nest site characteristics. However, we found that especially reed height and density are the most important variables. We think that the newly sprouting reed, which increased the concealment of the artificial nests, could cause higher nest survival rates starting in May. The effects of reed characteristics on nest survival are important mainly in April, before the new reed grows, which strongly affects the finding of the nests by visually searching predators, e.g. birds. An additional

contributed significantly to the difference of the model. With exception of water depth, values of each variable were higher at the intact nests. The  $F$ -value for a variable is a measure of the extent to which a variable makes a unique contribution to the prediction of group membership

possible explanation is that the higher densities of real nests in the interior, especially in May, obscure edge effects.

Finally, we had to deal with some methodological problems in relation to the identification of predators: (1) there were nests, where both eggs disappeared; (2) we could not identify all of the clues; (3) we found some nests which were predated by more than one predator species; and (4) the identification of predators was in several cases ambiguous.

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