



# **Study of edge effect on nest predation**

PhD thesis

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Debrecen, 2004.

## 1. INTRODUCTION

Recently the destruction of original, natural habitats has progressed rapidly. The main expression of this habitat destruction is fragmentation, which means the formation of a former extensive habitat to several small spots with smaller total area and isolation of spots (WILCOVE et al., 1986; MEFFE & CARROLL, 1994; BÁLDI, 1996). The small, isolated population created by fragmentation can become extinct with great chance because of genetic, demographic, environmental stochastic incidents or catastrophes. Furthermore, the harmful effects of matrix around the spot of habitat can also lead to extinction (WILCOVE et al., 1986).

When a spot of the original habitat become desolate, then the part of the rest habitat bordered by the open area (i.e. edge) faces with new environmental factors. In the edges the microenvironmental factors are different, which directly influence the structure of vegetation and through this indirectly the occurrence of animals and the interaction between them (BÁLDI & KISBENEDEK, 1999). The edge effects can be ranked into three classes (MURCIA, 1995): 1.) abiotic effects arise from the nearness of structurally different matrix, which borders the habitat spot; 2.) direct biotic effects mean the change in the abundance and distribution of the species because of the direct, physical neighbourhood of the edge (e.g. for desiccation, for wind, for higher density of vegetation). This is determined by the physiological tolerance of the species and by the distance from the edge. 3.) The indirect biotic effects mean the change of the interaction between the animals, such as predation, nest parasitism, competition, herbivoria, pollination by animals or zoochory seed dissemination.

The experiments with artificial nests can be divided to two large groups: in one of the groups the nest survival and nest predation are studied on the nests of individuals of given bird species or taxon. In the other case artificial or in other words dummy nests are made, and put out to the experimental area in convenient arrangement with eggs. The nests are controlled in determined periods to measure the nest predation.

According to the majority of former studies, nest predation is higher at habitat edges than at interiors. The ecological trap hypothesis states that songbirds often choose nest sites at the edges because of better conditions for nest building and/or better possibility for feeding (GATES & GYSEL, 1978). All of these indicate higher density of preys for predators and so it results in decrease of nesting success (MØLLER, 1989; STORCH, 1990). Some studies refute the higher nest predation rates at habitat edges (ANGELSTAM, 1986; RATTI & REESE, 1988), however, according to the reviews the nest predation increases at the edges (ANDRÉN, 1995;

PATON, 1994; HARTLEY & HUNTER, 1998). In our review, our main aims were to (1) conduct a meta-analysis of the primary edge effect studies to test whether nest predation rates were higher near edges than in the interior; (2) explore edge effect patterns across geographical locations, vegetation types, nest and egg types, and exposure times; and (3) quantify how nest predation rates changed in relation to distance from the edge.

Most of the nest predation studies focused on field – forest edges (ANDRÉN, 1995), and little work has addressed nest predation in non-forested habitats, as reedbeds (HOI & WINKLER, 1988, 1994; HONZA et al., 1998; KRISTIANSEN, 1998; BÁLDI & 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 & WINKLER (1988) and KRISTIANSEN (1998), a non significant but lower predation at the edge by HONZA et al. (1998), while the 6 experiments at three sites by BÁLDI & BATÁRY (2000) resulted in contradictory outcomes. For this reason we made investigations on nest predation in the reedbeds of Lake Neusiedl. 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. Beside, we also tested the effects of vegetation characteristics and nest concealment on the success of artificial nests. We predicted that greater nest concealment results in higher nest survival.

Most recent papers support the view of MAJOR & KENDAL's review (1996), that artificial nest studies are strongly biased for providing absolute nest predation rates, but are generally sufficient for relative assessment, e.g. to compare nest predation levels in different habitats (WILSON et al., 1998; BULER & HAMILTON, 2000; DION et al., 2000; but see DAVIDSON & BOLLINGER, 2000; PÄRT & WRETENBERG, 2002; THOMPSON & BURHANS, 2004). Marshes and wetlands are strongly threatened habitats, so it is important to study the reproduction of marshland-birds in the point of view of nature conservation too. There are studies investigating the nest predation of marsh-nesting passerines (ILLE et al., 1996; JOBIN & PICMAN, 1997; HONZA et al., 1998; EISING et al., 2001; SAWIN et al., 2003), however most of them were based on either real or dummy nests (exceptions: HANSSON et al., 2000; HOI et al., 2001). The purposes of our study were: 1) to describe the breeding parameters of Great Reed Warbler (*Acrocephalus arundinaceus*) at Lake Velence, Hungary; 2) to compare the survival rates of real and artificial nests in the mid- and late breeding season and 3) to compare the nest site characteristics of successful and not successful real and artificial nests in the mid- and late breeding season.

In our last study we compared the nest predation in edge and interior of four European reedbeds. We chose this habitat because it is seriously diminishing in West-Europe

(OSTENDORP, 1989, HAWKE & JOSÉ, 1996), and harbours a unique and specific biota (HAWKE & JOSÉ, 1996), including bird species declining in West-Europe, like the Bittern (*Botaurus stellaris*), Sedge Warbler (*Acrocephalus schoenobaenus*), Great Reed Warbler (*A. arundinaceus*) and Savi's Warbler (*Locustella luscinioides*) (HAGEMEIJER & BLAIR, 1997). Our aims in this study were to describe nest predation pattern in reedbed edges and interiors using artificial passerine nests, and evaluate the results for conservation purposes.

## 2. METHODS

We used three datasets in our meta-analysis: (1) a set of peer-reviewed papers chosen based on an extensive literature search from 1972 to 1999 in three large databases (Ecology Abstracts, Biosis, and ISI); (2) data from our own published and unpublished experiments; and (3) studies used by PATON (1994), although we excluded three of papers PATON used that presented insufficient data for our analysis. We selected studies that measured nest predation and provided information on distance from edges. Due to the large diversity of experimental designs, we recalculated nest-predation estimates for all studies to obtain reliable and comparable results. Then we conducted a likelihood-ratio chi-square test for each experiment to determine statistical significance of homogeneity of predation across the edge. Afterwards we estimated the effect size from the *p*-value in some steps. Effect size is a statistical measure that portrays the degree to which a given event is present in a sample. To better understand the variations in edge effect, we segregated experiments into several categories including geographical location, landscape type, vegetation type of studied edges and that of the adjoining edges, nest and egg type, and exposure time. We investigated how much nest predation increased for each unit change in distance to an edge. Furthermore we tested ANGELSTAM's (1986) hypothesis, which suggests that edge effects are most likely to occur where there are marked contrasts in the productivity gradient between the habitat patch and its matrix (sharp edges, e.g., forest to field).

Our study was conducted during April, May and June in 2001 at the Lake Neusiedl, in Austria. We made our investigation on both edges of the reedbed as well as in the reed interior with artificial nests resembling the nest of Great Reed Warbler nest, into which we put one Quail and one plasticine 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 and June too. Between two nests we left at least 30 meters distance. A nest was considered predated if at least one of

the eggs showed any sign of damage or had disappeared. At each nest we measured the distance from the edge (in the interior the distance from the canal), the water depth (only at the water – reed edge), the reed-density, the reed-height and the reed-thickness. Using the Mayfield-method we calculated the daily nest survival rates, which we compared with the  $z$ -test.

In 2002 we investigated the breeding phenology (number and size of eggs, number of hatched and fledged nestlings) of Great Reed Warbler at Lake Velence, in Hungary, and we recorded certain vegetation parameters with the same method (besides the distance from the edge and the water depth as well). We also placed out artificial nests next to each real nest at a distance of ca. 30 meters, when the real nest next to it contained at least the first egg and it was collected after the closing of breeding of the real nest. We collected an artificial nest, when the real nest next to it fledged or failed. An artificial nest was controlled on the same day, when the Great Reed Warbler nest next to it. A dummy nest was considered successful, if both eggs were found, and none of them showed any sign of damage (when the real nest fledged). At each artificial nest the same reed parameters, the distance from the edge and the water depth were also recorded. In July we performed other nest predation experiment using the abandoned Great Reed Warbler's nests and artificial nests. The dummy nests were put out next to the real nests as earlier described. Both types of nests contained one Quail and one plasticine egg. After a 6-8 days exposure we collected all of the nests. Using the Mayfield nest survival method we calculated the daily survival rates for both experiments and nest types, which were compared between the real and artificial nests and between the two experiments with the  $z$ -test. The effect of vegetation characteristics as well the distance from edge and the water depth on nest survival was examined by performing discriminant analyses.

In the course of our last study we compared with meta-analyses our experiments done in reed habitats with artificial nests. We placed out nests made of chicken wire and lined with dry grasses and reed flowers. In size and appearance the nests resembled Great Reed Warbler (*Acrocephalus arundinaceus*) nests. The nests were fixed to two reed stems 30–60 cm high. Each nest contained one Quail and one plasticine egg, the latter was similar in size to the Great Reed Warbler's egg. Exposure times were different. A nest was predated, if at least one of the eggs was missing or damaged. Besides investigating edge effect, we also performed edge – edge and interior – interior comparisons.

### 3. RESULTS

Conducting the summary meta-analysis for the 64 experiments we found a significant positive edge effect, with more nests depredated in the edges than in the interiors. The categorical meta-analysis detected an overall edge effect in experiments in North America and northwest Europe, but no edge effect was found in Central America and central Europe. Using better resolution, however, marsh and deciduous forest edges had increased nest losses compared with the interior habitats, whereas coniferous forests, tropical forests, and fields had no significant edge effect. The adjoining habitat to the studied edge was related to nest-predation edge effect only when the adjoining habitat was a field. There was great variability in the results on nest and egg types. Ground and natural nest studies and studies with quail or real eggs generally showed edge effects. Edge effects were not significant with artificial nests exposed for typical incubation periods but were significant when nests were exposed for shorter periods and when natural nest were used in experiments. Distance from edge had a significant effect on nest predation rates. The largest effect size was for nests in 0-24.9 m distance category. Edge effects disappeared when experiments with nests in the first 50 m of the edge were excluded. Therefore, edge effects were most pronounced within the first 50 m from the edge. Our results confirmed ANGELSTAM's (1986) hypothesis: edge effect occurred at "sharp" edges but not at "soft" edges.

Overall, nearly half of the nests 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. At the grassland – reed edge the difference in survival between the edge and interior disappeared from May on, on the water – reed edge it remained detectable through the whole season. Interestingly, the two edges were significantly different in June, while at the water – reed edge the three quarter of the artificial nests were depredated, at the grassland – reed edge only 15 % of the nests were predated. If we pooled all data, we found a significant difference between edges and interior, and that the nests at the water – reed edge survived the least. We also compared the seasonal changes of the daily nest survival rates at every site. 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. Then 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. Four parameters contributed significantly to this difference: water depth, height of new reed, density of new and old reed. The non-predated nests were situated next to shallower water, and 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.

Of the 25 Great Reed Warbler nests, 13 were destroyed by predators, 11 were classified as successful and 1 nest was considered as deserted. Comparing the laying date with the nest survival of Great Reed Warbler's nests, we found that the survived nests were begun significantly earlier than the not survived nests. The survival of the artificial nests in May was significantly lower than the survival of the Great Reed Warbler's nests. We also found a similar difference between the abandoned and artificial nests in July, however we could not show any differences between the two experiments comparing the survival of the real nests and abandoned real nests and comparing the survival of the artificial nests. The results of the discriminant analyses show that the characteristics of survived and not survived nests are different, but only in the early season. The survival of the Great Reed Warbler nests were higher in taller reed and at shallower water. Density and the height of new reed was higher at the survived artificial nests in May. The other discriminant analyses in the late season did not result difference between the survived and not survived nests.

Altogether 175 (52 %) of the 337 nests were depredated. Nest losses showed great variation regarding site and time. Conducting the summary meta-analysis no edge effect was found, i.e. the nest predation at edges and in interiors was not different significantly. This tendency is in contradiction with expectations, although the predation pressure was lower in the interior of reed habitats than in the edges. The meta-analysis revealed an interesting pattern, however, the cumulative absolute effect size of edge – edge comparisons was larger than that of interior – interior comparisons. In the case of edge – edge comparison the larger effect size means that in this case there were larger differences in nest survival. Therefore, an interesting pattern of survival rate was found: small variation in the interior habitats and large variation at the edges

#### **4. DISCUSSION**

We reviewed papers on the relationship between nest predation rates and distance from

an edge and applied a meta-analysis. Our results support past reviews that showed increased nest predation at habitat edges, primarily within 50 m of an edge (PATON, 1994; HARTLEY & HUNTER, 1998). Regarding the diversity of geographic locations, edge types, landscapes, and other variables our results point to the key role of edge effect in landscape planning. We also showed that nest predation declined from the edge to the interior and disappeared, if the first 50 m was excluded.

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 only at the more sharp water – reed edge through the whole season. We agree with Angelstam's hypothesis (ANGELSTAM, 1986), 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. Furthermore 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 beginning 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.

We described the breeding phenology of Great Reed Warbler, similar parameters were found by MOSKÁT & HONZA (2002) around Bugyi, Apaj and Kiskunlacháza (40 km south of Budapest, Hungary). We found that the early nesting Great Reed Warblers reproduce better than late birds probably due to the early ones nesting in the reed edges with taller reed, so they can reduce the chance of nest predation due to the better cover and smaller visibility. The daily survival rate of dummy nests was significantly lower than the rate of real nests both in May and July. Many comparative studies show that the loss of the artificial nests is significantly higher than the loss of real nests (e.g. WILSON et al., 1998; DAVIDSON & BOLLINGER, 2000; BERRY & LILL, 2003; BOULTON & CLARKE, 2003), however, there are some investigations, which found lower predation on dummy nests than real nests (e.g. ROBEL et al., 2003) or no difference between the natural and the artificial nests (e.g. GREGOIRE et al., 2003). The survived Great Reed Warbler nests and the artificial nests in May were situated in higher reed, whereas the density of the reedstems was higher only in the case of the dummy nests. In the late season we could not show difference in the investigated nest site characteristics between the survived and not survived nests. This finding is similar to the results of BATÁRY et al. (2004), which showed that the effects of reed characteristics on nest survival are important mainly in April, before the new reed grows up. According to our results



we think that the Great Reed Warbler, one of the most threatened “edge living” marshland bird perhaps has to wait until the new reedstems begin to grow up to choose the best nesting place. So this could be one of the reasons, that the Great Reed Warbler arrive the latest from the Hungarian reed warblers (*Acrocephalus spp.*) (MOSKÁT & BÁLDI, 1999).

The absence of nest predation edge effect contradicts to the conventional wisdom of increased nest predation rates in the edges (reviews: PATON, 1994; ANDRÉN, 1995; HARTLEY & HUNTER, 1998; MANOLIS et al., 2000). However, most of the studies were conducted in forest edges. The smaller absolute effect size of interior – interior, than edge – edge comparisons reveals small variation in the interior, and large variation in the edge nest predation rates. Reedbed interiors are probably dominated by reedbed characteristic predation rates, while the large variation in nest losses among edges suggests that edges may have been dominated not by the habitat, but by the local, site-specific factors, which are dependent on landscape type and structure (DONOVAN et al., 1997), and geographic position.

## 5. PUBLICATIONS IN CONNECTIONS WITH THIS THESIS

### Articles:

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*Other publications:*

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## **6. PUBLICATIONS NOT IN THE RANGE OF THIS THESIS**

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References mentioned in the thesis can be found in the detailed version of PhD thesis.