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Microclimate and vegetation edge effects in a reedbed in Hungary

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Abstract. The aim of the study was to describe microclimate (surface and air temperature, humidity, light and wind intensity) and vegetation structure (density and height of reeds, and reed shoot structure) across the first 20 m of a sharp reedbed edge at Lake Velence, Hungary, in June 1996. There was a significant edge effect, although different variables contributed differently to the pattern. The reedbed edge had three bands: the first is characterised by very dense stand, where the shoots were thin and short; in the second band density declined, but reed shoots were thick and very high, and in the third band both density and height declined, but not shoot diameter. Microclimate variables showed similar pattern: reedbed edges were warm, dry, bright and windy, further inside temperature, light and wind intensity declined, humidity increased, and still further temperature and light intensity increased, and humidity decreased. I estimated that the edge effect penetrates into the reedbed up to ca. 15 m. The great variation of variables across the edge inevitable has significant impact on the occurrence of animals species; our knowledge, however, is too limited to predict the expected extinction of species owing to edge effect.

Key words: conservation, fragmentation, microclimate, reedbed, vegetation structure

Introduction

The effect of habitat fragmentation on the distribution of organisms is a key issue in conservation biology. Fragmentation implies that the originally continuous habitat transforms into several isolated remnant patches, and the area of the original habitat decreases (e.g., Meffe and Carroll 1994). In addition, the original habitat contracts even more than the topographic area of the remnant patches, because of the edge effect (review: Murcia 1995). This effect means that vegetation and the related species in the edges of habitat patches may differ from those in the interior habitats, owing to, for example, microenvironmental gradients. As patch area decreases, the proportion of edge increases. In forest patches this width is usually estimated to be ca. 50 m (Young and Mitchell 1994; Murcia 1995). If the shape of the patch is not circular, and it usually is not in real landscapes, the interior area decreases even more, or may disappear from even a seemingly large habitat patch. Therefore, the final extent of the original habitat strongly depends on the area and shape of the patches. To examine the structure and width of edges in different habitats may significantly contribute to the design and management of fragmented landscapes.

Although reedbeds are an important and diminishing conservation habitat, 'edge-studies' have focused almost entirely on forest edges (e.g., Murcia 1995). The lack of data from reedbed edges is surprising, since wetlands are declining at the fastest rate of any habitat on earth (Williams 1993). Central Europe is especially suffering from reed decline (van der Putten 1994). Reedbeds are important for nature conservation because they harbour special wildlife, and, in addition, they are economically important (e.g., Hawke and José 1996). Former investigations on reedbeds focused mainly on production biology (e.g., Dykyjová 1971), on species attacking reed shoots (e.g., Skuhravy 1981; Tscharntke 1989, 1992a), and on conservation and management of reed habitats (e.g., Gryseels 1989; Cowie et al. 1992; Ditlhogo et al. 1992; Hawke and José 1996). There are few investigations on the effects of fragmentation on some taxa (Tscharntke 1992b; Báldi and Kisbenedek 1998). Tscharntke (1992b) considered that fragmentation of reedbeds cannot be assessed by area alone.

In this study I describe microclimate and vegetation edge effects, which may be key factors determining the presence of animal species.

Study area and methods

The study was conducted at a large (>700 ha) reedbed of Lake Velence, called Bird Reserve (Hungary, 47°10′ N, 18°32′ E). The vegetation association was a floating reedbed, composed almost entirely of reed (*Phragmites australis* Trin.). The reed–water edge was sharp. Three transects were selected with similar (NW) exposure, about 100 m from each other. The transects were perpendicular to the edge of the reedbed, and they were 20 m long (Figure 1). Samples were taken at every metre from the outermost edge of the reedbed in June 1996. Altogether there were $3 \times 21 = 63$ sample points. I measured microclimatic variables: surface temperature, air temperature, relative humidity, light intensity and wind speed, and reed vegetation structure variables: density of last year's reed and new sprouting reeds, height of last year's and new sprouting reeds, number of nodes, leaves and the diameter of stems (Table 1).

The significance of edge effect was tested using MANOVA, after logarithmic transformation of those variables that violated the normality assumption. I used the SPSS/PC+ program package (Norusis 1990). The group means were compared by the T-method, also known as Tukey's honestly significant difference method (Sokal and Rohlf 1981).

Results

I rejected the null hypothesis that distance has no effect on the variables (MANOVA, multivariate test of significance: Hotelling's $T^2 = 35.468$, $df = 240$, $P < 0.0005$). The variation of SURFACETP, DENSOLD, HEIGHTOLD, NODES, LEAVES, and DIAMETER did not contribute to the edge effect (Table 2). Based on the observed

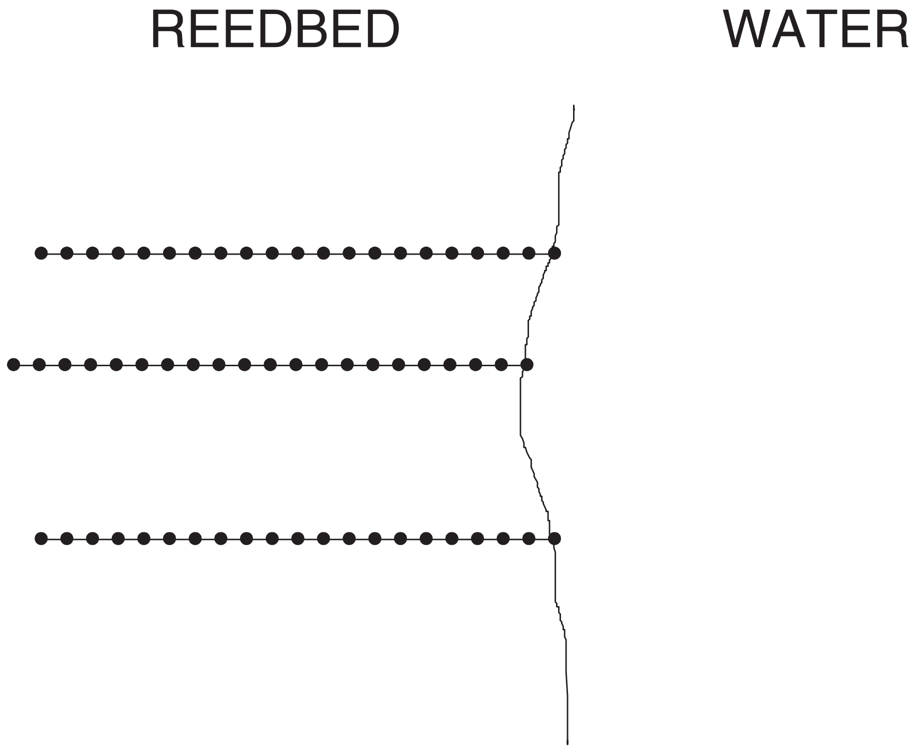


Figure 1. Scheme of the study design at the reedbed of Lake Velence, Hungary. Every black dot represents a measuring point.

trends in gradients and the honestly significant differences between measuring points, a characteristic three-band structure across reedbed edges was found (Figure 2): at the open water (band 1) the reedbed was very dense, with thin and short shoots. Then density declined, but reed shoots were thick and very high (band 2). Further inside, both density and height declined, but shoot characteristics seem to be unchanged (band 3). In correlation with this vegetation pattern, the first band, at the reedbed water edge, was warmer, drier, brighter and windier than interior parts. In the second band the temperature was lower, humidity was higher, and the light and wind intensity were low. Because of the sparse vegetation in the third band, temperature and light intensity increased, while humidity decreased.

The width of edge effect can be estimated for each significant variable based on the honestly significant differences. However, the only clear pattern was found for WIND, where the first measuring point was significantly different from all other points. The visually obtained three band structure across the reedbed edge was partly supported by the significant differences in AIRTP, HUMIDITY, LIGHT and HEIGHTNEW. In contrast to these nonlinear variables, DENSNEW declined linearly across the edge ($R^2 = 0.486,\ F = 57.653,\ df = 1,\ P < 0.0005$).

Table 1. Variables measured at three transects across the edge of a reedbed (Lake Velence, Hungary) and the averages ± SD (N) of the pooled data.

Variable	Explanation	Abbreviation	Average ± SD (N)
Surface temperature (°C)	Temperature of ground or water at the measuring point within 5 cm of the surface	SURFACETP	24.21 ± 2.23(61)[a]
Air temperature (°C)	Temperature of the air, ca. 15 cm above the surface	AIRTP	31.06 ± 1.65(60)[a]
Relative humidity (%)	Percentage relative humidity, was measured ca. 15 cm above the surface	HUMIDITY	61.82 ± 6.78(60)[a]
Light intensity (lux)	Intensity of light ca. 15 cm above the surface measured with a roline-RO2000 digital lux meter. If there was wind, and moving shadows, we repeated the measurement several minutes later	LIGHT	2265.67 ± 1386.08(60)[a]
Wind speed outside/inside (m/30 s)	Wind intensity was defined as the ratio of simultaneously measured inside and outside wind speed data. The latter was measured 3 m from the reed edge. The measures were taken ca. 15 cm above the surface	WIND	67.40 ± 34.57(63)/ 2.59 ± 10.33(63)
Density of last year reeds ($n/0.15\ m^2$)	Number of last year reed shoots within a $0.15\ m^2$ quadrat counted at 1 m height	DENSOLD	10.51 ± 17.31(63)
Density of new sprouting reeds ($n/0.15\ m^2$)	Number of new sprouting reed shoots within the same $0.15\ m^2$ quadrat counted at 1 m height	DENSNEW	22.75 ± 11.25(63)
Height of last year reeds (cm)	Average height of the last year reed shoots at the measuring point	HEIGHTOLD	217.84 ± 52.39(32)[b]
Height of new sprouting reeds (cm)	Average height of new sprouting reed shoots at the measuring point	HEIGHTNEW	248.41 ± 35.41(63)
Number of nodes ($n/10$ shoots)	Number of nodes of 10 new sprouting reed shoots at each measuring point	NODES	8.29 ± 1.90(630)[c]
Number of leaves ($n/10$ shoots)	Number of leaves of 10 new sprouting reed shoots at each measuring point	LEAVES	11.23 ± 1.85(630)[c]
Diameter of shoots (mm)	Diameter of 10 new sprouting reed shoots measured at the middle of an internodium at 1 m height at each point	DIAMETER	5.83 ± 1.62(630)[c]

[a] A few data were lost.
[b] Thirty-one points lacked last year reed shoots.
[c] Ten new sprouting reed shoots were measured at every point.

Table 2. Results of ANOVA of microclimate and vegetation structure across reedbed edges ($df = 20$).

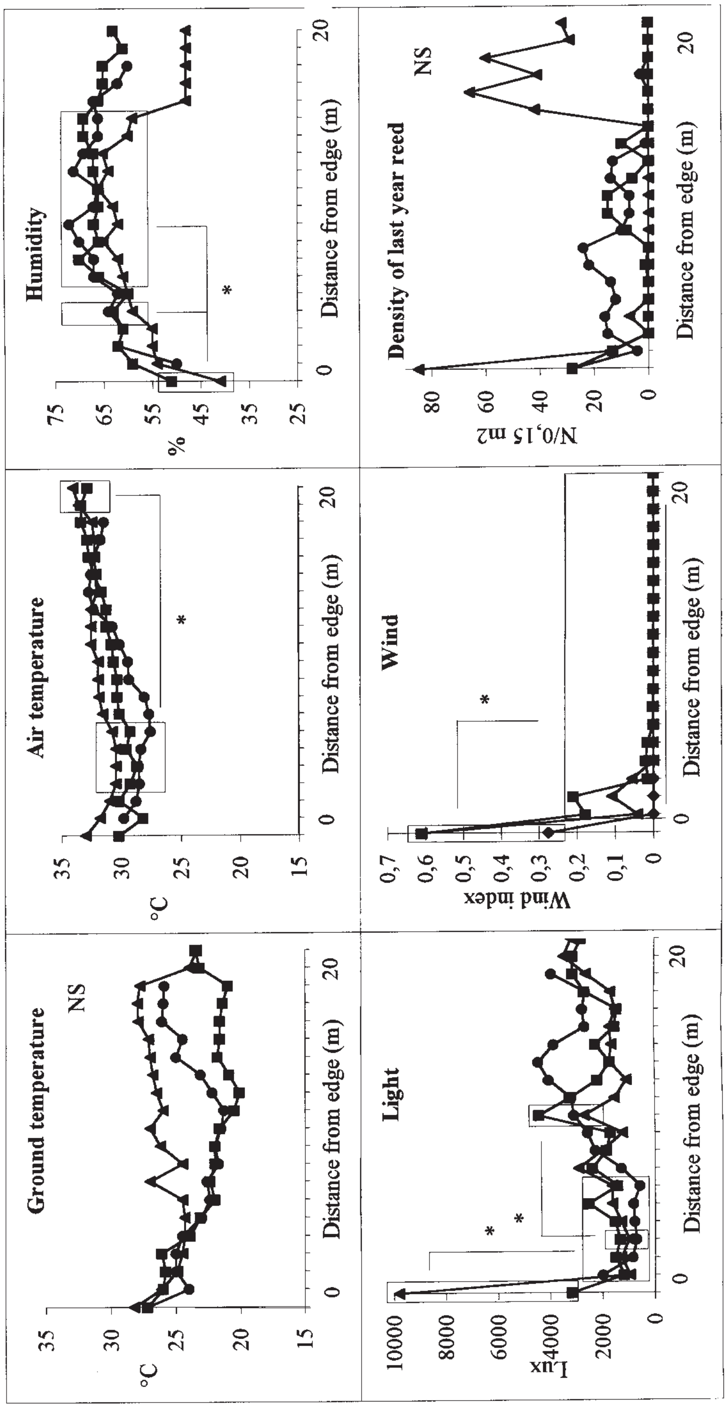
Variable	MS_{between}	F	P	
Surface temperature	0.0012	0.801	0.698	NS
Air temperature	0.0011	4.182	0.000	***
Relative humidity	0.0053	3.397	0.000	***
Light intensity	0.1115	3.827	0.000	***
Wind index	0.0363	13.114	0.000	***
Density of last year's reeds	0.2817	0.562	0.917	NS
Density of new sprouting reeds	0.0749	2.959	0.002	**
Height of last year's reeds	0.9504	0.599	0.891	NS
Height of new sprouting reeds	0.0067	2.780	0.003	**
Number of nodes	0.0033	0.677	0.825	NS
Number of leaves	0.9315	1.389	0.182	NS
Diameter of shoots	0.7930	1.364	0.195	NS

** $P < 0.01$; *** $P < 0.001$.

Discussion and recommendations

Most previous studies of transition zones between two different vegetation types were of forest habitats, and they usually found that the measured environmental and vegetation variables differed significantly between edge and interior habitats (Murcia 1995). I studied microclimate and vegetation variables across a reedbed edge, and I expected that the main changes of variables would be similar to that observed in forest edges, owing to the similar effects of vegetation cover. Indeed, I showed that reedbed edges are characterised by higher light transmittance, higher air and surface temperature and lower humidity, which is similar to patterns found in many forest edge studies (Matlack 1993; Young and Mitchell 1994; Chen et al. 1995; Jose et al. 1996). Vegetation density in forest edges was usually higher and the height or basal area was smaller than in interior forests (Chen et al. 1992; Brothers 1993; Matlack 1993; Young and Mitchell 1994; Casenave et al. 1995; Jose et al. 1996). These results accord with my observations, but only for the first half of the reedbed transects; that is, only two of the three characteristic bands were detected in forest edges. There are two possible explanations for this difference: (1) forest and reedbed edges have different structure, or (2) measurement across forest edges was not extended sufficiently to find this pattern.

Forest edges are usually considered to be ca. 50 m wide, mainly as a consequence of forest structure (Paton 1994; Murcia 1995). Edge width in reedbeds should be much smaller, because of the simpler and shorter vegetation. Although I did not find easily interpretable results for determining edge width, several variables showed characteristic patterns, suggesting that reedbed edges are different from interior parts at least for 15 m. Thus, a circular reed patch with a radius of 15 m will not support interior reed habitats. This result is important, because reed habitats are common



Ground temperature
NS
°C
Distance from edge (m)
Air temperature
*
°C
Distance from edge (m)
Humidity
*
%
Distance from edge (m)
Light
*
*
Lux
Distance from edge (m)
Wind
*
Wind index
Distance from edge (m)
Density of last year reed
NS
N/0,15 m2
Distance from edge (m)

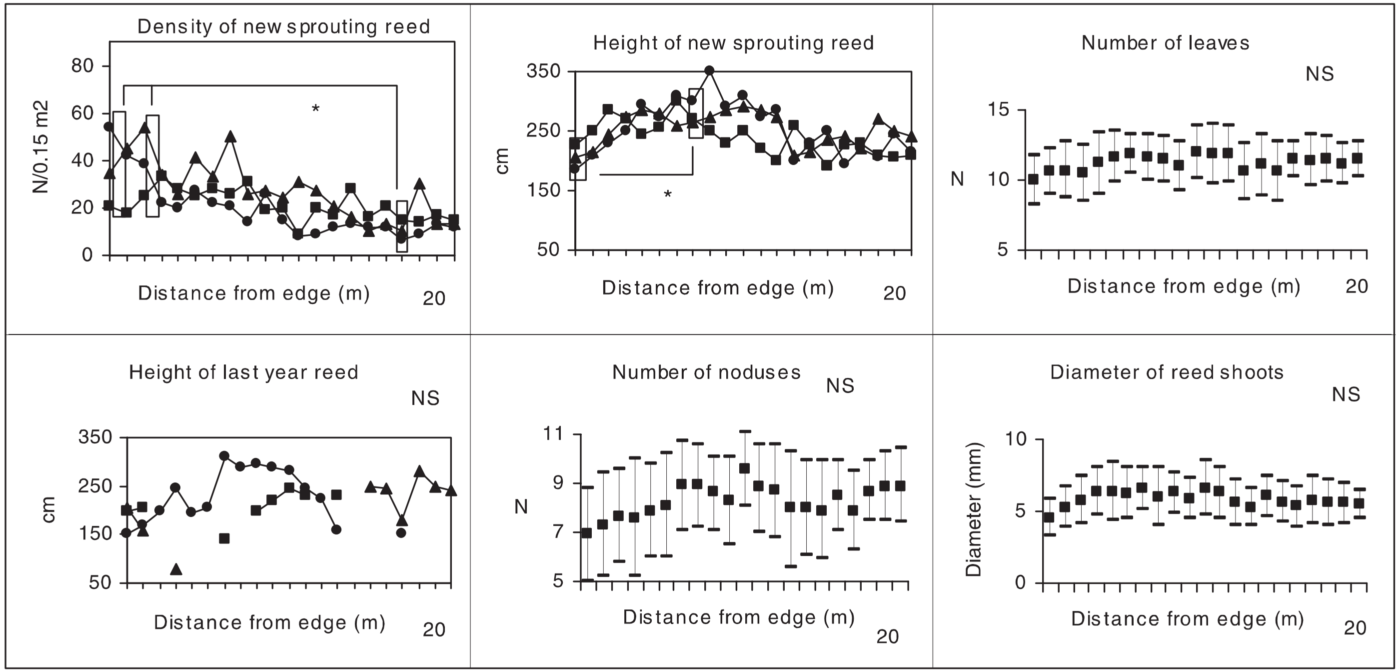


Figure 2. Variables measuring microclimate, reedbed structure and shoot structure in the first 20 m of a reedbed edge at Lake Velence, Hungary. The lines indicate Tukey's honestly significant differences: * : $P < 0.05$.

along dikes and channels, where they usually form narrow belts. However, these belts may lack interior habitats. Management for reedbed interior species should strive to create reed belts wider than 30 m. The size of reed patches may be important when designing the mowing of a reedbed. The wise use of reedbeds would entail leaving large remnant patches, instead of the common and more economical extirpation of large parts of reedbeds.

Which species are affected by reedbed edges? There is only one study that links edge effect and species distributions in reedbed edges: Báldi and Kisbenedek (1999) found that reedbed passerines prefer edges (Figure 3) owing to their dense vegetation, which provides nesting sites and excludes large predators. Based on other studies, edge preference or avoidance can be obtained only indirectly (Moskát and Báldi 1999). For example, the Great White Heron (*Egretta alba*), the Marsh Harrier (*Circus aeruginosus*) (Báldi and Kisbenedek 1998), and the Bluethroat (*Luscinia svecica*) (personal observation) are related to large reed patches. The first two species may avoid edges, because they cannot move in the dense vegetation, but for the Bluethroat, total area is probably all that is important. Several insect species prefer edges (Vásárhelyi 1995), but others, like the gall midge *Giraudiella inclusa* and the moth, *Archanara geminipuncta*, are related to thick shoots, which occur in interior reedbeds. In addition, the chloropid fly, *Lipara lucens*, prefers different shoot dia-

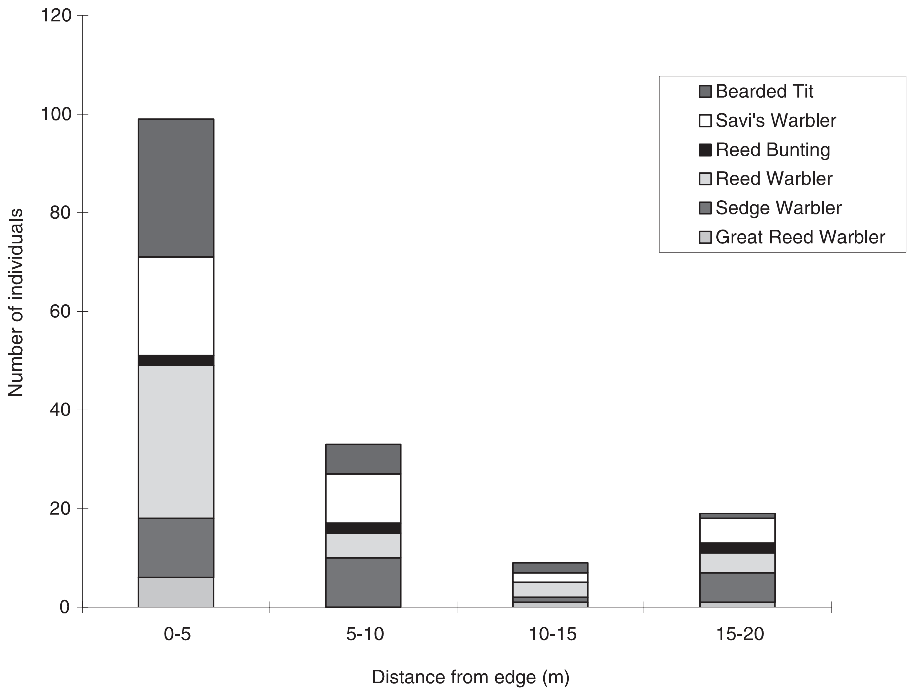


Figure 3. Distribution of the six most abundant bird species in the first 20 m of a reedbed edge at Lake Velence, Hungary (data from Báldi and Kisbenedek 1999).

meters in different stages of its life cycle (e.g. Chvála et al. 1974; Vásárhelyi 1995). Therefore, the creation of large reedbeds is essential for the conservation of reed-related species assemblages, because large reedbeds have the natural heterogeneity that is required by the different species. The present study highlighted the need to conduct more extensive investigations on the microclimate and vegetation gradients in different reedbed edges, and our poor understanding on factors influencing the occurrence of reed-living species.

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