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THE EFFECT OF REED CUTTING ON THE ABUNDANCE AND DIVERSITY OF BREEDING PASSERINES

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Reedbeds support high conservational value with their unique avifauna. Inadequate reed cutting methods can cause serious declines in the abundance of these bird species. The aim of this study was to investigate the influence of reed cutting on the abundance and diversity of breeding passerine species, mainly *Acrocephalus* warblers. The study was carried out at Lake Kolon in Central Hungary, in homogenous reed (*Phragmites communis*) vegetation. Sample areas of 1 hectare in size were cut during 4 consecutive winters. Areas not cut but of the same size functioned as control areas. Sampling was carried out during the breeding season by mist-netting. Lake Kolon's passerine avifauna at the cut areas showed decreased species richness and decreased abundance of most of the reed-nesting species, which also resulted in decreased diversity. The Savi's Warbler (*Locustella luscinioides*), the Moustached Warbler (*Acrocephalus melanopogon*), the Sedge Warbler (*A. schoenobaenus*), and the Reed Warbler (*A. scirpaceus*) showed definite avoidance of the cut areas. Only the Great Reed Warbler (*A. arundinaceus*) showed preference for the cut areas. The study also revealed that edges created between cut and non-cut areas are much less preferred by passerine species than natural edges.

Key words: *Acrocephalus* spp., edge effect, habitat preference, reed cutting, reedbed management

INTRODUCTION

Wetlands are amongst the most threatened habitats on Earth. In Europe only a small part of the former huge wetland areas remained in natural or semi-natural condition (OSTENDORP 1989, VAN DER PUTTEN 1997). In Hungary, by the end of the 20th century no more than 1% of the reedbeds remained (VÁSÁRHELYI 1995). Even this remaining part, which is still large compared to West-European countries, is threatened by different factors. Human activities, such as inadequate reed cutting methods, can lead to fragmentation, deterioration, and destruction of reedbeds (HAWKE & JOSE 1996). Also, reedbeds are threatened by natural processes such as eutrophication and physical filling, which can result in ageing and finally in the disappearance of these types of wetlands. The ageing process of eutrophic lakes and marshes was present in historic and prehistoric times as well, but before the land-drainage works and regulation of rivers, formation of new lakes and marshes and aging (transformation into other types of habitat) were balanced. In recent times, due to the strict regulation system of water bodies, no new marshes or natural wetlands are formed, but the ageing of the existing ones is still in progress. As reedbeds support huge value, in order to prevent them from biologic succession, we have to act against natural processes. Well planned and implemented conservation works can temporarily stabilize reedbeds (HAWKE & JOSE 1996), but the costs (from a financial aspect) are usually very high. Reed cutting was thought to be an effective method of fighting against eutrophication (GRYSEELS 1989), but up to our recent knowledge, the impact of normal (commercial) winter reed cutting on reducing the trophic level is still dubious (OSTENDORP 1995). As reed cutting can be a profitable economic activity (HAWKE & JOSÉ 1996), it has some advantages, even if it does not always support conservational purposes (BARBRAUD & MATHEVET 2000). That is why we have to be aware of the effects of reed cutting, to avoid overexploitation, which can lead to irreversible changes of the local ecosystem and its subsystems, such as the passerine populations.

The passerine avifauna of reedbeds has been intensively investigated from various aspects and by numerous authors since the beginning of the 20th century (CATCHPOLE 1982, LEISLER 1989, CSÖRGŐ 1995*a*,*b*, BÁLDI & KISBENEDEK 2000, GYURÁCZ & BANK 2000). However, only few researches were conducted on investigating the effect of reed cutting methods on the reed-nesting avifauna (BÁLDI & MOSKÁT 1995, GRAVELAND 1999, POULIN *et al*. 2002, POULIN & LEFEBVRE 2004, SCHMIDT *et al*. 2005). Considering that these effects involve fragmentation, deterioration, and unsustainable exploitation of natural habitats, which are key issues in conservation ecology, more attention should be paid to this topic.

This study is an integral part of a comprehensive ecological surveillance on the reedbeds carried out in Kiskunság National Park in Central Hungary. With this survey, we would like to contribute to the conservation of wetlands.

The goal of our study was to model the effect of reed cutting on the spatial pattern of reed-nesting passerine species. We looked for answers for the following questions: (1) What is the minimal area size that can be regarded as a representative sample of the interior part of a homogenous reedbed? (2) What is the effect of reed cutting on abundance and diversity of passerine species in the cut areas? (3) What is the effect of reed cutting on the abundance and diversity of passerine species in the neighbouring, non-cut areas? These questions were investigated via diversity and habitat preference/avoidance calculations and via the tracing of between-year individual movements. Due to recent studies on edge effect in reedbeds (MOSKÁT & BÁLDI 1999, BÁLDI 1999, BÁLDI & KISBENEDEK 1999), it was reasonable to investigate the edges between the two different areas (i.e. between cut and non-cut areas) separately from the interior parts

MATERIALS AND METHODS

The study area was located at Lake Kolon (46º48'N 19º20'E) in Central Hungary, in the Kiskunság National Park. Lake Kolon ranks among the wetlands of highest international importance, having been included in the list of Ramsar sites since 1997. Considering the OECD boundary system, the lake can be characterized by eutrophic water body state. The lake is mainly covered by different types of reed (Phragmitetalia) and sedge (Magnocaricetalia) assemblages, with little amount of open water surfaces. The major part of the lake is covered by common reed (*Phragmites australis*). The area covered by reed at Lake Kolon exceeds 1000 hectares. The study site was marked out in the interior part of the lake, next to a dike crossing the Lake, in homogenous reed vegetation.

The years of 2002 and 2003 constituted the control period (i.e. there was no reed cutting). During the control period, the homogeneity of the area was investigated via analyzes of distribution of reed-nesting bird species along the mist-nets. Also the sample quadrate size was defined for investigations of the subsequent years. For this, the correlation between the area size and the number of individuals was analyzed. In the study the area size was modelled and represented by transect length of the census route.

To model the effect of reed cutting, four quadrates (100 m by 100 m) were allotted in the study area in 2004 and 2005. In the recent study, never cut quadrates (which have not been cut at least for twenty years) were compared with quadrates that were cut during the winter before the particular breeding season (their vegetation consisted of new stems of reed only). Seiga machines were used for reed cutting.

In this study, the capture data were analysed from the period of 2002 to 2005, when sampling was carried out weekly during the breeding season (from March to July) by mist-netting. In order to minimize the effect of the activity on the breeding bird community, sampling took only 4 hours on each sampling day (started at sunrise). The place of capture was recorded with a precision of 1 meter along the 400 m long line of mist-nets. Each captured bird was ringed with an individually numbered aluminium ring. Only data on adult birds were analyzed in this study.

Each quadrate was divided into interior and edge parts during data processing. Capture records from the outer 25 metres of the quadrates were considered to be possibly influenced by the edge effect (BÁLDI 1999). Also, each edge was divided into two sections: the outer part of the edge (outer 10 metres) and inner part of the edge (inner 15 metres) (Fig. 1).

Edges were classed in three different categories: (a) edge of non-cut area towards the dike, (b) edge of non-cut reed towards the cut area, and (c) edge of cut reed towards non-cut area.

For each different habitat type (interior and edge parts of cut and non-cut quadrates), we calculated the number of passerine species (S), the number of total individuals per 100 m of the transect (N), the Shannon diversity value (H'), and the evenness (E) and the variance of diversity value (VarH').

For the evaluation of passerine diversity, we used Magurran's method (MAGURRAN 1988). Diversity values were compared with special two-sample t-tests (HUTCHESON 1970). Species-specific avoidance/preference values for the different habitat types were calculated as a comparison to the interior part of non-cut areas. The avoidance/preference values were calculated in three steps: (1) for each habitat type, the average number of individuals (belonging to the particular species) was extrapolated for a 100 m long transect section. This way the average abundance of the species was calculated. (2) The abundance value of the particular habitat type was decreased by the abundance value calculated for the interior part of non-cut area. (3) This differential value was divided by the abundance value calculated for the interior part of non-cut area. This way relative values were created, with a lower limit of –100% (total avoidance). Theoretically, there is no upper limit of this value, although in practice, the highest one was 150%.

The above investigations were made for the five most abundant species (Savi's Warbler – *Locustella luscinioides,* Moustached Warbler – *Acrocephalus melanopogon*, Sedge Warbler – *Acrocephalus schoenobaenus*, Reed Warbler – *Acrocephalus scirpaceus*, Great Reed Warbler – *Acrocephalus arundinaceus*), since these could comply with the sample size criteria.

RESULTS

Testing the homogeneity of the study area (in the control period)

The correlation between the area size and the total number of individuals proved to be linear: $r^2 = 0.9871$ (2002, n = 162) and $r^2 = 0.9956$ (2003, n = 124) (Fig. 2), which verified the presumptions about homogeneity of the area. In the case of each abundant species, the linear trend was present as well: Moustached Warbler $r^2 = 0.9935$, n = 34, Sedge Warbler $r^2 = 0.9484$, n = 14, Reed Warbler $r^2 =$

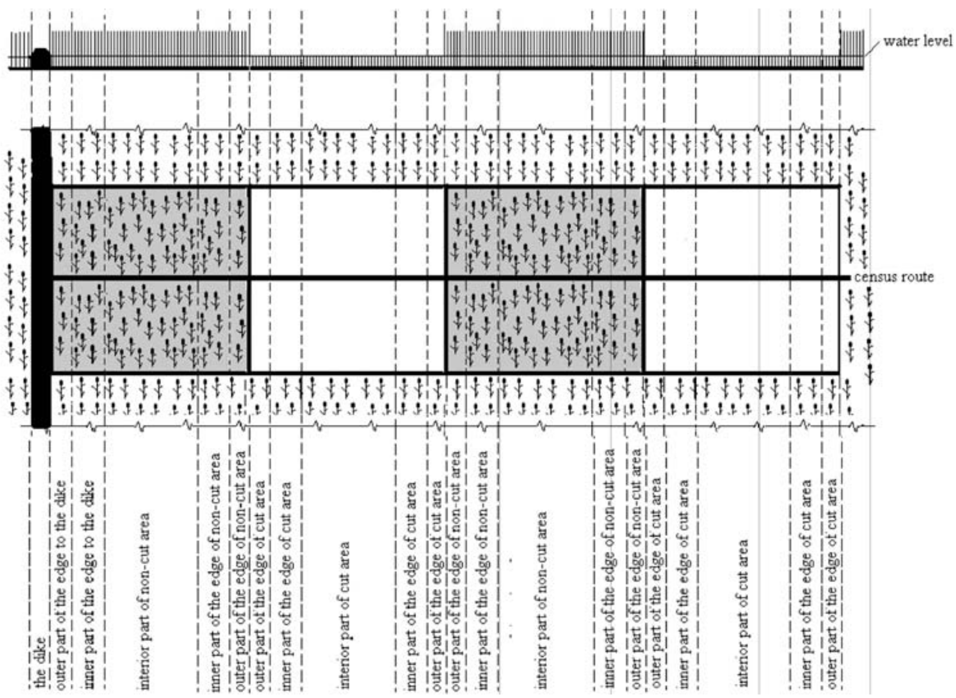

Fig. 1. The schematic map of the zones assigned in the study area at Lake Kolon, Central Hungary, in profile (the upper part of the figure) and in plan (the lower part of the figure) view. The grey boxes represent the non-cut areas, the white unfilled boxes represent the cut areas. Both the cut and the non-cut areas are surrounded by homogenous reed vegetation

Table 1. Diversity values of different parts of the study area (S: average number of species, H' Shannon diversity value, E: evenness, VarH': variance of Shannon diversity, N: number of total individuals per 100 m. NCI: interior part of non-cut reed, CI: interior part of cut reed, ED1: edge to dike, outer 10 m, ED2: edge to dike, inner 15 m, EC1: edge of the cut reed to non-cut reed, outer 10 m, EC2: edge of the cut reed to non-cut reed, inner 15 m, ENC1: edge of the non-cut reed to cut reed, outer 10 m, ENC1: edge of the non-cut reed to cut reed, inner 15 m). The different parts are illustrated on Fig. 1.

Type of area	S	H'	E	VarH1	N
NCI	7.8	1.31	–0.64	0.0085	119.7
CI	4.7	1.27	–0.83	0.0148	28.7
ED1	5.0	1.36	–0.85	0.0019	166.7
ED2	4.7	1.47	–0.96	0.0052	109.3
EC1	3.7	1.11	–0.87	0.0029	80.0
EC2	4.7	1.25	–0.82	0.0068	56.0
ENC1	2.5	0.77	–0.83	0.0044	45.0
ENC2	3.3	1.27	–1.01	0.0071	106.7

0.9755, n = 97, Great Reed Warbler $r^2 = 0.9874$, n = 7 (2002) and Moustached Warbler $r^2 = 0.9935$, n = 28, Sedge Warbler $r^2 = 0.9420$, n = 10, Reed Warbler r^2=0.9813, n = 63, Great Reed Warbler $r^2 = 0.9288$, n = 5 (2003).

The effects of winter reed cutting on the passerine avifauna

The effects of winter reed cutting on the passerine avifauna were described via (a) the difference in the diversity, (b) habitat avoidance/preference, (c) individual between-year movements, and (d) formation of edges between cut and non-cut areas.Difference in bird diversity among habitats

The number of passerine species (S), the number of total individuals per 100m of the transect (N), the Shannon diversity value (H'), the evenness (E) and the variance of diversity value (VarH') calculated for the different habitat types are shown in Table 1.

The total number of passerine species was significantly lower in the interior part of the cut areas than the interior part of the non-cut areas ($\chi^2 = 7.1$, df = 1, p = 0.01, see also Table 2).

The diversity of the interior part of the cut area was significantly lower than that of the non-cut area. Regarding both the outer 10 m and the inner 15 m of the edges, the edge towards the dike (the 'natural' edge) was significantly more diverse than the edges of either cut or non-cut areas (Table 3). Habitat avoidance/preference

Table 2. Presence (+) or absence (-) of Passerine species in the interior parts of the studied reedbed at Lake Kolon, Central Hungary. See Fig. 1 for area description

Species	Interior part of non-cut reed	Interior part of cut reed
Barn Swallow (*Hirundo rustica*)	+	-
Pied Wagtail (*Motacilla alba*)	-	+
Robin (*Erithacus rubecula*)	+	-
Bluethroat (*Luscinia svecica*)	+	-
Whinchat (*Saxicola rubetra*)	+	-
Savi's Warbler (*Locustella luscinioides*)	+	-
Moustached Warbler (*Acrocephalus melanopogon*)	+	+
Sedge Warbler (*A. schoenobaenus*)	+	+
Marsh Warbler (*A. palustris*)	+	-
Reed Warbler (*A. scirpaceus*)	+	+
Great Reed Warbler (*A. arundinaceus*)	+	+
Chiffchaff (*Phylloscopus collybita*)	+	-
Bearded Tit (*Panurus biarmicus*)	+	-
Long-tailed Tit (*Aegithalos caudatus*)	+	+
Blue Tit (*Parus caeruleus*)	+	-
Penduline Tit (*Remiz pendulinus*)	+	+
Red-backed Shrike (*Lanius collurio*)	-	+
Tree Sparrow (*Passer montanus*)	+	-
Reed Bunting (*Emberiza schoeniclus*)	+	+

Reed cutting influenced the habitat usage of the passerine species, which is represented by the habitat avoidance/preference of the five most abundant species (Fig. 3). The sample sizes of the Moustached Warbler, the Sedge Warbler and the Reed Warbler allowed statistical analyses. All the three species showed significant avoidance of the interior part of the cut areas (Moustached Warbler $\chi^2 = 20.28$, df = 1, p = 0.001, Sedge Warbler $\chi^2 = 4.15$, df = 1, p = 0.05, Reed Warbler $\chi^2 = 18.08$, df = 1, p = 0.001). Although the sample size of the Savi's Warbler and the Great Reed Warbler did not allow statistical analyses, they were not excluded from this part of the study, as these two species showed the most marked avoidance/preference (total avoidance of cut areas in the case of the Savi's Warbler, and marked preference for edges of cut areas in the case of the Great Reed Warbler).

Regarding the edges of the cut area, the Moustached Warbler showed significant avoidance (for the inner part of the edge of the cut area $\chi^2 = 7.98$, df = 1, p = 0.01, for the outer part of edge of the cut area $\chi^2 = 5.68$, df = 1, p = 0.05). The

Table 3. Comparison of diversity values with t-tests. Abbreviations are the same as in Table 1.

Result of comparison	t	df	p
H'(NCI)>H'(CI)	6.9765	66	<0.001
H'(ED1)>H'(EC1)	18.5256	184	<0.001
H'(ED1)>H'(ENC1)	13.3572	141	<0.001
H'(EC1)>H'(ENC1)	12.4100	136	<0.001
H'(ED2)>H'(EC2)	12.1862	135	<0.001
H'(ED2)>H'(ENC2)	11.9750	210	<0.001
H'(ENC2)>H'(EC2)	9.5539	139	<0.001

Sedge Warbler showed slight, but not significant avoidance of the inner part of the edge of the cut area ($\chi^2 = 0.46$, df = 1, NS) and slight, but not significant preference for the outer part of the edge of the cut area ($\chi^2 = 0.205$, df = 1, NS). The Reed Warbler showed significant avoidance of the inner part of the edge of the cut area ($\chi^2 = 3.74$, df = 1, p = 0.05, and the outer part of edge of the cut area ($\chi^2 = 5.20$, df = 1, p = 0.05).

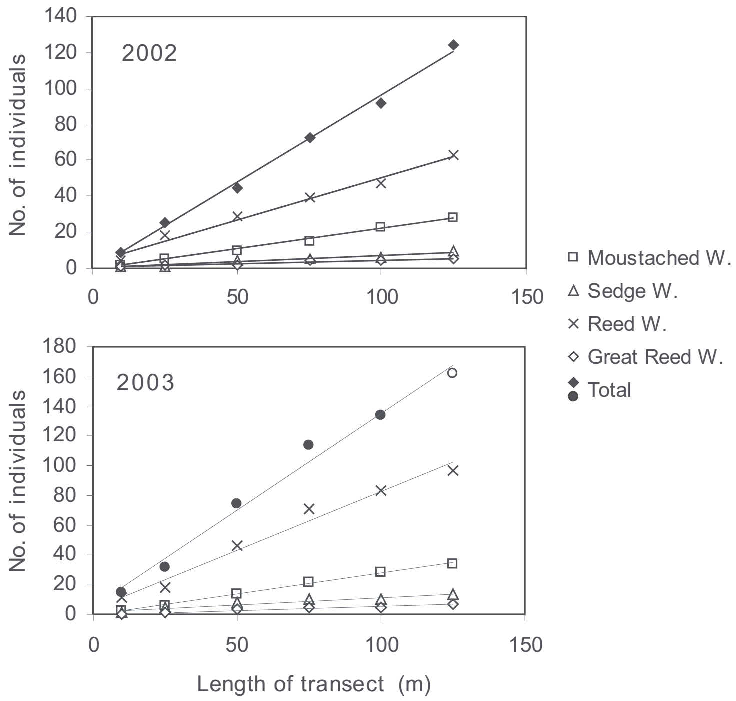

Fig. 2. Correlation between number of individuals of four species (the Moustached Warbler, the Sedge Warbler, the Reed Warbler and the Great Reed Warbler) caught with mistnests at Lake Kolon and length of transect in two different years (2002 and 2003)

DISCUSSION

Reedbeds are representatives of globally endangered wetland vegetations (HALLS 1997). In Hungary, the major part of the wetlands had been drained during the 20th century (NÉMETH 1996). In the last 1000 years, almost 99% of reedbeds in Hungary have disappeared (VÁSÁRHELYI 1995), and although there is a slight recent increase in the quantity of reedbeds (Gefajnep Project 1996), the remaining part, especially the most valuable areas (in terms of nature conservation status), are threatened by the different effects of human activities and natural processes. Reed cutting is one the human activities that affect the wildlife of reedbeds.

Generally, in the central part of Europe, which can be characterized by continental climate, most passerine species avoid rather than prefer the cut areas (OSTENDORP 1988, BÁLDI & MOSKÁT 1995), which leads to a decreased species number and a decreased number of individuals in the case of most species. Sometimes this is not reflected in the result of diversity index calculations (BÁLDI & MOSKÁT 1995), and cut areas can be characterized by equal or even higher values (i.e. in terms of the Shannon-Wiener index) than non-cut areas. Of course, this cannot be interpreted in the way that new-cut areas are as important in terms of biodiversity conservation as non-cut areas.

At Lake Kolon, the passerine avifauna of the cut areas can be characterized by decreased diversity, and by decreased abundance of most of the reed-nesting species. Interestingly, studies conducted in the Mediterranean region concluded that species richness was equal in cut and non-cut areas (POULIN & LEFEBVRE 2004). This contradiction can be attributed to the difference in the beginning of the vegetative season of reed caused by the different climatic factors. The main difference is that when long-distant migrants, such as the Reed Warbler and the Sedge Warbler arrive in Hungary, the new stands of reed are in the beginning stage of growth, thus presenting unsuitable conditions for breeding. Studies have revealed that uncut areas can be good feeding places of reed nesting bird species. The relatively small size of the territory of the reed-nesting *Acrocephalus* warblers does not allow the birds to find enough food inside their territories, and it is reported by different authors that these species use some communal feeding places (outside the territories). We found no evidence for the case that birds leave their territories for feeding in cut parts.

The difference in species number between non-cut and cut areas can be explained by the fact that more passerine species avoided the new cut area and that less 'new' species (i.e. species that were not found in the non-cut area) occurred there. None of the 'new' species that occurred only in the new cut areas are regarded as reed-nesting species.

It is very important to consider the above mentioned two major effects (decreased species richness and decreased abundance of most of the species) of reed cutting on the breeding passerine assemblage of the reedbeds, since approximately 40% of the reedbeds of Hungary are subject to some kind of economic reed cutting activity (VÁSÁRHELYI 1995). If the extent of winter reed cutting is not strictly regulated by nature conservation authorities, overexploitation can possibly lead to rapid population decline of reed-nesting passerine species even in a closer future period.

Reed cutting influenced the habitat usage of the different species in various ways and to a varied extent. As the effects of reed cutting can be contradictory in the case of the different species, it is reasonable to assign priorities. At Lake Kolon the Moustached Warbler and the Savi's Warbler are regarded as the most valuable ones of the investigated species because both their overall population size in Europe (BIRDLIFE INTERNATIONAL 2004) and the total size of their breeding areas (and its carrying capacity) are smaller compared to the three other investigated species. As a direct effect of reed cutting, the Moustached Warbler and the Savi's Warbler showed marked avoidance of the new cut areas. The Reed Warbler and the Sedge Warbler also significantly avoided the new cut areas, whereas the Great Reed Warbler showed preference for new cut areas. In the case of the Great Reed Warbler the main positive effect of reed cutting is the formation of edges (e.g. suitable breeding place for the species).

The size and pattern of both cut and non-cut areas should be precisely planned. One of the most important effects of the area size and the pattern is the edge effect, which is detectable in reed belts in a 10–20 m wide zone, and makes a serious difference between the interior and the edge parts. For example, if a reed bed is cut in a mosaic pattern, and the non-cut parts are relatively small, those species that prefer the interior parts will avoid the whole area (BÁLDI 1999). As the ratio between interior and edge parts is heavily influenced by not only the patch size but also by the shape of the patch, it is reasonable to carry out the cutting so that the shape of the uncut area resembles a square (BÁLDI 1999). Another very important consequence of the pattern of reed cutting, which influences the passerine community, is food availability. If huge homogenous cut areas are formed, it can make the recolonization process of arthropods (the main food resource for reed-nesting passerine species in spring and summer) slow (SCHMIDT *et al.* 2005).

It is well known that the size of the non-cut, reed-covered area influences the abundance and the density of the reed-nesting passerine species, as their area size and habitat requirements are different (DYRCZ 1980, HÅLAND & BYRKJELAND 1982, CATCHPOLE 1982, THOMAS 1984, SHENNAN 1986, LEISLER & CATCHPOLE 1992, CSÖRGŐ 1995*b* BÁLDI 2004, 2006). The Savi's Warbler requires considerably large territories, but its territory can consist of several smaller patches. The Moustached Warbler avoids small patches. The Sedge Warbler prefers larger patches as well, but in a way this species is different from the other investigated *Acrocephalus* species. Although it breeds in homogenous reedbeds as well, it usually finds its optimal breeding habitat in other, often drier vegetation types, e.g. in herbaceous or sedge vegetation. The Reed Warbler is not as sensitive to patch size as the Moustached Warbler, and it breeds in not too sizeable reed belts as well. The Great Reed Warbler is a typical edge-nesting species; accordingly its optimal habitat can be characterized by a dominance of edge parts. To sum it up, it can be concluded that large homogenous reedbeds, as their breeding area are the most important for the Savi's Warbler and the Moustached Warbler, also important for the Reed Warbler, and less important for the Sedge Warbler and the Great Reed Warbler. That is why, while managing sizeable reedbeds, we have to concentrate on the conservation of the Savi's Warbler and the Moustached Warbler. Taking into consideration the edge effect, it is advisable to maintain at least 100 m wide reed belts when planning and performing the reed cutting activity in huge reedbeds.

The effects mentioned above are the ones that occur in the first breeding season after winter reed cutting. Since there can usually be a marked difference in the vegetation structure of reedbeds (e.g. in terms of stem diameter, quantity of detritus in the lower region, etc.) depending on how much time passed since the last cut, it would be important to investigate the medium-term (two, three or four years) effects of reed cutting on the passerine avifauna as well.

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