THE EFFECT OF MOWING ON NEXT-YEAR PREDATION OF GRASSLAND BIRD NESTS: EXPERIMENTAL STUDY

ABSTRACT The effect of mowing on next-year nest predation was studied in grassland areas on the outskirts of Cracow (south Poland). In 2004 and 2005, nesting success at three sites with two plots each – one unmowed for 2–3 years and one mowed every year – was assessed experimentally with artificial nests baited with two Japanese Quail Coturnix japonica L. eggs. Biomass samples were collected for estimations of the standing crop of vegetation. Mowing was found to be correlated with nest predation pressure on the unmowed plots in two meadows that had greater vegetation cover. At the third site, nest predation and vegetation cover did not differ between the mowed and unmowed plots. All selected sites were classified as Arrhenatherum elatius grassland. Also birds communities of study sites were similar in regard to occurrence of small ground-nesting passerine species: Grasshopper Warbler Locustella naevia Bodd., Reed Bunting Emberiza schoeniclus L., Whinchat Saxicola rubetra L., Yellow Wagtail Motacilla flava L. Artificial nests were destroyed mainly by corvids and only few percent were recognized as destroyed by mammals. The intensity of nest destruction differed greatly between years, probably because Magpies Pica pica L. were less active in 2005.

KEY WORDS: grassland, birds, mowing, artificial nests, predation

1. INTRODUCTION

Grassland birds are in rapid decline in Europe (Tucker et al. 1994), Siriwardena et al. 1998, Tomiałojć and Stawarczyk 2003). Several explanations for this observed pattern have been suggested: 1) lack of food supplies in winter (Parish and Sotheron 2004); 2) decreasing food resources such as weed seeds or invertebrates due to agricultural practices that involve the application of herbicides or pesticides (Benton et al. 2003); 3) increasing human pressure, especially the impact of free-ranging domesticated predators and human-caused disturbance (Miller and Hobbs 2000, Lepczyk et al. 2003, Finney et al. 2005); 4) landscape fragmentation due to the increasing abundance and activity of nest predators (Chalfoun et al. 2002) and the shrinking of suitable habitats (Davis 2004).

Egg destruction and nestling mortality as a result of nest predation are critical factors affecting the recruitment of young birds to the next generations (Lack 1954). The intensity of nest predation is often strongly correlated with vegetation density (Wray and Whitmore 1979, Riley et al. 1992, Clawson and Rotella 1998, Howard et
which can also explain the variability of the abundance and diversity of birds (Reed 1986, Davis 2004). Some agricultural practices such as intensive livestock grazing lead to increased nest predation pressure by reducing vegetation density (Vickery et al. 2001, Fondell and Ball 2004). Mowing combined with hay removal is a widely used agricultural management practice, also employed for active conservation of protected grassland areas. Yearly haying affects the vegetation structure, diminishes its density in the next year, and reduces the biomass of the standing crop. Investigations of differences in the abundance of birds on mowed and unmowed plots have shown that mowing can have a harmful impact on some bird species (Watson and Rae 1997, Dale et al. 1997, Horn and Koford 2000). However, there are no experimental findings indicating the factors responsible for the observed dissimilarities between mowed and unmowed grasslands. Besides the changes in vegetation addressed in this paper, haying may affect the abundance of breeding birds directly by destroying nests and killing nestlings (Kershner and Bollinger 1996, Kruk et al. 1997, Green et al. 1997). It is also likely to reduce food supplies (Vickery et al. 2001), especially by decreasing the numbers of some invertebrates such as spiders (Araneae) (Cattin et al. 2003) and ground beetles (Carabidae) (Haysom et al. 2004). Haying should be expected to increase predation in the following year; this could be an important factor explaining decreased breeding success. The present experiment, employing artificial nests, was intended to test this hypothesis and to explore the patterns of predation in ground-nesting passerines on unmowed and annually mowed grasslands. The investigated factor, increased predation due to mowing, may potentially affect small ground-nesting passerines: the Reed Bunting Emberiza schoeniclus L., Meadow Pipit Anthus pratensis L., Whinchat Saxicola rubetra L., Grasshopper Warbler Locustella naevia Bodd., Yellow Wagtail Motacilla flava L., Stonechat Saxicola torquata L., Yellowhammer Emberiza citrinella L. and River Warbler Locustella fluviatilis Wolf. The European populations of most of these species are in severe decline (Vorisek 2004, Tomišalojć and Stawarzycy 2003, Vickery et al. 2004, Baillie et al. 2005).

2. STUDY AREA AND METHODS

Data were collected in 2004 and 2005 from three grasslands in three localities: A (42 ha; 199 m a.s.l.), B (34 ha; 198 m a.s.l.) and C (84 ha; 230 m a.s.l.), all situated on the outskirts of Cracow (south Poland). All of the selected sites are remnants of an extensive complex of homogenous wet meadow that developed in the Vistula river valley.

All meadow communities studied were classified as Arrhenatherum elatius grassland – (Arrhenatheretum elatioris Br.-Bl. ex Scherr. 1925.). In the site A ruderal and nitrophilous plants greatly contributed to the species composition of the unmowed plot, probably due to cultivation of this plot in the past. In B site plots also had a few species characteristic for wet Molinietalia meadows.

Two plots per site were selected: one mowed once or twice per season and another unmowed for 2–3 years. The experimental sites were selected to have similar distances to streams or ditches, nearest natural edges, groups of trees and other factors that may affect nest predation pressure (Stephens et al. 2003, Herkert et al. 2003). To delimit the plots optimally, Magellan PorMark2 GPS was used in the field and ArcGIS 8.3. was used for mapping. On each experimental plot (80 × 80 m) a grid with points every 20 m was demarcated, and 25 artificial nests, baited with two quail eggs, were placed directly on the ground at the grid points. The nests were woven of dry grass so as to resemble natural Yellowhammer nests (Busse 1990); the use of unnatural-looking artificial nests may lead to biased estimations of predation rates (Davis and Bollinger 2000, Part and Wretenberg 2002). The locations of the artificial nests were marked with thin sticks (60 cm high, 1 cm diameter) situated 1.5 m north of the nests. The nests were handled with rubber gloves, although this practice is probably unnecessary (Skagen et al. 1999). To decrease the probability that the nests would be destroyed by humans, the nests were set out early in the morning. The
experiment was begun on the average date of the start of the breeding season in Poland for small ground-nesting passerines (Busse 1990): 18 May, 2004, and 24 May, 2005 (in the latter year, vegetation cover developed more slowly due to low temperatures in early spring). The nests were checked on the third, sixth and ninth days after they were set out. The number and locations of depredated nests (at least one quail egg destroyed) were recorded, and eggshell remnants were collected. In 2004, one plasticine egg was placed in each nest for later diagnosis of predator type (Major and Gowing 1994). Grass close to the nests was not trampled during the manipulations.

To assess vegetation density in early June 2004 and at the end of May 2005, plant biomass samples were taken from randomly selected locations. Aboveground biomass was collected from a circle (area 1,500 cm²) at midday during two consecutive days each year, in the same weather conditions, and weighed immediately. To compare the experimental plots generally, the vegetation density (%) of whole plots was visually estimated in 2004. Thickness was assessed arbitrarily and independently by a colleague not directly responsible for the study. In July 2004, phytosociological analyses were performed for each of the six experimental plots, describing the composition, structure, abundance and classification of the plant communities (Matuszkiewicz 2001). The mean height of plants was assessed for whole plots.

To compare selected sites: A, B and C in regard to avian abundance and species diversity, in 2004 the birds were counted according to the Combined Version of Mapping Method worked out by Tomiałojć (1980). The counts were made for whole sites during quiet, rainless mornings before the midday break in the birds’ activity. All simultaneously singing territorial males were counted. At the end of the season the number of territories for each species was estimated, the assumption being that this equals the number of breeding pairs.

The study sites are on the outskirts of Cracow and are visited by local people. To assess the probability that they could find or stumble upon nests, after the experiment the marker sticks were removed and fieldworkers attempted several times to find nests on the mowed and unmowed plots.

Differences in the mean number of days of nest survival were examined separately for 2004 and 2005 by two-way ANOVA, with site (A, B and C) as the random factor and treatment as the fixed factor (absence/presence of mowing). Before analysis the data were square root transformed to increase homogeneity of variance (Ferguson and Takane 2004). Possible differences in vegetation cover were also evaluated by two-way ANOVA with the same effects taken separately for both years. Vegetation density data were transformed using $1/(g \times m^{-2})$ transformation, to avoid heterogeneity of variance (Ferguson and Takane 2004). Post-hoc comparisons were done by Duncan’s test. Breeding pair density data for each site were used to separate similar groups in cluster analysis. The Unweighted Pair Group Method (UPGMA) was used for 36 breeding bird species as the grouping variable and Euclidean length as the distance measure. To confirm the results the Single Linkage clustering method was also used (Quinn and Keough 2002). All analyses employed STATISTICA 7.1 (Statsoft 2004).

3. RESULTS

3.1. Vegetation density

In 2004, visually determined vegetation density (0–100%) was lowest on the unmowed plot in site A (70%). The rest of the plots had 90–100% vegetation thickness. The mean height of plants on the unmowed plot in site A was also lowest (30 cm). Other plots had 50–70 cm mean vegetation height. The pattern was similar in 2005.

Collecting plant biomass varied from 0.6 to 3.2 kg × m⁻² in 2004 and from 0.5 to 2.7 kg × m⁻² in 2005. The significant “site × mowing” interaction for both years indicates that the mowing effect depended on the site (site × mowing: $F_{2,52} = 6.9, P = 0.002$ in 2004; $F_{2,59} = 3.5, P = 0.036$ in 2005). Vegetation cover on mowed plots was lower only at the sites B and C (Fig. 1); the difference in standing crop biomass between those two sites was not significant and was relatively lower in 2005 (site B: $P = 0.006$ in 2004, $P = 0.221$ in 2005; site C: $P < 0.001$ in 2004, $P = 0.094$ in 2005). The
factor "site" influenced vegetation biomass in both years. However, the differences in 2004 were marginally significant (2004: $F_{2,52} = 3.0$, $P = 0.058$; 2005: $F_{2,59} = 9.2$, $P < 0.001$).

3.2. Survival of artificial nests

The number of destroyed nests varied from 2 to 25 per plot and differed considerably between study years. Of the 150 nests set out in each year, after 9 days of the experiment only 10 were not destroyed in 2004; 47

nests survived in 2005. Among the plots, the mean nest survival time during the experiment varied from 0 to 8.3 days, and differed between 2004 and 2005. In 2004 the effect of mowing had a marginally significant influence on the mean duration of nest survival (mowing: $F_{1,2} = 14.1$, $P = 0.064$). For all sites in 2004, mowed and unmowed plots differed in this regard, (Fig. 2), but the differences were not significant for the site C and site A (C: $P = 0.199$, A: $P = 0.122$). In 2005 the differences were significant for the B and C plots.

![Fig. 1. Vegetation biomass from three sites A, B, C in each year of the experiment, mean ± SE (raw data); (*) $P < 0.05$, (***) $P < 0.001$.]

![Fig. 2. Nest time survival for three sites A, B, C in each year of the experiment, mean ± SE (raw data); (*) $P < 0.05$, (***) $P < 0.001$.]
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(B: \( P < 0.001 \), C: \( P < 0.001 \)). Comparison of mean nest survival time for the A site plots showed no significant differences (2004: \( P = 0.122 \); 2005: \( P = 0.830 \)). Because of this, the “site \( \times \) mowing” interaction turned out to be highly significant (\( F_{2,144} = 19.1, P < 0.001 \)). Site also significantly influenced nest survival (\( F_{2,144} = 27.5, P = 0.001 \)) (Fig. 2).

3.3. Plasticine eggs

During the experiment in 2004, only 60 of 150 dummy eggs exposed were found again. Birds destroyed 29% (17) of the 60, and the size of the beak marks indicated the work of the Magpie \textit{Pica pica} L. Small mammalian carnivores destroyed 10% (6). Rodent teeth marks were found on 6% (4). The rest of the eggs had no surface marks left by predators.

Quail eggshell remnants were present in only a few nests. Identification of the predator was impossible in most cases, except for one shell that had distinct beak marks.

3.4. Bird communities

In terms of the abundance of small ground-nesting passerines, the B and C sites were more similar to each other than to the A grassland (Table 1).

UPGMA clustering with bird species abundance as a grouping variable also demonstrated the similarity of the C and B grasslands, with the A meadows differing considerably (Fig. 3). Single Linkage clustering generated a similar pattern.

### Table 1. Abundance of small ground nesting passerines (breeding pair densities per 1 ha, + denotes species present but no breeding activities observed, – species absent).

<table>
<thead>
<tr>
<th>Sites</th>
<th>A (42 ha)</th>
<th>B (34 ha)</th>
<th>C (84 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stonechat \textit{Saxicola torquata} L.</td>
<td>–</td>
<td>0.29</td>
<td>0.24</td>
</tr>
<tr>
<td>Yellow Wagtail \textit{Motacilla flava} L.</td>
<td>0.24</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Whinchat \textit{Saxicola rubetra} L.</td>
<td>1.19</td>
<td>2.65</td>
<td>1.79</td>
</tr>
<tr>
<td>Reed Bunting \textit{Emberiza schoeniclus} L.</td>
<td>1.67</td>
<td>0.88</td>
<td>1.31</td>
</tr>
<tr>
<td>River Warbler \textit{Locustella fluvialis} Wolf.</td>
<td>–</td>
<td>0.29</td>
<td>0.71</td>
</tr>
<tr>
<td>Meadow Pipit \textit{Anthus pratensis} L.</td>
<td>–</td>
<td>+</td>
<td>0.12</td>
</tr>
<tr>
<td>Grasshopper Warbler \textit{Locustella naevia} Bodd.</td>
<td>0.24</td>
<td>1.47</td>
<td>1.55</td>
</tr>
<tr>
<td>Yellowhammer \textit{Emberiza citrinella} L.</td>
<td>–</td>
<td>–</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Fig. 3. Dendrogram for ornithological data (diversity and abundance) for three sites A, B, C. Unweight Pair Group clustering and Euclidean distance was used for 36 breeding bird species as a grouping variable.

4. DISCUSSION AND CONCLUSIONS

The working hypothesis was that mowed plots should be characterized by greater nest predation intensity and lower vegetation density than unmowed ones. Thus was confirmed for the B and C meadows, but the pattern observed for the A meadows was markedly different. There were no differences in vegetation biomass or nest survival time between the mowed and unmowed plots at this site (Figs 1 and 2). The ornithological data also reflected the different character of this grassland (Table 1, Fig. 3). Ruderal and nitrrophilous species producing low vegetation
cover in both years of the study made up a considerable proportion of the plant species growing on the unmowed A plot.

The study was done in areas visited by local inhabitants, so the potential effect of human disturbance may be important. Tests, however, indicated that people were unlikely to find or stumble upon nests (in several attempts, none of the artificial nests were located). Using artificial nests to assess predation intensity is a technique often used. Some surveys have found no relationship between experimental results and real predation pressure. In some of those studies, however, not enough attention was paid to making the nests look natural, or the nests were baited with plasticine eggs only (Weidinger 2001, Vander Haegen et al. 2002, Zanette 2002); this could lead to problems in interpreting the results of artificial nest experiments (Major and Kendal 1996). Also, the selection of sites for nests above the ground (Weidinger 2001, Zanette 2002) must be more arbitrary than for nests on the ground. Many other experiments show a strong relationship between the survival of natural-looking artificial nests and the intensity of natural nest predation (Wilson and Brittingham 1998, Davison and Bollinger 2000, Part and Wretenberg 2002). In this study the main question was the effect of annual mowing, so the exact degree of predation pressure at all sites was not as important as the relative differences in nest predation between mowed and unmowed plots.

The distances between the artificial nests were small (20 m), and their density was much higher than in natural breeding. This experiment was conducted mainly to show differences in the proportions of suitable nesting places between mowed and unmowed grasslands. For the survey, unrealistic “breeding” densities were imposed in order to effectively assess these differences on an appropriate spatial scale. In many experimental studies, nests have been set out 20 m apart (Bergin et al. 1997, Conner and Perkins 2003) or even closer (Fenske-Crawford and Niem 1997).

A great disadvantage of using artificial nests is the lack of breeding pair activity which may increase the effectiveness of predators (Weidinger 2002). On the other hand, hatching birds can actively defend broods against small mammals like rodents, which can increase nest success (Weidinger 2002). The use of quail eggs, as in this study, may lead to underestimation of the intensity of rodent predation, because of their size and relatively thick shells (Yahner and Mahan 1996, Maier and DeGraaf 2000). This is why the proportion of nests destroyed by rodents was also assessed using artificial eggs. The scent of plasticine does not attract rodents (Bayne and Hobson 1999).

In this study almost 25% of the artificial eggs were destroyed by Roman snails Helix pomatia L. Snails were occasionally observed feeding on plasticine eggs. In some cases they were able to destroy 90% of the egg surface by removing the 2 mm thick plasticine layer. This often prevented correct identification of the predator, especially if the teeth marks were only slightly impressed, calling into question the accuracy of the estimate of small mammal predation. Consequently, the use of artificial eggs was not continued in the second year. In 2005 the differences in nest survival between mowed and unmowed plots at the B and C sites were higher than in 2004. The year-to-year differences in biomass showed the reverse pattern. It follows that vegetation density was only one of the nesting success predictors and that other factors may also play a significant role. In 2004, foraging by Magpies close to experimental plots was intense. The mean number of young per magpie pair was considerably higher in 2004 (few young per pair). In 2005 none of the observed Magpie pairs had fledglings. These are probable reasons why predation intensity was found to be greater in 2004. Giuliano and Daves (2002) also found large differences in predation rates between successive years.

Despite the problems in distinguishing all factors responsible for the observed nest predation intensity, the relation between mowing and nest predation seems important. This study demonstrated that annual mowing is one of the factors that can increase nest predation pressure by decreasing vegetation biomass. These results are consistent with the suggestion that vegetation cover is particularly important for nesting success

The conclusions of this experiment should be considered in planning active protection of grassland areas that need to be mown to avoid succession. Annual hayng, which considerably decreases the biomass of the standing crop in the next year, may negatively influence nesting success. If conservation priorities involve protecting ground-nesting passerines, a mowing scheme that includes at least one fallow year but maintains the meadow vegetation should be implemented.

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5. REFERENCES


Davis K.D. 2004 – Area sensitivity in grassland passerines: effects of patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan – Auk 121: 1130–1145.


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