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Set-aside fields in agri-environment schemes can replace the market-driven abolishment of fallows

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ABSTRACT

Economic pressures from increased commodity prices and the growing demand for land for biomass plantations led to the abolition of compulsory set-aside fields in the European Union in 2008, affecting ca. 10% of total agricultural area. This area is now managed more intensively, and this is expected to adversely affect farmland biodiversity. Unfortunately, no mitigation of set-aside loss was introduced. Here we examined, whether or not set-aside fields managed in voluntary agri-environment schemes have the potential to improve farmland bird populations, as indicators of farmland biodiversity. We chose one, two and three year-old set-aside fields sown by a grass–legume mixture when established and selected winter cereal fields and semi-natural grasslands in Hungary as control sites. Relative abundance of birds was assessed; species were assigned to feeding guilds and classified according to their European conservation status. Species richness of herbaceous plants, cover of bare ground and vegetation height were used as covariates. Set-aside fields had higher species richness and abundance of birds compared to the adjacent winter cereal fields, similar to semi-natural grasslands. We found a positive correlation between set-aside age and farmland bird species richness and abundance. This can be explained mainly by the altered vegetation, especially the shorter vegetation height from the second year in the set-aside fields. We found no difference in the distribution pattern of species richness and abundance between feeding guilds according to set-aside age and habitat types. The wide scale application of voluntary set-aside management in agri-environment programs therefore has a high potential to mitigate the negative effects from the loss of compulsory set-aside schemes, and thus need the allocation of considerable resources in the forthcoming reformed CAP.

1. Introduction

Agricultural management alters natural ecosystems worldwide. It has long history and covers the highest proportion of land in Europe, resulting in farmlands with great diversity of wildlife adapted to this anthropogenic environment. Half of all species in Europe depend on agricultural habitats (Stoate et al., 2009); however, farmland biodiversity faces different challenges in Western and Central-Eastern Europe (Tryjanowski et al., 2011). Therefore, intensive agricultural management and the continuous decline in the area of natural habitats is probably the most important conservation challenge in Europe (Stoate et al., 2009). A better understanding of management strategies that diversify the landscape, such as establishing set-asides, are of crucial importance to conserve Europe's biodiversity. Farmland birds are one of the most well-monitored groups; several long-term and wide-scale databases on their population status are available (Gregory et al., 2005). Because of their mobility, they are appropriate indicators of agriculture's effects not only on local fields, but also at the landscape scale.

Over the last decades farmland biodiversity has collapsed in much of Europe, and has also showed negative trends in the United States and Australia, illustrated not only by the decline of common farmland birds, but other animal groups as well (Gregory et al., 2005; Fischer et al., 2010; Hendrickx et al., 1997; Sauer et al., 2003). This collapse was attributed mostly to the intensification of land use and farmland management (de Heer et al., 2005; Donald et al., 2001; Hole et al., 2002; Voříšek et al., 2010). Intensification was driven by the demand for more agricultural production after World War II, and resulted in serious overproduction in the European Union (EU) in the 1980s (Buckingham et al., 1999). To decrease overproduction, set-aside was introduced, first as voluntary (1988), then as mandatory (1992) agro-economic measure of the Common Agricultural Policy (CAP) of the old member states of the EU (EU15) taking whole fields out of production (Buckingham et al.,

Abbreviations: AES, Agri-environment Scheme; CAP, Common Agricultural Policy; ESA, Environmentally Sensitive Area; EU, European Union; SPEC, Species of European Conservation Concern.

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1999). By 1993/1994 approximately 6% of all agricultural lands, i.e. around 6.4 million ha, was set-aside in the 15 EU countries (Sotherton, 1998). Later, a maximum of 10% of arable land was managed annually as set-aside (Morris et al., 2011). Several countries introduced volunteer fallowing under agri-environment schemes (AESs) as well (e.g. the UK, Finland, France, Italy), and also in Hungary during the EU accession in 2002 (Ángyán et al., 2003). Set-aside fields were established not only in Europe, but covered extensive areas in the United States as well (Herkert, 2009; van Buskirk and Willi, 2004).

Although mandatory set-aside fields were established to control production, a number of studies from Western Europe and the USA have proven their value as important habitat for farmland birds (Buckingham et al., 1999; Corbet, 1995; Gillings et al., 2010; Henderson et al., 2000a; Herkert, 2009; van Buskirk and Willi, 2004). The environmental benefits of set-aside are derived mostly from the lack of drastic disturbances during management, no arable crop production and any chemical use (Buckingham et al., 1999; Henderson et al., 2000a; Kovács-Hostyánszki et al., 2011a; Mcmahon et al., 2010; Tscharntke et al., 2011; van Buskirk and Willi, 2004). However, the duration of optimal set-aside remains controversial. Farmland birds usually prefer both rotational and non-rotational set-aside fields over crop fields (Firbank et al., 2003). It has been suggested that rotational set-aside are more effective in supporting higher densities of birds than non-rotational set-aside (Buckingham et al., 1999). They are patchier and have more structurally complex vegetation in the first year compared to the older set-aside fields, which might be crucial for ground-feeding birds, enhancing visibility and availability of food resources (Butler and Gillings, 2004; Henderson et al., 2000a; Schaub et al., 2010). Therefore the maintenance of patchy and heterogeneous vegetation structure during the later years by appropriate management methods could significantly improve the value of non-rotational set-aside fields.

The pressure from the agricultural market and the increased demand for land for bioenergy crop plantations finally led to the abolition of compulsory set-aside in 2008 in the EU. This sudden continent-wide land-use change was predicted to result in wide scale agricultural intensification, including an increase in chemical use on fields, which had previously been set-aside, and a decline in farmland heterogeneity (Gillings et al., 2010; Rowe et al., 2009; Stoate et al., 2009). However, considerable areas of set-asides were still retained on the least productive fields, these changes are supposed to adversely affect farmland biodiversity (Fahrig et al., 2011). Unfortunately, no EU-wide impact assessment or mitigation for set-aside loss was introduced.

Although the abolition of set-asides caused large scale land use change across the EU, the evidence to predict the consequences and develop indicators is geographically restricted. Most of the available data come from countries characterised by intensive agriculture, such as the UK, and only few evidence of this exists from Central or Eastern Europe. Although these countries have large areas under agricultural management and still harbour valuable ecosystems with high biodiversity, rich and dense farmland bird assemblages compared to most Western-European countries owned to the current generally more extensive agricultural management (Báldi and Batáry, 2011; Donald et al., 2002; Tryjanowski et al., 2011). Few studies on abandonment are available (Orlowski, 2005; Skorka et al., 2010; Verhulst et al., 2004), but as far as we know, our study represents the first study on the effects of AES set-aside fields on farmland birds in Central Europe and provides an example of an agri-environment set-aside scheme. Moreover, the relationship between population declines and agricultural change has been driven by different mechanisms in Central and Eastern Europe, therefore AESs e.g. set-aside management should not be directly extrapolated from Western Europe (Báldi and Batáry, 2011).

The status of farmland birds in Hungary is largely driven by the changes in farmland management and land use. Two-third of the country is under agricultural management, and high areas are sown by winter cereal every year. As in most Central European post-socialist countries, intensive socialist agriculture collapsed after the political change in 1989 (Stoate et al., 2009), resulting in significant extensification (very low chemical input, millions of new land owners, abandonment, etc.) across Central and Eastern Europe, with an increase of farmland bird populations (Gregory et al., 2005; Stoate et al., 2009). Of the 74 bird species associated with agricultural habitats in Europe, 41 species occur in Hungary. As far as population trends, 27 species appear stable, 10 have increased and only four show declining populations from 1990 to 2000 (Burfield and van Bommel, 2004). At the EU27 level, several species have a considerable part of its breeding population in Hungary. For example, of the 18 farmland bird species more than 5% of their populations breed in Hungary that comprises only 2.1% of the EU's land surface. From those 29 species that show mostly a decline in the old member states of the EU (EU15), 12 show a stable population trend in Hungary (Burfield and van Bommel, 2004). From a qualitative perspective, 30 species of the total 41 farmland bird species in Hungary are listed as Species of European Conservation Concern (SPEC) (Burfield and van Bommel, 2004) because they are threatened in most of the western European countries. According to more recent data the Hungarian farmland bird population index has been declining since 2005 (Báldi and Szép, 2009), while current analyses suggest an increase in 2008 (Tibor Szép, pers. comm.).

In this study we aim (i) to assess the effectiveness of set-aside for birds by comparing winter cereal and set-aside fields; (ii) to examine how bird species richness and abundance change over the course of set-aside age; (iii) to relate vegetation changes to bird assemblages; and (iv) to test habitat type, set-aside age and vegetation effects on certain bird species groups according to foraging guilds and the conservation status of the observed bird species.

2. Material and methods

2.1. Study sites

The study sites were located in the Heves Environmentally Sensitive Area (ESA) (47°37′N, 20°31′E), Eastern Hungary. The Heves ESA was established in 2002 and covers around 40,000 hectares in the framework of the zonal action schemes of the National Agri-environmental Protection Programme (NAPP). The area is flat, characterised mostly by arable fields and grasslands; there are only a few woodlots, treelines, channels, and built-up areas. The main crops are cereals, sunflower and oilseed rape. The grasslands are extensively mowed or grazed, mainly by cattle and sheep, and no chemicals are applied. The Heves ESA is an important breeding and foraging habitat for several bird species. From about 400 bird species occurring in Hungary, more than 250 have been already recorded in the area. The most important are the breeding populations of great bustard (*Otis tarda*), imperial eagle (*Aquila heliaca*), red-footed falcon (*Falco vespertinus*), roller (*Coracias garullus*) and the great abundance of common farmland birds, like skylark (*Alauda arvensis*), corn bunting (*Miliaria calandra*) and yellow wagtail (*Motacilla flava*) (Báldi et al., 2005).

Environmentally Sensitive Areas (ESAs) have been designated in regions under extensive farming, where the maintenance and support of nature-friendly management regimes serve to protect the habitats and species. The Heves ESA was designed for the protection of rare farmland birds, especially the great bustard. Among the available voluntary schemes are the great bustard arable, alfalfa and grassland program. Creation of set-aside fields is part of the arable farming action plan. Fields have to be managed by regular crop rotation: cereal 20–25%, alfalfa 20–30%, oilseed rape and other crops (pea, sunflower, corn, etc.) 25–30%, set-aside 20–25% of all the farmer's fields. Fields can be taken out of production for 1–3 years. When a field is set aside, a three component seed mixture is sown into the fields after the last harvest in the autumn, containing two grass (e.g. *Festuca pratensis, Festuca arundinacea, Poa pratensis, Dactylis glomerata*) and one leguminous (*Medicago sativa*) plant species. Vegetation is mown once per year from 15th June, after the peak nesting periods for ground-nesting bird species, leaving the cut vegetation on site.

For our study, one, two and three years old set-aside fields were chosen, each with an adjacent winter cereal field pair, with six, six and five replicates (only 5 three-year old set-aside fields were available; the number of the available set-aside fields was restricted in general). Six semi-natural grasslands were also assigned, in order to compare the cereal and set-aside fields with semi-natural habitats (see map in Kovács-Hostyánszki et al., 2011b). All the cereal fields were managed similarly, fertilised with about 90 kg nitrogen/ha/year. Cereal fields were constituted by wheat (*Triticum aestivum*). Grasslands were managed extensively, without fertiliser application and grazed or moved once per year after the bird surveys. The most dominant species were Kentucky bluegrass (*Poa pratensis*), pseudovina (*Festuca pseudovina*) and meadow foxtail (*Alopecurus pratensis*). The mean area (±SE) of the study sites was 20.97 ± 1.78 ha. The paired set-aside and cereal fields were in similar size (difference in the field area within pairs: mean ± SE 1.88 ± 2.17 ha) and relief.

2.2. Bird census

The relative abundance of birds was assessed by point count method (Bibby et al., 1992) two times during April and May in 2008. Each site was visited between 05:00 and 10:00 and the order in which the points were sampled was reversed during the second visit. Birds were counted in 5 min periods mostly in the whole area of the fields within 100 m of the sampling point that were positioned in the interior of the fields, ignoring field boundaries and edge habitats (average number of points per field: mean ± SE: 4.51 ± 0.34). Visits were made only under good weather conditions (no rain, no strong wind). Birds were recorded by sight or sound; all individuals were noted but birds only flying over the field were ignored unless they were hunting. For each census point the higher count of each species was used from the two visits as the basic unit to compare relative bird abundances between field types.

Bird species were assigned to feeding guilds: insectivores (including also species relying partly on macroinvertebrates and non-seed plant material) and granivores (Haraszthy, 1998). Some species fell into both insectivores and granivores categories, their score was divided equally between each type (the total individual species score equals one) (Atkinson et al., 2002). See Appendix S1 with the list of species and total abundance, and their feeding guilds. Species were also classified according to their conservation status, namely whether listed as SPEC (Burfield and van Bommel, 2004). SPEC means species of European conservation concern. We pooled the SPEC1, SPEC2 and SPEC3 categories for our analysis.

2.3. Vegetation survey

A vegetation survey was conducted at each study field the same year to assess the species richness of herbaceous plants and cover of bare ground (in percent) and to estimate vegetation height (in cm). The cover of bare ground was assessed in each quadrat by eye, vegetation height was measured as the height of the tallest stems. Ten 2 m by 2 m quadrates were assigned at each study field, located at various distances (10–50 m) from each other depending on the field size. All quadrats were at least 20 m away from the field edge. Quadrats were distributed all over the field semi-randomly: from the randomly selected first quadrat the next ones were assigned in "horse-step" to the left until the 20 m wide edge zone, where we changed direction to the right. The distance of the horse-step varied according to the field size: the distance unit (two units forward and one to the left/right) was 10 m under 20 ha, 25 m between 20 ha and 40 ha and 50 m above 40 ha.

2.4. Statistical analyses

The effectiveness of set-aside management was measured as the difference of the dependent variable between the cereal and adjacent set-aside fields (Kleijn et al., 2006). The total number of bird species and individuals in the cereal field was subtracted from its set-aside field pair. As set-aside and cereal fields in each pair were next to each other, there was no confounding effect of landscape or other factors, except management. To account for differences in field size, raw census data were standardised to one census point (3.14 ha) at each field. To account for different sampling efforts in different fields, we applied sample-based rarefaction with the Mao Tau estimator to standardise species richness. We used the EstimateS software (Colwell, 2009). A *t*-test was used to compare the estimated number of species and individuals between the field pairs. The change of effectiveness by set-aside age was tested by General Linear Model.

The difference in vegetation in the studied habitats was assessed by plant species richness, vegetation height and bare ground surface. Furthermore, heterogeneity of vegetation structure was calculated using two parameters: variability of vegetation height and variability of bare ground surface. These parameters were calculated as the coefficient of variation ($CV = SD/mean \times 100$) from the raw vegetation height and bare ground surface data, estimating the variability in the whole field (Lepš, 2004). All the five vegetation variables were tested in the function of habitat type using General Linear Mixed Models (GLMMs).

Species richness and abundance of insectivorous, granivorous and SPEC bird species were compared among the five different habitat types. Analyses were conducted in two steps. First GLMM were fitted to test the effect of habitat type (fixed factor with five levels: winter cereal, one, two and three years old set-aside field and semi-natural grassland). Second vegetation height, bare ground surface and plant species richness were added to the model as covariates preceding habitat type. Since variability of vegetation height and variability of bare ground strongly correlated with the other vegetation parameters, their effect was tested separately, together with habitat type. Due to this procedure we tested if the differences among the habitat types are attributed to the vegetation. We used multivariate models testing for the non-linear (quadratic) effects of the vegetation variables. Quadratic terms were removed from the models in a backward selection in the case of non-significance. Analysis was conducted at the census point level. Bird data from each census point were matched against vegetation data collected from the entire field. In few cases log-transformation of species richness and abundance values helped to achieve normal model residual distribution. The lack of spatial independence of the paired set-aside and cereal fields (LOCATION) and among the quadrates/bird census points assigned at one field (FIELD) was considered by two random factors in nested design: LOCATION/FIELD. Multivariate comparisons of means by Tukey contrasts and Holm correction were performed between habitat types. Analyses were performed using the nlme and stats packages of R 2.10.0 (Pinheiro et al., 2009; R Development Core Team, 2009).

3. Results

In total 1347 individuals of 51 bird species were involved in the analyses (Appendix A). For bird species richness and abundance there were significantly more bird species and individuals in set-aside fields than in the paired cereal fields (*t*-test: species richness: $t = -2.46$, $df = 23.98$, $p = 0.021$; abundance: $t = -4.36$, $df = 24.39$, $p < 0.001$). The effectiveness increased with the age of set-aside fields in case of bird species richness ($F = 10.3$, $df = 2$, $p = 0.002$) with a significant difference between the three-year old set-aside and the younger set-aside, but not for bird abundance ($F = 2$, $df = 2.37$, $p = 0.129$) (Fig. 1).

From the 51 species 32 were classified as insectivores (including 10 species that feed on macroinvertebrates), five species as granivores, 10 species belonged to both of these categories, and four species were predators. Thirty-two species were listed in SPEC. The GLMM models indicated a significant habitat type effect on the species richness and abundance of all bird groups except the abundance of granivores, where it was marginally significant (Table 1). We found the least number of species and individuals in each functional group of birds in winter cereal fields, and one-year-old set-aside fields never showed significantly higher values than the cereal sites. Species richness and the abundance of insectivores and granivores increased with the age of set-aside fields, and were highest in the three-year old fields, when compared to the semi-natural grasslands. A similar pattern was found for SPEC species (Fig. 2a–c).

All vegetation variables, i.e. plant species richness, vegetation height, bare ground surface, height variability and bare ground variability, were influenced by habitat type (Table 1). Plant species richness was higher in set-aside fields and semi-natural grasslands than in the cereal fields. The species richness showed a non-significant increase with increasing time of set-asides and higher values in set-aside fields than in grasslands (Fig. 3a). The vegetation height was as high in the one-year-old set-aside fields as in the cereal fields, but decreased significantly from the second year, with similar values in the third year of set-aside and in the grasslands (Fig. 3b). The percentage of bare ground was significantly higher in the set-aside than in the cereal fields and grasslands, and increased without a significant difference with the age of set-aside (Fig. 3c). Height variability was similar in the set-aside fields and semi-natural grasslands and higher than in cereal fields (Fig. 3d). Bare ground variability in winter cereal fields and set-aside fields were similar, and lower than that in grasslands (Fig. 3e).

Vegetation height had a negative effect on the species richness and abundance of insectivorous species. The percentage of bare ground surface enhanced the abundance of insectivorous, granivorous and SPEC species. Plant species richness had a positive effect on the species richness of SPEC and on the abundance of insectivorous species. The species richness of insectivores peaked at the percentage of bare ground of approximately 30% and showed an increase above 20 plant species. Vegetation height variability had positive effect on species richness of insectivores and abundance of granivores. The abundance of insectivores peaked at 40 cm, the species richness of SPEC species at 35 cm and the abundance of SPEC species at 40 cm vegetation height variability. Bare ground variability had no effect in any cases. The effect of habitat type remained significant only in the case of species richness and abundance of insectivores after including the vegetation variables as covariates (Table 2).

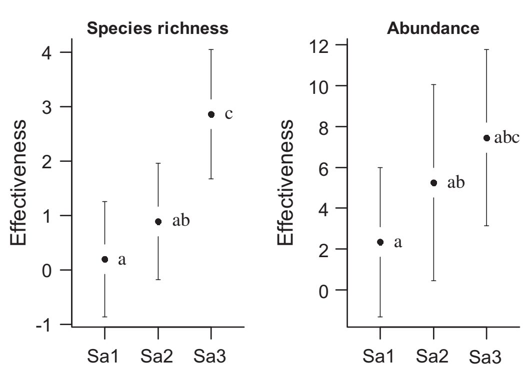

Fig. 1. The effectiveness of set-aside management in species richness and abundance of birds, and their change with the age of set-aside (one, two and three years old set-aside fields). The effectiveness was calculated as the difference in species richness or abundance of birds between the set-aside and its winter cereal field pair. Mean + 95% confidence interval (CI); different letters indicate significant difference between habitats.

Table 1
Effects of habitat type (winter cereal, one-, two- and three-year-old set-aside fields and semi-natural grasslands) on the listed variables according to the results of General Linear Mixed Models in the Heves ESA, Hungary. Significant *p*-values are in bold.

	Num. *df*	Den. *df*	*F*	*p*
Birds				
Species richness				
Insectivores	4	13	16.98	**<0.001**
Granivores	4	13	2.50	0.094
SPEC	4	13	8.69	**0.001**
Abundance				
Insectivores	4	13	14.18	**<0.001**
Granivores	4	13	4.91	**0.012**
SPEC	4	13	6.93	**0.003**
Vegetation				
Species richness	4	13	35.16	**<0.001**
Height	4	13	3.29	**0.045**
Bare ground	4	13	11.92	**<0.001**
Height variability	4	13	10.54	**0.001**
Bare ground variability	4	13	3.79	**0.030**

4. Discussion

In our study we addressed the question of how could agri-environment scheme set-aside fields be used to mitigate the loss of market regulated fallows to conserve farmland birds. Set-aside fields are generally considered valuable habitats for farmland biodiversity, however, there are some controversial results on their effectiveness as habitat for farmland birds, especially among the rotational (1 year) and non-rotational (several years) forms (Firbank et al., 2003; Henderson et al., 2000a,b; van Buskirk and Willi, 2004). We proved the effectiveness of set-aside management both in term of higher species richness and abundance of birds compared to the adjacent winter cereal fields. A wide range of insectivorous and granivorous species favoured set-aside fields at a comparable level to semi-natural grasslands. These results correspond with previous studies conducted in Western Europe, which underscored the high value of set-aside fields as preferred nesting and foraging habitats of farmland birds (Bracken and Bolger, 2006; Firbank et al., 2003; Henderson et al., 2000a,b; van Buskirk and Willi, 2004). The majority of these Western European studies found the one year old rotational set-aside fields more beneficial for farmland birds, while we found a clear increase in preference for two and three years old set-aside fields. However, previous Western European studies that have shown rotational set-aside fields to be preferred have been based on natural regeneration, not sowing, which enable us only to moderate comparison (Firbank et al., 2003; Henderson et al., 2000a).

Our explanation is based on mostly the vegetation structure and food availability as an indirect inference made from the vegetation structure. We found that vegetation in set-aside fields show significantly higher compositional and structural heterogeneity compared to winter cereal sites. Cereal fields were poor in weed

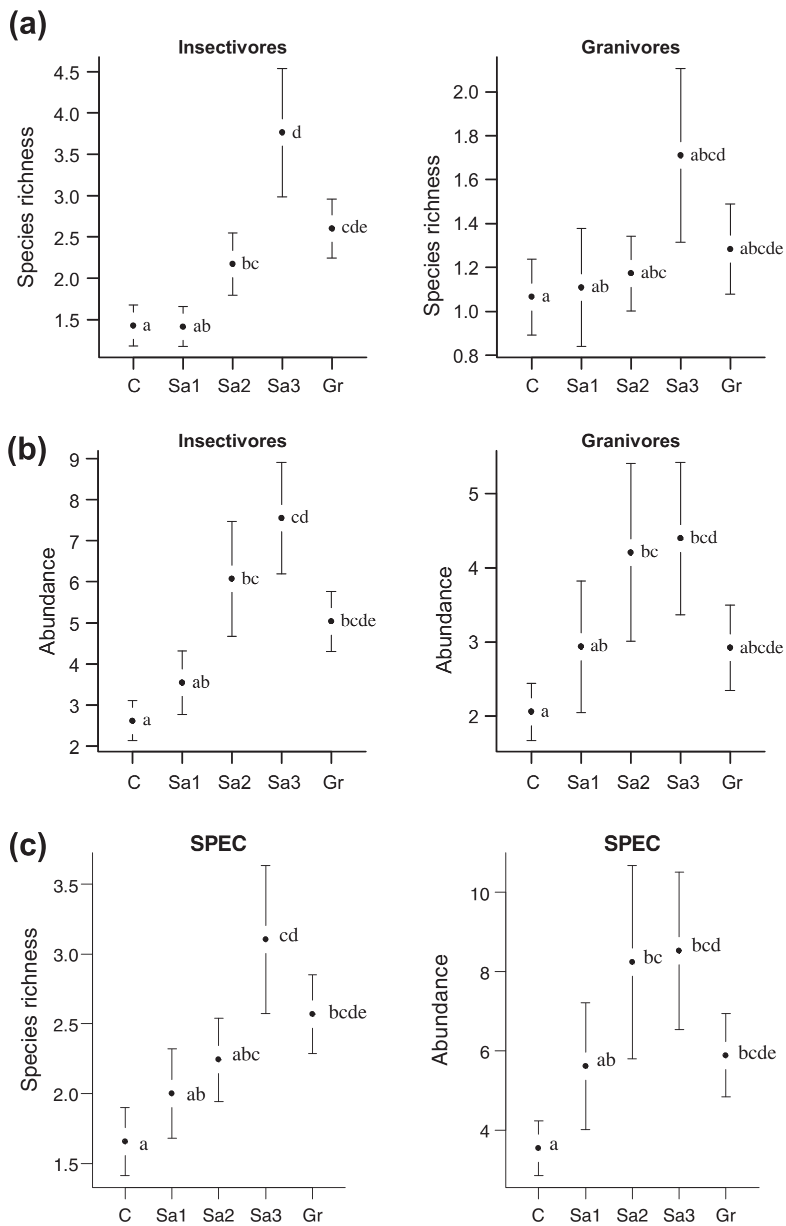

Fig. 2. The average species richness (a) and abundance (b) of insectivorous and granivorous bird species; and (c) the average species richness and abundance of species listed in the Species of European Conservation Concern list (SPEC) (Burfield and van Bommel, 2004) in winter cereal fields (C), one, two and three years old set-asides (Sa1, Sa2, Sa3) and semi-natural grasslands (Gr) in the Heves Environmentally Sensitive Area, Hungary. Mean ± 95% CI; different letters indicate significant difference between habitats.

species, characterised by tall crop with only few bare ground patches, creating a uniformly tall and closed structure. The semi-natural grasslands were characterised by their relatively high number of plant species, dominated by grasses that formed shorter vegetation than in cereal fields. The percentage of bare ground was similarly low, the vegetation height, however, had higher variability. Vegetation on the set-aside fields was more species rich than in the cereal fields, and provided higher structural heterogeneity of vegetation height, which is favoured by most farmland birds (Erdős et al., 2009; Schaub et al., 2010). The three age classes of the set asides fields that we studied (1, 2 and 3 years old) differed mostly in the height of vegetation. After the set-aside fields were taken out of production, a high number of weed seeds from the soil seed bank took root, largely due to the sown grass and leguminous species, the lack of dense arable crop, the consequent beneficial light conditions, and the lack of fertilisers and herbicides (Kleijn and Vandervoort, 1997; Kovács-Hostyánszki et al., 2011b). First year set asides had high species richness, but similarly tall vegetation as cereal fields, which prevented farmland birds to use the one-year old set-aside fields. From the second year vegetation became considerably shorter due to its cut in the end of the first year. Furthermore, the variability of both the vegetation height and bare ground surface was higher on the set-aside fields than in the cereal fields. We argue that beneficial management of these set-aside fields is crucial for farmland birds, requiring annual mowing to maintain heterogeneous vegetation with patches of both short and taller plants (Hansson and Fogelfors, 1998).

Previous studies in the UK argued that with annual mowing non-rotational set-aside tends to become denser and more homogenous after the first year of management, more typical of intensive grassland. This is less suitable for many bird and invertebrate species, which prefer open ground patches (Firbank et al., 2003; Henderson et al., 2000b). This is partly the consequence of higher nitrogen content and the poor soil seed bank due to the annual

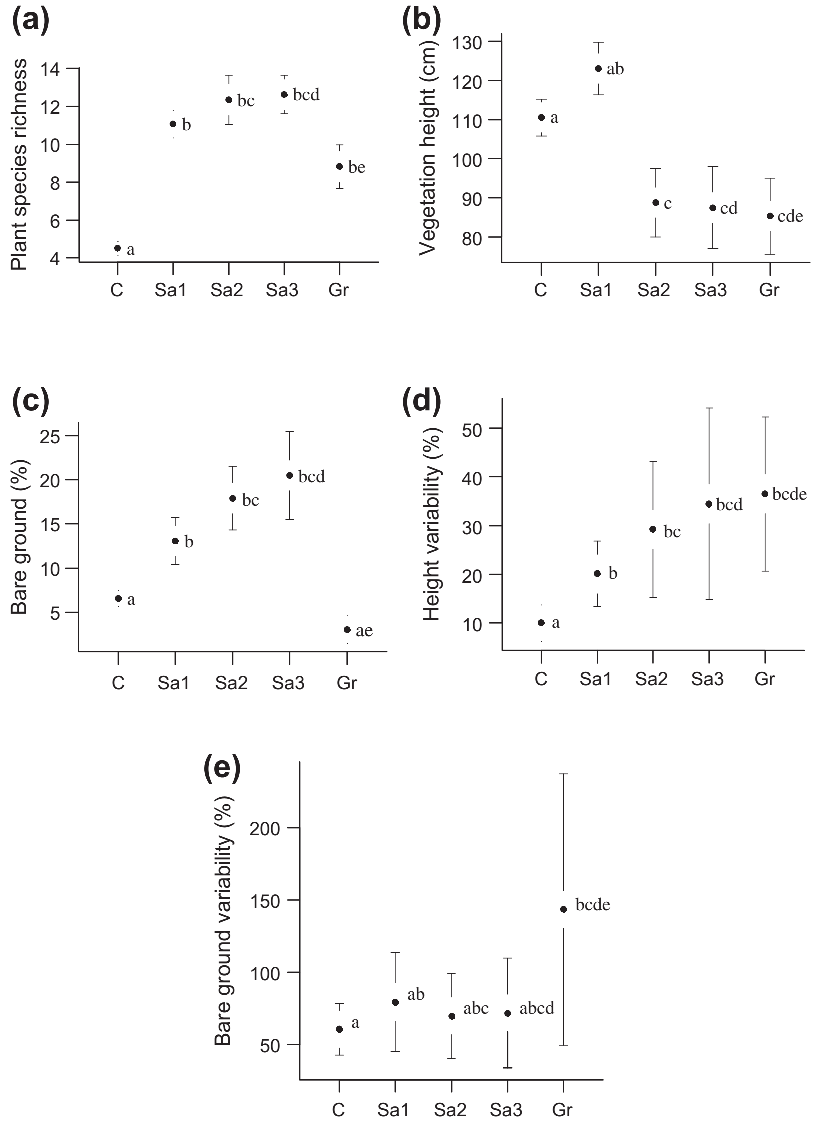

Fig. 3. The average (a) plant species richness, (b) vegetation height (cm), (c) bare ground surface (%), (d) height variability (coefficient of variation, CV) and (e) bare ground variability (CV) in winter cereal fields (C), one, two and three-year old set-aside fields (Sa1, Sa2, Sa3) and semi-natural grasslands (Gr) in the Heves Environmentally Sensitive Area. Mean + 95% CI; different letters indicate significant difference between habitats.

intensive management over the past decades (Kleijn et al., 2009).Furthermore the damper climate also allowed grasses to dominate the sward in the Western European set-aside fields, while the relatively dry Hungarian summers might result in grasses less likely to dominate the set-aside sward after 2–3 years.

Our study identified the important role of local spatial scale, i.e. vegetation heterogeneity reflects food availability. We found that abundance of several insect taxa increases significantly even in the one-year-old set-aside fields (Kovács-Hostyánszki et al., 2011a). The largely inaccessible food resources at the one-year-old set-aside fields with high and dense vegetation made these habitats less suitable for birds, which tall vegetation was surely the most important driving effect of the low bird species richness and abundance in the one-year-old set-aside fields (Atkinson et al., 2004; Butler and Gillings, 2004; Schaub et al., 2010; Vickery et al., 2001). However, in the second year the considerably lower sward height with increased openness of vegetation resulted in better foraging conditions in the invertebrate rich set-aside fields (Kovács-Hostyánszki et al., 2011a). This explains the increased species richness and abundance of birds in the two and three years old set-aside fields. The mosaic pattern of bare ground patches within the vegetation seems to have an important role in habitat selection of both insectivorous and granivorous bird species (Schaub et al., 2010). Granivores generally prefer arable fields and many of them also utilise crop seeds (Robinson et al., 2001), although the higher plant species richness in the set-aside fields provides a more diverse seed supply and the diet of many granivorous bird species relies on insect food during the breeding season (Wilson et al., 1999). In this study, the three-year old set-aside fields were sometimes preferred even more than the semi-natural grasslands, perhaps because grasslands had a lower coverage of bare ground, which is known to be beneficial for farmland birds (Schaub et al., 2010).

Two and especially three years old set-aside fields seemed to be beneficial for SPEC species. Therefore, like other extensive agricultural practices, set-aside management seems to promote species of a conservation concern in Europe (Batáry et al., 2007; Stoate et al., 2003). The restoration of birdlife in the intensive Western European agricultural landscapes might be assisted by a sufficiently rich pool of farmland birds in Central Europe. However, to maintain this high level of biodiversity in Central Europe locally appropriate

Table 2
Effects of plant species richness and vegetation structure on bird species richness and abundance of different foraging guilds and SPEC species according to the General Linear Mixed Models. Significant *p*-values are in bold.

	Bird species richness									Bird abundance								
	Insectivores			Granivores			SPEC			Insectivores			Granivores			SPEC		
	df	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*
Model I.																		
Vegetation height	1.8	21.03	**0.002**–	1.10	0.88	0.370	1.10	0.60	0.456	1.10	22.71	**0.001**–	1.10	1.87	0.201	1.10	3.79	0.080
Quadratic (vegetation height)																		
Bare ground cover	1.8	13.85	**0.006**+	1.10	1.55	0.241	1.10	4.19	0.068	1.10	21.17	**0.001**+	1.10	15.04	**0.003**+	1.10	17.49	**0.002**+
Quadratic (bare ground cover)	1.8	5.34	**0.050**–															
Weed species richness	1.8	16.67	**0.004**–	1.10	2.78	0.127	1.10	14.24	**0.004**+	1.10	14.99	**0.003**+	1.10	1.43	0.260	1.10	4.26	0.066
Quadratic (weed species richness)	1.8	5.99	**0.040**+															
Habitat type	4.8	4.26	**0.039**	4.10	2.22	0.140	4.10	2.70	0.093	4.10	2.18	0.145	4.10	1.41	0.299	4.10	1.50	0.276
Model II.																		
Vegetation height variability	1.11	56.33	**<0.001**+	1.11	0.64	0.440	1.10	21.60	**0.001**+	1.10	59.91	**<0.001**+	1.11	11.45	**0.006**+	1.10	19.05	**0.001**+
Quadratic (vegetation height var.)							1.10	9.89	**0.010**–	1.10	11.28	**0.007**–				1.10	5.53	**0.041**–
Bare ground variability	1.11	2.28	0.159	1.11	1.35	0.270	1.10	2.70	0.131	1.10	0.03	0.870	1.11	0.04	0.836	1.10	0.21	0.653
Quadratic (bare ground var.)																		
Habitat type	4.11	5.08	**0.015**	4.11	2.61	0.094	4.10	2.62	0.098	4.10	2.98	0.073	4.11	2.31	0.122	4.10	1.57	0.255

agri-environment measurements are needed. Integration of set-aside management into the agri-environment schemes may contribute to the conservation of farmland bird populations even beyond the promoted area.

5. Conclusions

We showed that set-aside management under agri-environment schemes can positively affect the local distribution of birds during the breeding season. Since the abolishment of mandatory set-asides in the EU, when the market regulated set-aside fields largely disappeared (Stoate et al., 2009), our findings show a promising way to counteract the negative effects on farmland birds: well-designed AESs have the potential to mitigate the loss of market regulated set-asides. We expect that AES set-asides are unlikely to be worse in quality than those in market regulated schemes; it may even be better. In addition, our results from a less studied, but diverse region of Europe provide some novel insights into the effects of set aside management. For example, contrary to the conclusions of van Buskirk and Willi (2004), we found a positive correlation between set-aside age and farmland bird species richness and abundance. We suspect that this discrepancy is due to the limited evidence that were available for the van Buskirk and Willi review (Kleijn and Báldi, 2005).

The European Commission along with the new CAP reform from 2013 identified the potential for introducing 'environmental set-aside' as Ecological Focus Areas (Hart and Baldock, 2011; Morris et al., 2011). Policy discussions will probably take place on the legal proposals during the second part of 2011. Therefore all the available information about the efficiency and suitable management of these set-aside fields are urgently needed. The CAP reform in 2013 provides a good opportunity to restore farmland biodiversity that was lost after 2008 due to abolishment of set-aside. Our study proved a promising way for its restoration effort.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2012.03.039.

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