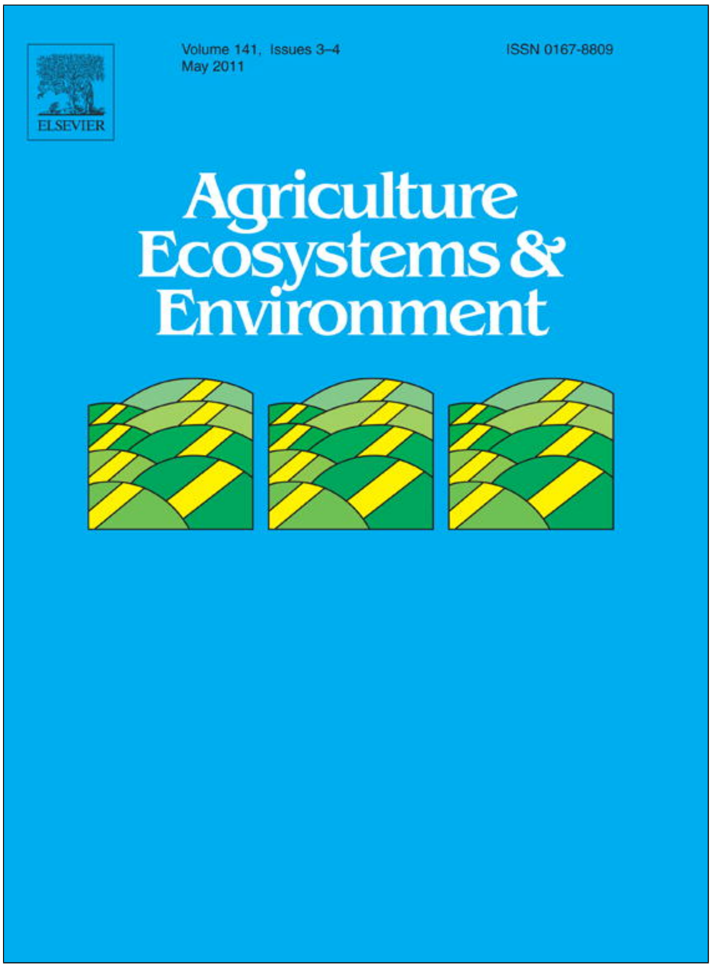
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Set-aside promotes insect and plant diversity in a Central European country

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ABSTRACT

The area of non-cropped habitats has been decreasing in Europe largely due to land conversion into cropland and energy crops. In Hungary, special agri-environment schemes in Environmentally Sensitive Areas require the establishment of sown set-aside fields especially for endangered bird species. We tested if these set-aside fields are beneficial for plants and insects of agricultural landscapes. We compared the herbaceous flora, grasshopper (Orthoptera), bee (Apidae) and butterfly (Rhopalocera) fauna of five field types (1, 2 and 3 year-old set-aside, winter cereal fields and semi-natural grasslands). Species richness, abundance and species composition of insects were tested against field type and plant species richness. The wheat fields were the poorest habitats for all taxa. The species richness and abundance of the studied insects were usually higher in set-aside than in cereal fields with no significant difference between set-aside of different age. We found the highest number of orthopteran species and butterfly individuals in semi-natural grasslands. At community level, field type and plant species richness had a significant effect on orthopteran assemblages. Butterfly assemblages were significantly affected by field type. Bee assemblages were not significantly related to the above variables. We can conclude that set-aside fields provide important habitat patches for plants and insects, in some cases with similar value to semi-natural grasslands. Our results emphasise the importance of set-aside within the Hungarian agri-environment scheme. Establishment of set-aside management in other Central European countries will likely to be of a similar value as the Hungarian set-aside fields.

1. Introduction

Farmland insect communities collapsed dramatically in Western Europe during the last few decades apparently as a result of intensive farmland management (Hendrickx et al., 1997). Their impoverishment is partly due to the consequent loss of their food plants at the intensive agricultural areas (Biesmeijer et al., 2006). The large amount of artificial fertilisers and herbicides altered the farmland flora by enhancing only the crop species, while reducing the diversity and cover of the native plant species due to crop competition and direct mortality caused by herbicides (Haddad et al., 2000). Replacement of natural grasslands and extensive arable fields by monocultures has caused a dramatic decline in the extent and floral diversity of habitats available for bees (*Hymenoptera: Apoidea*) and butterflies (*Lepidoptera*), leading to their considerable decline in Europe (Ouin et al., 2004; Goulson et al., 2008). The species diversity of plant communities is important not only for pollinator insects, herbivorous orthopterans (*Orthoptera*) respond to changes of vegetation too (Kemp et al., 1990). Furthermore, direct toxicity by insecticides has resulted in a remarkable decrease of diversity and abundance of wild bees, butterflies and orthopterans and caused a dramatic simplification of insect assemblages in the second part of the 20th century (Johansen, 1977; Haddad et al., 2000; Biesmeijer et al., 2006). Because of the importance of these insect groups as biomass components in ecosystems and their key role in food webs as consumers of plants and as food source for other insects and vertebrates (Wilson et al., 1999), the efficiency of ecosystem services may have declined due to the decline of insect populations, as demonstrated by the pollination crisis (Kremen et al., 2002).

In contrast to practices that promoted intensification, set-aside was introduced in the 1980s to counteract the increasing surplus of agricultural production in Europe (Sotherton, 1998). Management of such set-aside fields had been varied. The first introduced practice in the UK, for example, required rotational management taking arable fields out of production for one year (Corbet, 1995). Later, a non-rotational option for 5–10 years (or long-term set-aside) was also made available. In both cases, fields were sown with a seed-mixture or left to regenerate naturally (Sotherton, 1998; Van Buskirk and Willi, 2004). This resulted in reduced

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tillage with more diverse vegetation than in the cropped fields. For many taxa, set-aside fields provided more suitable habitat than intensively managed grass or arable crops (Gathmann et al., 1994; Steffan-Dewenter and Tscharntke, 1997), and options that create habitat similar to set-aside have been integrated into agri-environment schemes in some European countries. For example, in the UK non-rotational grass and rotational stubble management have been present in successive agri-environment schemes since 1991 (Sotherton, 1998).

A key question in set-aside schemes is the duration of setting aside (Tscharntke et al., in press). Several different insect communities seem to benefit from a shorter or longer period of set-aside (Steffan-Dewenter and Tscharntke, 1997; Corbet, 1995; Tscharntke et al., in press). In contrast to land abandonment there is annual vegetation control, preventing the spread of invasive plant species that is a common problem in the Central and Eastern European (CEE) countries (Chytry et al., 2009). Altering vegetation during succession from year to year might host different insect communities.

Since 2007, the increasing commodity prices and the need for energy crops has led to the setting of zero-rate and subsequent abolition of mandatory set-aside from the EU Common Agriculture Policy (Rowe et al., 2009). Consequently, set-aside as a condition of receiving the Arable Area Payment disappeared from EU states, but in some countries, set-aside has survived as part of agri-environment schemes, so in Hungary. In Hungary, set-aside was introduced as part of the national agri-environment scheme in 2002 following accession to the European Union (EU) (Ángyán et al., 2003). In contrast to most EU states, set-aside in Hungary is a measure designed specifically to have biodiversity and environmental benefits rather than curb production. In a spatially restricted scheme for the protection of the great bustard *Otis tarda*, and other protected bird species, farmers have to take 5–10% of their arable fields out of production during the five-year-long contract period (Ángyán et al., 2003). The maximum period for setting aside a given field is three years.

In CEE countries, any beneficial conservation value of set-aside may have considerable importance to counteract the potential negative effects on farmland biodiversity of more intensive agricultural practices following the introduction of the EU CAP in 2004 (Schmitt and Rákosy, 2007). However, in Hungary and other CEE countries, the supposed positive effect of set-aside on biodiversity is still anecdotal. Results from other regions can be extrapolated to CEE countries only with great care (Kleijn and Báldi, 2005).

There have been several studies reporting generally negative effects of intensive agricultural management in crop fields on wild plants and arthropods in Central Europe (Batáry et al., 2008; Hyvönen and Salonen, 2002; Kovács-Hostyánszki et al., 2011), and revealing the importance of semi-natural grasslands for maintaining farmland biodiversity (Batáry et al., 2007). In this study, we investigated the importance of set-aside fields as potentially valuable habitats for herbaceous flora and three major insect taxa (orthopterans, bees and butterflies). One-, two- and three-year-old set-aside fields were compared with winter cereal fields and semi-natural grasslands, providing crucial data about the response of plants and insects to the different management practices, and thus enhancing knowledge of conservation management in agricultural landscapes. We hypothesised that (i) set-aside fields are richer in species and individuals of butterflies, bees and orthopterans than winter cereal fields, but poorer than semi-natural grasslands; (ii) community composition of the studied insect taxa is affected by field type and plant species richness; (iii) age of set-aside fields is positively related to vegetation complexity and species richness and abundance of bees, orthopterans and butterflies; (iv) plants (especially those that are insect-pollinated) are good predictors of all studied insect taxa.

2. Methods

2.1. Study area and study design

The study was conducted in 2008 in the Heves Environmentally Sensitive Area, Eastern Hungary, established in 2002 as part of the national agri-environment programme. The study sites were located between Besenyőtelek and Poroszló, north from Lake Tisza (47°42′N-47°38′, 20°25′E-20°36′E). From a bird's-eye perspective the Heves region is a large scale mosaic of arable fields, dry and wet alkaline grasslands and semi-natural grasslands. Dominant plant species in the semi-natural grasslands are golden foxtail grass *Alopecurus pratensis*, pseudovina *Festuca pseudovina*, kentucky bluegrass *Poa pratensis*. Characteristic plant species are the Pannonian yarrow *Achillea pannonica* and Siberian statice *Limonium gmelinii*.

A total of 39 fields (17 set-aside, 16 wheat and 6 grassland) were selected for sampling (see Appendix S1 in Supplementary Material). Winter wheat was chosen as a control because it is the commonest crop type in the region, likely to be sown instead of set-aside. Semi-natural grasslands were sampled to obtain a comparison between arable fields and extensively cultivated, more natural habitats. To test an effect of set aside age, one-, two- and three-year-old set-aside fields were chosen with six replicates (only five three-year-old set-aside fields were available). Each set-aside field was paired with a winter wheat field with a minimal possible distance between the paired fields. In one case, we paired a wheat field with two set-aside fields because of the restricted number of available sites. All set-aside fields had been sown in autumn after the last crop harvest. The seed-mixture contained one leguminous (usually *Medicago sativa*) and two grass species (e.g. *Lolium* spp.). Fields were kept chemical-free during set-aside period, and mown once a year in the second half of June. The winter cereal fields were managed extensively with an average of 70 kg Nitrogen per ha per year and one herbicide and one insecticide spray during spring, applying the same chemicals. The cereal fields were harvested in the second half of June. The semi-natural grasslands were fertiliser and chemical free, grazed rather extensively or mown once in late May–June.

2.2. Vegetation survey

Herbaceous vegetation was surveyed once in June. Ten 2 × 2 m quadrats were assigned at each study site, located randomly at various distances depending on the field size and at least 20 m away from the field edge. The species richness and cover of herbaceous plants was assessed in each quadrat by eye. Vegetation height was measured as the height of the tallest stems. For the analyses, plant species richness pooled in each field was used.

2.3. Insect sampling

2.3.1. Butterfly

Butterflies were sampled using transect counts. The 39 fields were classified into three groups according to their size (5–30 ha, 30–40 ha, and 40–55 ha). We used 10, 20 and 30 min transects in the three categories, respectively, to adjust sampling effort to field size (Krauss et al., 2003). In case of 20 and 30 min long surveys transects were divided to 10 min long subsamples. Sampling was carried out on four occasions between May and August with ca 4 weeks in between counts. On each occasion, we sampled all of the 39 fields in a randomized order within three consecutive days. Transect counts were performed between 9:00 a.m. and 6:00 p.m. under suitable weather conditions (temperature >18 °C, no rain, wind speed <20 km/h). A single observer walked all transects with a standard velocity of 50 m/min and counted all butterflies to species level seen within 5 m to left, right and forward. The period of time devoted to the capture and identification of some specimens was not included in the sampling time. The same pathways were walked on every visit. Data from the four sampling occasions were pooled within transects.

2.3.2. Orthopteran

Orthopterans were also sampled by transect counts using the same field size classification method as for butterflies. The sampling was carried out once in August when most of the species were adults and specimens could be reliably identified to species based on their calling songs or eidonomy. Transect counts were performed between 9:00 a.m. and 6:00 p.m. under suitable weather conditions (sunny weather only with transient clouds). Each 10, 20 or 30 min transect was divided into 5 min long subsamples to calculate species accumulation curves (Colwell, 2006). Between these 5 min long sessions the observer walked away for 30–40 m before restarting counts to avoid the repeated detection of the same individuals. A single observer walked all transects and counted all orthopterans heard or seen within 5 m to left, right and forward on species level. Data were analysed at field level.

2.3.3. Bee

Bees were sampled by coloured pan traps (Duelli et al., 1999). A group of a white, a yellow, a blue and a green pan trap were exposed on a woody post in the interior part of all the 39 study fields. Pan traps were 40 cm above the vegetation, and as vegetation height increased, the traps were placed higher. The four different colours were selected based on spectrophotometric measurements to attract a wider range of bee species, which differ in the detected photospectrum. Traps were opened for four consecutive one-week long periods from the second week of May until second week of June. Traps were filled with ethylene glycol–water mixture (1/4, v/v) and a small amount of detergent to reduce the surface tension and enhance the efficiency of sampling. Sampled bees were identified to species level. Data from the four sampling periods and from the four different coloured traps were pooled within fields.

2.4. Statistics

To measure the effect of field type (fixed factor with five levels: winter cereal field, one-, two- and three-year-old set-aside fields or grassland) and plant species richness we used General Linear Mixed Models (GLMM). Since there was significant intercorrelation between these two explanatory variables their effect was tested in separate models. In the case of bees, only the species richness of insect-pollinated plants was applied. The response variables were: species richness (area adjusted sample size) of orthopterans, bees, butterflies, plants and insect-pollinated plants, abundance of the three insect taxa, and estimated species richness and abundance (equal sample size) of orthopterans and butterflies. Response variables were logarithm transformed, when the distribution of model residuals was not normal. The lack of spatial independence between samples was taken into account by using location as random factor: set-aside and cereal fields were nested within pairs. In one special case where a wheat field was paired with two set-aside fields, the unbalanced design was controlled for with the applied random factors, giving the same location codes for the two set-aside fields and the cereal field. A post-hoc Tukey HSD-test following one-way ANOVA was performed for a pair-wise comparison between field types. Analyses were performed using the nlme package of R 2.9.0 software (Venables and Ripley, 2002; Pinheiro et al., 2007; R Development Core Team, 2009).

In case of orthopterans using the 5 min subunits for species records we calculated an estimated species richness per study site. Abundance-based Coverage Estimator (ACE) was applied using EstimateS, Version 8.20 (Colwell, 2006) and the recorded species richness was divided by ACE to obtain the species saturation per site. Species saturation was 90.9% in cereal fields, 79.4% in one-year old, 75.6% in two years old, 85.4% in three years old set-aside fields and 82.5% in grasslands in case of orthopterans. Since species saturation was lower than 80% in the case of two field types, we also present estimated species richness for orthopterans.

Butterfly sampling was conducted in 10 min long sampling units, which means no possibility for calculation of species richness saturation in case of the smaller sites (10 min long sampling time in total). Therefore, to make all sites comparable, ACE values were calculated for 10 min long sampling time in case of the larger fields, where observation was done in 20 and 30 min respectively. To avoid effects of season-dependent species turnover, we pooled the first 10 min of all four transect walks (four replicates during the season) per habitat, then the second and finally the third 10 min. Intermediate sized habitats with 20 min transect walks had therefore two steps, large habitats three steps to calculate the estimated species richness for a 10 min long sampling session. In case of the small sites the observed species richness data were used in this case in the following analyses. Beside observed abundance values, abundance of orthopterans and butterflies was calculated reducing sample size to 10 min in all fields in order to standardise sampling effort.

In order to find out how field type and plant species richness affect the community composition of insect assemblages, we applied partial redundancy analyses (RDA). Separate analyses were conducted for orthopterans, bees and butterflies. The species matrices were constrained by field type and plant species richness (insect-pollinated plants in case of bees). Hellinger transformation was performed for each species matrix allowing the use of ordination methods such as RDA, which is Euclidean-based, with community composition data containing many zeros (Legendre and Gallagher, 2001). Calculations were carried out using the vegan package (version 1.16, Oksanen et al., 2008) of R 2.9.0 software (R Development Core Team, 2009).

3. Results

3.1. Species richness and abundance

In total 2160 individuals of 28 orthopteran, 6791 individuals of 95 bee and 1940 individuals of 29 butterfly species were detected in winter cereal fields, set-aside fields and semi-natural grasslands (see Appendix S2 in Supplementary Material).

In the GLMM, field type had a significant effect on the species richness of plants, insect-pollinated plants, orthopterans and butterflies, the abundance of all three insect taxa, the estimated species richness of orthopterans and butterflies and the species density of butterflies (Table 1). We found the least plant, orthopteran and butterfly species and individuals in the winter cereal fields (Fig. 1a–c). The Tukey HSD pairwise test showed that significantly higher numbers of butterfly, plant, insect-pollinated plant species and butterfly abundance was already present in the one-year-old set-aside fields than in winter cereal fields (Fig. 1a, c, d). The species richness of butterflies, plants, insect-pollinated plants and butterfly abundance were higher also in the older set-aside fields and grasslands than in the cereal fields. There was no significant difference between field types in case of bee species richness (Fig. 1d). The Tukey HSD-test showed the age of set-aside did not significantly relate to any community matrix for the studied taxa. Significantly higher observed and estimated butterfly abundance were found in the semi-natural grasslands than in the one- and two-year-old set-aside fields (see further figures about the effects of habitat type on the abundance of the three insect taxa in Appendix S3 in Supplementary Material).

Plant species richness significantly and positively correlated with species richness, estimated species richness and abundance of

Table 1
Results of General linear mixed models for the species richness and abundance of orthopterans, bees, butterflies, plant species richness and species richness of insect-pollinated plants, estimated species richness and abundance of orthopterans and butterflies in winter cereals, one-, two- and three-year old set-aside fields and grasslands in the Heves ESA, Hungary. Significant *p*-values are in bold.

	Habitat			Plant species richness		
	df	*F*	*p*	df	*F*	*p*
Species richness (area adjusted sample size)						
Orthoptera	13	10.27	**<0.001**	16	9.04	**0.008**
Bee	13	2.40	0.103	16	3.71	0.072
Butterfly	13	24.82	**<0.001**	21	0.09	0.767
Plants	13	68.84	**<0.001**			
Insect-pollinated plants	13	37.03	**<0.001**			
Abundance						
Orthoptera	13	4.69	**0.015**	16	5.67	**0.030**
Bee	13	3.36	**0.043**	16	0.54	0.473
Butterfly	13	51.38	**<0.001**	21	0.54	0.472
Species richness (estimated, ACE)						
Orthoptera	13	5.79	**0.007**	16	5.68	**0.029**
Butterfly	13	30.01	**<0.001**	21	0.45	0.508
Abundance in the first 10 min (equal sample size)						
Orthoptera	13	2.31	0.112	16	3.81	0.069
Butterfly	13	21.38	**<0.001**	21	2.06	0.166

orthopterans, but was not correlated significantly with butterflies (see Appendix S4 in Supplementary Material). The species richness of insect-pollinated plants was not correlated significantly with the species richness and abundance of bees (Table 1).

3.2. *Redundancy analyses*

The partial RDA showed that field type and plant species richness had a significant effect on orthopteran communities. Neither the field type nor the species richness of insect-pollinated plants influenced significantly the species composition of bee communities. The butterfly assemblages were significantly affected by field type, but not by plant species richness (Table 2; see Appendix S5 in Supplementary Material).

4. Discussion

We found that in Hungary set-aside fields were richer in plants, butterflies and orthopterans than winter cereals, and poorer than semi-natural grasslands regarding orthopteran species richness

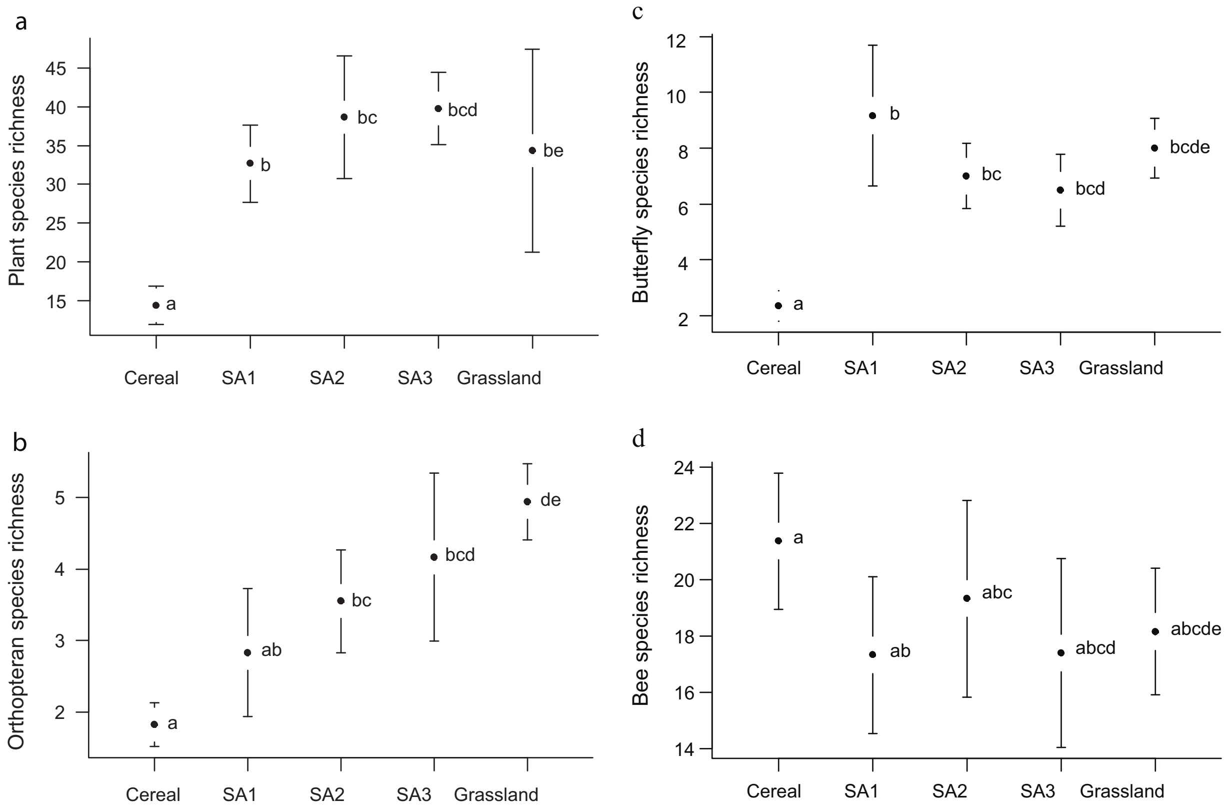

Fig. 1. The species richness of (a) plants, (b) orthopterans, (c) butterflies and (d) bees on winter cereal fields, one, two and three years old set-aside fields (SA1, SA2 and SA3) and grasslands in the Heves Environmentally Sensitive Area.

Table 2
Results of redundancy analyses (RDA) analysing the effects of habitat type and plant species richness on the species composition of orthopteran, bee and butterfly assemblages. *F*-values mean pseudo-*F*. Significant *p*-values are in bold.

	Habitat		Plant species richness	
	F	*p*	*F*	*p*
Orthoptera	3.93	**<0.001**	0.56	**0.044**
Bee	1.08	0.230	1.10	0.269
Butterfly	4.50	**<0.001**	1.52	0.100

and abundance of butterflies. Species composition of butterfly and orthopteran assemblages was also different for the field types.

Plants were directly affected by set-aside management, which requires sowing in the first year and annual mowing, yet these seemed to allow the presence of a high number of plant species, which is true also for insect-pollinated plants. The direct toxicity of herbicides and indirect effects of application of inorganic fertiliser probably prevented most of the wild plant species from surviving in winter cereal fields (Hyvönen and Salonen, 2002). In set-aside fields, however, communities of colonising and surviving wild plant species began a succession process (Corbet, 1995). Beside the sown leguminous and grass species, the lack of herbicide application allowed the growth of several wild plants from the seed bank and consequently a diverse and dense vegetation developed within the first year of set-aside, similarly to the results of studies performed in the UK (e.g. Firbank et al., 1993). Furthermore, since the sown vegetation usually does not constitute dense sward in the first year, it could benefit plant diversity (see Kuussaari et al., in press). The annual mowing of vegetation provided light supply for those plants that could not compete with the fast growing pioneer ones in the first year. All these differences of field treatment resulted in different species composition and increasing species richness during the first years of set-aside, exceeding in some cases even the species richness of semi-natural grasslands owned to intensive secunder succession (Kleijn and Vandervoort, 1997). Semi-natural grassland swards have usually received less frequent and invasive management and therefore became structurally and compositionally less diverse over time.

The strongest effect of field type (i.e. crop and management) was demonstrated for species richness, abundance and composition of orthopterans. Orthopterans have generally lower dispersal ability, compared to that of bees and butterflies and therefore their exposure to local factors such as field management should be more consistent than in the other two taxa. Moreover, they live within the vegetation and usually feed on plant tissues (Chapman and Joern, 1990), which makes them tightly related to small scale habitat patterns, microclimatic features of the vegetation layer and species composition of the plant association in which they live (Kemp et al., 1990; Szövényi, 2002). Orthopteran species richness and abundance were lowest in the cereal fields, which might be the consequence of the homogeneity of those habitats in terms of vegetation structure, microclimatic features and plant species composition. Set-aside fields showed intermediate values of average species richness of orthopteran assemblages between those of the cereal fields and semi-natural grasslands, with a tendency to increase with the set-aside age. Set-aside fields with their higher plant species richness might present a structurally more heterogeneous environment with more diverse food sources and microclimatic conditions than cereal fields, allowing more orthopteran species to colonise it. Abundance of orthopterans was higher in the set-aside fields than in the cereal fields and, interestingly, even than in the semi-natural grasslands. In set-aside fields, where the level of anthropogenic disturbance is intermediate in comparison to that in cereal fields and semi-natural grasslands, the regulatory processes shaping community structure may be much less rigorous than they are in the semi-natural grasslands, e.g. due to fewer predators. Considering data only from the first 10 min of observation in each field, there was no field type and only marginal plant species richness effect on the estimated abundance. Orthopteran insects often show aggregated spacing in their habitats because of patchy resources and calling aggregations of males (Bradley, 1985). That aggregated pattern may increase the variance of our abundance data, when only the data of the first 10 min long sections were taken into account. That increased variance may explain why no effect of field type could be detected when calculating with samples reduced uniformly to the first 10 min.

Butterfly species richness in set-aside fields and semi-natural grasslands was significantly higher than that in cereal fields. We did not find any differences between one-, two- and three-year-old set-aside fields. These results are partly in agreement with Steffan-Dewenter and Tscharntke (1997) who found that set-aside management in short-term (1–4 years) did not enhance the number of butterfly species. However, in their study, species richness was significantly higher in old meadows which had been set-aside for >30 years. Although the species richness was similar, the RDA revealed that species composition of butterfly assemblages in grasslands and set-aside fields was quite different. This stems from the different vegetation of the two field types, as grasslands were dominated by *Poaceae* species, while set-aside fields were covered mainly by *Cruciferae* and several annual herb species. Therefore grasslands were occupied mainly by satyrid butterflies using grasses as larval host plants, while set-aside fields hosted many pierids, caterpillars of which feed primarily on cruciferous plant species. The difference in species composition may explain the fact that butterfly abundance and density was significantly higher in grasslands than in set-aside fields. Grasslands were occupied by more sedentary and smaller sized species (e.g. small heath *Coenonympha pamphilus*, silver-studded blue *Plebejus argus*, common blue *Polyommatus icarus*), which can form populations of higher density. Species composition in the winter cereal fields, even if represented by only few species, was more similar to that of the set-aside fields than to the semi-natural grasslands.

Bee species richness and abundance were highest in winter cereal fields with a significant field type effect on bee abundance. There was, however, no significant difference between the field types for species composition. The slightly higher number of bee species and individuals caught in the cereal fields than in the set-aside fields and grasslands might be the consequence of the lack of flowers in the former. In the absence of flowers, as it is in cereals, the coloured pan traps might act as "super-flowers" for the bees due to less competition with the real flowers (Kovács-Hostyánszki et al., 2011). The lack of difference in bee species richness in set-aside fields and semi-natural grasslands was probably the consequence of the similar species richness of insect-pollinated plants. The strong link between bees and insect-pollinated plants may be the reason why studies on the effects of set-aside on bees had variable results (Gathmann et al., 1994; Steffan-Dewenter and Tscharntke, 2001). It is not the set-aside regime, but the presence of rich insect-pollinated plant association that is important for this group (Sárospataki et al., 2009), which may not always be the case in set-aside.

Previous studies in grasslands showed high species richness and abundance of orthopterans and bees in the Heves region compared to other regions of the Hungarian agricultural landscape (Batáry et al., 2007, 2010). We found in some cases a similarly high number of insects in set-aside of all ages than in semi-natural grasslands. Moderate disturbance by annual mowing can maintain diverse vegetation and enhance the species richness of insect communities (Siemann et al., 1999; Goulson et al., 2008). A more intensive management typical for winter cereal fields results in more simplified vegetation and further population decrease of insects and their consumers. Although, the species richness and abundance of orthopterans, bees and butterflies did not show a significant difference between the different age groups of set-aside, their communities might vary during the succession of set-aside fields (Steffan-Dewenter and Tscharntke, 1997). The dominance of pollinators and natural enemies is expected to increase significantly in set-aside after only one year (Corbet, 1995). However, this study confirmed the considerable importance of one-year-old set-aside, especially in the case of butterflies. Since three years might be still a short time for the succession process of set-aside fields, further studies are necessary to investigate how the flora and fauna of set-aside fields change during longer periods in CEE countries. Our results indicate that set-aside management could provide appropriate habitat for plant and insect species related both to arable fields and grasslands, offering special opportunity in biodiversity conservation of agricultural landscapes. They might provide important ecosystem services even in the adjacent and surrounding crop fields that would be worth to investigate in future studies. Therefore maintenance of set-aside policy and introduction of new agri-environment schemes for set-aside has a considerable importance in the CEE region, especially in the face of increasing demand for cereal grains and bioenergy crops.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.agee.2011.03.004.

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