Agriculture, Ecosystems and Environment 166 (2013) 28–34

Contents lists available at SciVerse ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Effects of grazing and biogeographic regions on grassland biodiversity in Hungary – analysing assemblages of 1200 species

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ARTICLE INFO

Article history:
Received 30 November 2010
Received in revised form 25 February 2012
Accepted 7 March 2012
Available online 31 March 2012

Keywords:
Agri-environment scheme
Arthropod
Assemblage composition
Bird
Central Europe
Plant

ABSTRACT

Agricultural intensification is a major threat to biodiversity. Agri-environment schemes, the main tools to counteract negative impacts of agriculture on the environment, are having mixed effects on biodiversity. One reason for this may be the limited number of species (groups) covered by most studies. Here, we compared species richness and abundance of 10 different species groups on extensively (0.5 cattle/ha) and intensively (1.0–1.2 cattle/ha) grazed semi-natural pastures in 42 fields in three Hungarian regions. Plants, birds and arthropods (leafhoppers, true bugs, orthopterans, leaf-beetles, weevils, bees, carabids, spiders) were sampled. We recorded 347 plant species, 748 territories of 43 bird species, and 51,883 individuals of 808 arthropod species. Compared to West European farmlands, species richness was generally very high. Grazing intensity had minor effects on α and β diversity, abundance and composition of the species assemblages. Region had significant effects on species richness and abundance of four taxa, and had strong effects on β diversity and species composition of all taxa. Regional differences therefore contributed significantly to the high overall biodiversity. We conclude that both grazing regimes deliver significant biodiversity benefits. Agri-environmental policy at the EU level should promote the maintenance of large scale extensive farming systems. At the national level, the effectiveness of agri-environment schemes should be improved via promoting and using research evidence.

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1. Introduction

Biological diversity declines at an alarming rate, and one of the main causes is intensification of agriculture in response to the demand for food, fibre and fuel (Tilman et al., 2001). In particular, the increased use of inorganic fertilizers, pesticides and machinery, and changes in land use influence biodiversity directly (de Heer et al., 2005). These changes have led to cascading effects, like loss of food resources for insectivorous birds, or change in pollination networks (Biesmeijer et al., 2006; Vickery et al., 2009; Batáry et al., 2010).

The increased attention for biodiversity and the ecosystem services provided by it (such as pollination, biological control, seed dispersion), promoted the development of more nature friendly, sustainable forms of agriculture. The potential loss of income associated with nature-friendly management is in many countries financially compensated by means of agri-environment schemes (AES). AES are important drivers of land use in Europe, as most countries have agri-environmental programs. In the EU alone, the annual budget amounts to roughly €5 billion/year (Farmer et al., 2008). The available evidence suggests that AES have mixed effects on biodiversity. Conservation management may have positive, negative or no effect, on both targeted and non-targeted species groups (Kleijn and Sutherland, 2003; Kleijn et al., 2006).

Most of the studies that have been carried out so far share a number of biases that may have an impact on their outcome. First, there is a significant bias towards studies on one or a few popular taxa, like birds, butterflies or plants (Schuldt and Assmann, 2010). This is consistent with most patterns in ecology (e.g. Báldi and McCollin, 2003), but it provides a biased knowledge, which

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doi:10.1016/j.agee.2012.03.005

is probably insufficient to adequately support decision making. The influence of farmland management on several species-rich and/or important taxa remains largely unknown. Additionally we still know very little about the impact of one type of management on a wide range of taxa. With the recent interest in ecosystem services, many of which are related to the diversity of species-rich and/or difficult-to-identify groups, studies that examine simultaneously the response of a wide range of taxa are urgently needed to support effective conservation planning (Schuldt and Assmann, 2010).

Second, most studies have been carried out in intensively farmed areas of West Europe (UK, The Netherlands, France, Germany) (Stoate et al., 2009). Extrapolation of research results from one biogeographic region to another is hazardous at best (Whittingham et al., 2007), suggesting we have very little information of what conservation strategies may be effective in the low intensity, species rich farmlands in Central and Eastern Europe (CEE) (Kleijn and Báldi, 2005; Stoate et al., 2009). Insight in conservation management that is effective in CEE countries is particularly valuable, as they host large populations of species that are declining or have gone extinct in several West European countries (Donald et al., 2002; Gregory et al., 2005).

Third, species richness and abundance as descriptors of assemblage structure are the most widely used measures of success or failure of farmland habitat management under AES. However, these are often misleading indicators of habitat quality (Vanhorne, 1983; Mortelliti et al., 2010), at least if not complemented by compositional analysis, the third basic descriptor of assemblages (Worthen, 1996). The composition of species assemblages is rarely considered in studies examining biodiversity responses to conservation management on farmland, although this can reveal important impacts since two assemblages may have the same species richness but nevertheless consist of completely different species. It is of high conservation relevance, as the protection of only one assemblage is seemingly sufficient to maintain biodiversity if measured as species richness alone, while composition can reveal the differences among assemblages.

In this study we evaluated biodiversity responses to different grazing regimes in semi-natural grasslands in Hungary. These grasslands cover 12% of the country, and are the most important agricultural habitat for biodiversity (Ángyán et al., 2003). Grasslands are managed by grazing and mowing. Fertilisers and pesticides are applied on less than 5% of Hungarian grasslands (Nagy, 1998; Nagy, pers. commun.). Recently, a number of papers have been published on a large scale field study carried out in the framework of the EU-funded "EASY" project (Kleijn et al., 2006). In these papers we mainly focused on individual taxa, and used taxon specific approaches and analyses (Báldi et al., 2005; Batáry et al., 2007a,b,c, 2008; Sárospataki et al., 2009). Here, we use the complete dataset, consisting of 10 taxa and approximately 1200 species (plants, birds and various arthropod taxa belonging to different functional groups) to provide a summary analysis on the effects of grazing intensity and regional differences. This will contribute to a better general understanding of effects of AES, because of the multi-taxon approach and the study location in the less known Pannonian region of CEE (Sundseth, 2009).

First, we compared species richness of Hungarian grasslands with data from West European farmlands collected with the same sampling protocol to see if CEE farmlands are indeed more diverse across many taxa than West European ones. Second, we evaluated the effects of grazing intensity and region on 10 taxa, using all three basic descriptors of assemblage structure, i.e. species richness, abundance and composition (Worthen, 1996). For the latter we explored compositional differences using diversity partitioning and multivariate techniques. Third, we evaluated the potential of the studied taxa to indicate the effect of grazing intensity. Finally, we formulated recommendations for AES design that effectively maintains high biological diversity on low input farmlands.

2. Methods

2.1. Study areas

Study fields were equally distributed among the three most widespread grassland types in the Great Plain of Hungary (Molnár et al., 2008a), referred to here as the Alkali, the Meadow and the Heves biogeographic regions, respectively. The three regions differed in their grassland type and landscape structure. Two were located between the Danube and the Tisza Rivers (Fig. A1 in the Supplementary Data). The first, Alkali region was situated on the former flood plain of the Danube River, which is flat and is characterised by large landscape units. As a consequence of river regulations, salinisation has accelerated, resulting in secondary Pannonic alkali steppe vegetation on solonchak-solonetz soil, with common grass species (blue grass *Poa pratensis*, false sheep's fescue *Festuca pseudovina*, bermudagrass *Cynodon dactylon*), and salt resistant species (sea wormwood *Artemisia santonicum*, sea lavender *Limonium gmellini*, chamomile *Matricaria chamomilla*). The Meadow region was located in the northern part of the Danube-Tisza interfluves. The main characteristic of this region was the patchy habitat structure: a mosaic of swamp meadows, calcareous purple moorgrass (*Molinia caerulea*) meadows, salt steppes and Pannonic sand steppe grasslands, with scattered woodlots and farms. Dominant plant species were blue grass, false sheep's fescue and bermudagrass, while characteristic species were purple moorgrass, tufted hairgrass (*Deschampsia caespitos*) and cinquefoil (*Potentilla*) species. The Heves region was situated near the River Tisza, 100 km to the east of the two former regions (Fig. A1 in the Supplementary Data). It consists of dry and wet alkali grasslands and marshes on solonetz soil. Dominant plant species were blue grass, false sheep's fescue, quackgrass (*Elymus repens*) and *Scorzonera cana*. Characteristic species were the sea plantain (*Plantago maritima*), sea wormwood, whitetop (*Cardaria draba*) and yarrow (*Achillea*) species.

The extensively managed study fields fit the grassland management prescriptions of the Hungarian agri-environmental program: low density of livestock (0.5–1.2 animal/ha depending on pasture productivity, but set to 0.5 animal/ha for the studied regions), no use of artificial fertilisers or pesticides, no burning, winter grazing, reseeding, harrowing or ploughing, and maintaining clean ditches, and roadsides, etc.

2.2. Sampling design

We selected field pairs with high and low grazing pressure in the vicinity of each other, so that the systematic differences of fields within pairs can be attributed to the intensity of grazing and other environmental factors have little effect (Kleijn et al., 2006). Each region had 7 field pairs (42 fields in total), consisting of an extensively and an intensively grazed field. For both types, the intensity of grazing was roughly constant over the last five years. The grazing regimes were typical of the "puszta" grasslands. The cattle density was about 0.5 cattle per hectare on extensive, and 1–1.2 cattle per hectare on intensive fields. Except for grazing intensity there were no other differences in management. Within regions, fields were in the same grassland type. At the time of study, in 2003, agri-environment schemes (AES) had only just begun operating. Therefore, we were not able to compare fields with and without AES (cf. Kleijn et al., 2006). However, there were extensive fields managed by the national parks for years in the same way, as AES

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