Impact of low input meadows on arthropod diversity at habitat and landscape scale

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Abstract

In Switzerland, in order to preserve and enhance arthropod diversity in grassland ecosystems (among others), farmers had to convert at least 7 % of their land to ecological compensation areas – ECA. Major ECA are low input grasslands, traditional orchards, hedges and wild flower strips. In this paper the difference in species assemblages of 3 arthropod groups, namely spiders, carabid beetles and butterflies between intensively managed and low input meadows is investigated by means of multivariate statistics. On one hand, the consequences of these differences are analysed at the habitat level to promote good practices for arthropod diversity in grassland ecosystems. On the other hand, the contribution of each meadow type to the regional diversity is investigated to widen the analysis to the landscape level.

Keywords: agri-environmental scheme, arthropods, biodiversity, low input meadows, multivariate statistics

Introduction

By their variety and abundance in terrestrial ecosystems, arthropods are of particular importance from the biodiversity conservation and economical point of view. In grassland ecosystems, arthropods are responsible for very important ecological functions: they are grass consumers (herbivores), integrate the organic matter in soil (decomposers), help plants to reproduce (pollinators) and feed on other organisms that may be pests (predators). In this context, management operations influencing arthropod diversity may alter these basic ecological functions, as it has been demonstrated in several studies (Curry, 1994). Some operations like mowing have a direct impact on invertebrates by killing individuals or removing them from the habitat. Indirect effects may also occur through changing the habitat, by altering the vegetation (species composition and structure) and consequently by affecting micro-climatic conditions. In Switzerland, efforts have been made to reduce the negative impact of intensive management in grassland ecosystems on biodiversity by introducing an ecological compensation area (ECA) scheme. The management of ECAs is regulated in order to achieve environmental goals: restrictions in fertilisation, pesticide use, prescribed dates for mowing (Walter *et al.*, 2004). This paper aims to compare species richness and species composition of spider, carabid beetle and butterfly communities in extensively and intensively used meadows in two regions of the Swiss plateau. Furthermore, the variability in species richness and species composition due to the management intensity and the region is tested on a comparative basis.

Regions and sampling methods

The study was carried out in 2 regions of the central Swiss Plateau: region 1, Nuvilly, 30 km W of Fribourg, altitude 580-720 m and region 2, Ruswil, 20 km NW of Lucerne, altitude 650-800 m.

Region 1 comprises a total surface of 515 hectares, consisting of grassland (37 %), arable land (55 %), and forests (6 %). Three grassland ECA types, usually small areas of approx. 400 m^2, can be found on the perimeter, namely extensively used meadows (EUM, no fertilisation, late mowing), low intensity meadows (LIM, restricted fertilisation, late mowing), and meadows in traditional orchards with standard fruit trees (TO). As meadows in traditional orchards are usually intensively used (fertilisation and mowing not restricted), they are further associated with intensively used meadows (IUM).

Region 2 comprises a total surface of 885 hectares, mainly consisting of grassland (59 %), arable land (15 %) and forests (17 %). In region 2, the same ECA types occur.

Spiders, carabid beetles in 1999 and butterflies in 1998 were recorded in 21 EUM, 2 LIM, 7 TO and 5 IUM in region 1, and in 14 EUM, 7 LIM, 8 TO and 5 IUM in region 2. Details about spider and carabid beetle collections, and butterfly observations are presented in Jeanneret *et al.* (2003). For analysis of the management intensity impact, EUM and LIM were grouped under extensively used meadows, and TO and IUM under intensively used meadows.

To test the effect of the management intensity and the region on the species richness, ANOVA was performed. Testing was carried out on the species assemblages with redundancy analysis (RDA) and a partial RDA (Ter Braak, 1996). In RDA, the significance of a particular environmental variable can be assessed by Monte Carlo testing (bootstrapping). Partitioning of variation was then performed through partial RDA (Borcard *et al.*, 1992) to differentiate between ‘pure’ management intensity variation from variation due to the region.

Results and discussion

Altogether 26,674 spiders and 20,150 carabid beetles belonging to 96 and 92 species respectively were collected from the 69 sites. Spider species richness was not dependant on management intensity (extensively used vs. intensively used meadows) in either region (ANOVA, $P = 0.08$). To the contrary, carabid species richness was significantly influenced by the management intensity in both regions (ANOVA, $P < 0.05$).

Altogether, 2636 butterflies belonging to 30 species were observed on the 68 sites. Butterfly species richness was significantly higher in the extensively used than in the intensively used meadows and significantly higher in region 1 than in region 2 (ANOVA, management intensity $P < 0.05$, region $P < 0.05$).

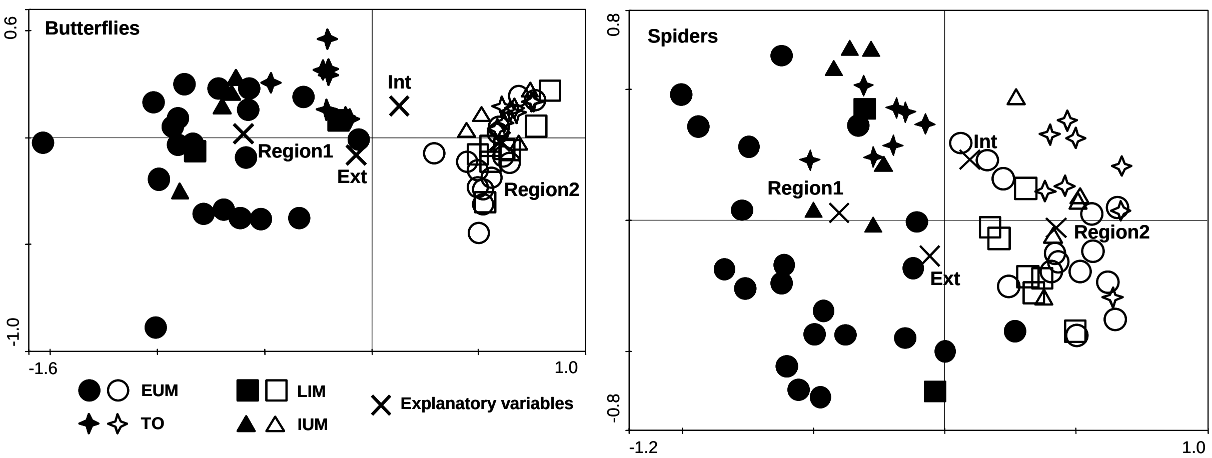

Figure 1. RDA ordination diagram of the sites based on butterfly and spider assemblages with management intensity and region variables displaying 21 % of the variance for spiders and 38 % for butterflies (first and second axes). Filled symbols: region 1; empty symbols: region 2. Ext = extensively used, Int = intensively used. See text for further explanation of meadow types.

The RDA ordination diagram of the sites based on spider assemblages differentiated region 1 from 2 and extensively used (EUM+LIM) from intensive meadows (IUM+TO) (Figure 1). On the whole, management intensity and region explained a significant part of variation in spider assemblages (Monte Carlo permutation test: $P < 0.05$). The canonical coefficients which allow inference about the relative importance of explanatory variables (Ter Braak, 1996) showed that first axis is a 'region gradient' and second axis a 'management intensity gradient'. Therefore, spider assemblages are first influenced by the region and second by the management intensity. Furthemore, the question was whether there is still a difference in spider assemblages among management type after accounting for the effect of the region. This was investigated by specifying the region as covariable in a partial RDA. The partial test (partial RDA) gave a F-ratio of 3.0 and $P < 0.05$. In conclusion, there remains a systematic difference in spider assemblages among management intensity after accounting for the region effect.

Ordination of the sites based on carabid beetle assemblages showed a very similar picture and is therefore not presented. Furthermore, as was the casewith spiders, management intensity and region explained a significant part of the variation ($P < 0.05$). First axis represented a 'region gradient' and second axis a 'management intensity gradient'. Management intensity remained significant after accounting for the effect of the region (partial RDA, F-ratio 12.96, $P < 0.05$).

For butterfly assemblages, sites of the same region were grouped together showing a substantially higher variation among the meadows of region 1 compared with region 2 (Figure 1). This difference was due to the larger species richness in region 1 (29 species altogether) in comparison to the poor species richness of region 2 (15 species altogether). Nevertheless, butterfly assemblages significantly differentiated extensively used from intensively used meadows independently of the region effect (partial RDA, F-ratio 2.2, $P < 0.05$).

Conclusions

Over the two studied regions, management intensity significantly affected the arthropod assemblages showing that extensification enhanced diversity at a regional scale, although species richness may not be affected in all cases. Region 1 and region 2 had their own specific pool of spider, carabid and butterfly species. As explanatory variable, region stressed not only two different biogeographic situations but also summarised regional abiotic factors. Among abiotic factors, landscape features such as habitat variability and heterogeneity, arrangement of cultures, percentage of semi-natural habitats, and their influence on arthropods might be analysed to better understand the differences between regions.

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