Do bryophytes reflect the diversity of vascular plants and birds in marginal habitats?

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Abstract: Linear marginal habitats play the most important role in creating the biodiversity of agricultural landscapes. We studied the diversity of bryophytes, vascular plants and breeding birds in 70 field margins in the Sudetic Foreland (SW Poland).

There was a positive correlation in the total number of species between these groups. We found bryophytes to be a useful indicator of the biological diversity in areas of intensive agriculture. The amount of trees and shrubs (expressed as the number of species, specimens and the total volume) was the factor of the greatest importance with regard to the number of bryophyte species, and the same relation was observed in vascular plants and birds. Moreover, marginal habitats should be managed in an environmentally friendly way, because they play an important role as refuges of threatened bryophytes which are currently not legally protected.

Key words: bryophytes, vascular plants, birds, agricultural landscape, biodiversity

Introduction

Agricultural landscapes cover about half of Europe's territory, although broad range (10-80%) refers to particular countries. In Poland the cultivated fields constitute over 54% of the area (Chmielewski & Węgorek 2003). Since 1970 a significant decrease in the number of species in different habitats is noted. Species Trend Indicator based on bird, butterfly and mammal populations (average quotas for the continent) shows loss of almost all groups of organisms (Fig. 1.). However, natural habitats have lost "only" about 2% of species, whereas the loss in arable lands reached as much as 23% (de Heer et al. 2005). One of the most important reason of such situation was a disappearance of marginal habitats in arable lands. It refers especially to field margins which are the commonest type of these habitats, present in some form at the edges of all agricultural fields. The aim of this paper is to show the biological richness occurring in field margins of SW Poland, based on three groups of organisms: bryophytes, vascular plants, and breeding birds. We concentrate particularly on the first group, because it's diversity in agricultural landscapes is weekly recognized, and we believe it can be indicative for the total biodiversity in these habitats.

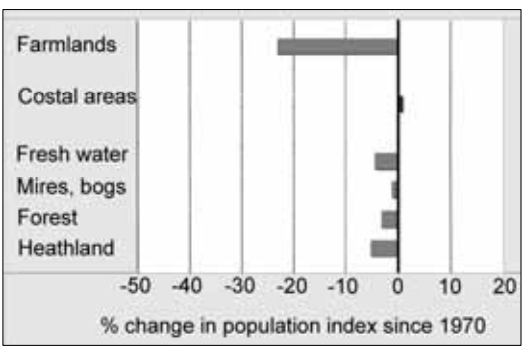

Fig.1. Species trends per habitat (after Heer et al. 2005)

Field margins – what are they?

Here, the term field margin is adapter form Marshall & Moonen (2002) and defined as the whole of the semi-natural habitats between two neighboring crop edges. Field margins comprise the boundary which usually has a structure, such as a hedge, grass bank or ditch, and a boundary strip, which may be a farm track or non-sown vegetation strip. They are the most common form of non-cropped, semi-natural habitats in Polish agricultural landscape. Among a great diversity of margins we can point out some types according to function and vegetation structure: balks (embankments, wide borders of plots), field paths (fruit tree alleys, railway embankments), and vegetation along the banks of streams (herb layer, rush layer, shrub layer, rows of trees). Recently, perennial field margins are generally considered to have important ecological functions, which were described in an extensive literature (e.g. Agriculture, Ecosystems & Environment 2002, Marshall & Moonen 2002, Marshall et al. 2002). Within a vast area dominated by fields, they are the only refuges for plants, fungi and animals, especially those connected with afforested habitats. Margins are the main breeding and feeding habitat for many birds, including species of high conservation concern in Europe. Plant cover growing on margins has positive influence on the adjacent cultivated fields. Marginal habitats are buffer zones protecting streams against the chemical contamination of water.

What is known about bryophytes of such habitats?

To date we know only two papers concerning bryophytes of farmland in the Lower Silesia (Koła 1989; 1993). However, none of them based on research carried out in marginal habitats, so they described the bryophytes of arable fields only.

What would we like to know – the aim of the research?

First of all we would like to recognize the diversity of bryophytes occurring in different types of field margins, and to check how the diverse structure of these habitats influences the species richness. The other important question was the relationship between bryophytes, vascular plants and breeding birds. Finding these relationships positive may suggest that bryophytes are good biodiversity indicators and can be used as a surrogate taxon for overall species richness.

Study area

Research was carried out in the region of Sudetic Foreland (Lower Silesia, SW Poland), which is representative for agricultural landscape of western Poland (Fig. 2). Apart from large fields, a mosaic of relatively small patches still exists, owned by individual farmers. Marginal (mostly linear) habitats with different structure are very common on this territory. The research was done in 70 study plots, i.e. marked out 500 m long sections of separate field margins. The sections were internally homogenous, but differed in width (5-30 m) and other characteristics of structure, especially the amount of trees and shrubs.

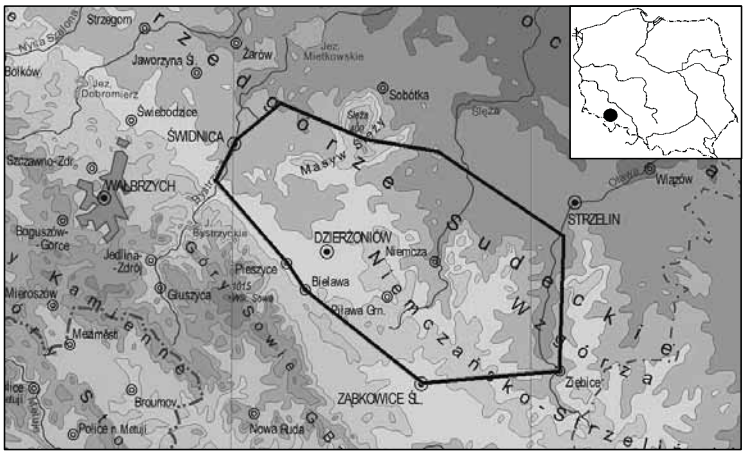

Fig.2. The study area

Methods of habitat division

The basic categories of margins were divided with regard to the amount of trees and shrubs (volume calculated as ratio of trees and shrubs height, width and length). We distinguished field margins without trees and shrubs, with a small amount of trees and shrubs, shrub lines, tree and shrub alleys. Apart from this, study plot was divided into several zones of different vegetation. The main criterion of such division based on the phytosociological condition – homogeneous composition and structure of divided stands. Example of distinguished zones in one of the field margins is presented in the figure 3. The number of subdivided zones depended on the type of margin and its width.

Fig.3. Particular zones in one of the marginal habitat: 1 – path embankment (Pp), 2 – field path (Dc), 3 – upper part of the ditch and its embankment (Sc), 4 – ditch or stream (Rc), 5 - zone dominated by *Rubus* sp. (J)

Methods of field investigations and data analysis

Data were collected in each of the 70 field margins. Due to the ecological features of bryophyte species (mostly ephemeral) growing in midfield islets and on the verges of roads, the bryological survey was carried out during October, November and December 2007. Data referred to bryophytes were collected in form of special floristic-ecological field relevé (Tab.1.), which contained the following information: margin name and localization, date, presence of particular zones, number of bryophytes species, their frequency, fertility and habitat.

In case of vascular plants data were collected in three transects perpendicular to the margin course and of 10 m wide. In each transect the phytosociological relevé were made in zones of vegetation mentioned above. Lists of species obtained from each margin were used in correlations.

Ornithological research was done using mapping method in two breeding seasons, 2006 and 2007. Three morning counts of birds were conducted in each margin and season. Results from 2006 were taken in analyses.

Pearson correlations between the indices of bryophyte, plant and bird communities were calculated. The association between the number of bryophyte species (dependent variable) and biophysical characteristics of the field margin was examined with forward stepwise multiple regression analysis (Statistica 7.1, StatSoft Inc.). Eleven independent variables were used describing: a) margin structure (amount of trees and shrubs – PC1 from PCA analyses, margin width - PC1 from PCA analyses, presence of road, presence of ditch), b) homogeneity of the margin vegetation (percent of dominance of *Prunus spinosa, Phragmites australis, Urtica dioica* and *Rubus* sp. in the plant community), c) margin surroundings (distances to the nearest forest and village, the number of adjacent fields; these variables were log transformed).

Tab. 1. An example of floristic-ecological field relevé.

Date	**Name of the margin**			**Localization**	
3.XI.2007	BORO1			Borowica - margin along field path and ditch	
Zone	Pp	Dc	Sc	Rc	J
Width (m)	0.9	3.0	2.5	2.0	2.8

No.	**Name of the species**		**Zone**	**Frequency**
1	*Amblystegium serpens*		J, Sc	1
2	*Anthoceros agrestis*	c.spor.	Pp	1
3	*Atrichum undulatum*	c.spor.	J	2
4	*Barbula unguiculata*		J, Sc	1
5	*Brachythecium albicans*		Pp, Sc	1
6	*Brachythecium rutabulum*		Pp, J, Rc	3
7	*Brachythecium salebrosum*		J, Sc	1
8	*Brachytheciastrum velutinum*		J, Sc	1
9	*Bryum argenteum*	c.spor.	Dc, Pp, Rc	2
10	*Ceratodon purpureus*	c.spor.	Pp, Dc, J, Rc	2
11	*Dicranella schreberiana*	c.gem.	Pp	1
12	*Ephemerum serratum* var. *angustifolium*	c.spor.	Pp	1
13	*Oxyrrhynchium hians*		J, Sc	1
14	*Fissidens taxifolius*		J, Sc	1
15	*Fissidens bryoides*		J, Rc	2
16	*Plagiomnium affine*		J, Sc	1
17	*Plagiomnium undulatum*		J,Sc	1
18	*Plagiothecium laetum*	c.gem.	J, Sc	1
19	*Pohlia nutans*	c.spor.	J, Pp, Rc	1
20	*Riccia sorocarpa*	c.spor.	Pp	1
21	*Tortula truncata*	c.spor.	Dc, Pp, Rc	3

Explanations: Zones: Pp – path embankment; Dc– field path; Sc – upper part of the ditch and its embankment; Rc – ditch or stream; J – zone dominated by *Rubus* sp.; Frequency: 1 – rare, 2 – frequent, 3 – common.

Results

Vascular plants - the total number of reléves made in marginal habitats: 912; the total number of species in transects: 414, average number of species per margin: 66 (min. 35, max. 122).

Birds – the total number of species: 46 in 2006 and 47 in 2007 (9,7 per margin in both years), number of pairs: 1080 pairs in 2006 (average 15,4 p/margin), and 1246 pairs in 2007 (17,8 p/margin) Dominating species: *Acrocephalus palustris* - 24,4% pairs and *Emberiza citrinella* - 15,8% pairs (means for two years). Ecological groups: Forest species – 39% in 2006, Forest-arable mosaic species – 35% (data from 2006).

Bryophytes – the total number of species: 90 (average 21 species per margin). The total number of species protected in Poland: 5, The total number of species threatened in Poland: 5. The E categories have: *Anthoceros agrestis, Fossombronia wondraczekii*. Within R category we found: *Archidium alternifolium* (Wierzcholska S., Dajdok Z., Wuczyński 2007), *Ephemerum serratum* var. *angustifolium* and *Syntrichia papillosa*.

Bryophytes as indicators – strong positive correlations were found between the number of bryophyte species and both, the number of species and breeding pairs of birds (Fig. 4a, 4b). The number of bryophyte species was also positively correlated with number of vascular plants (Fig. 5a) and volume of trees and shrubs (Fig. 5b).

Factors affecting bryophytes diversity – results of the multiple regression analysis showed, that the only variable significantly linked with bryophyte richness was the amount of trees and shrubs, explaining 49% ($p<0,0000$) of the variation observed.

Conclusions

Linear marginal habitats play the most important role in creating the biodiversity of agricultural landscapes. Positive strong correlations in the diversity of bryophytes, vascular plants and breeding birds indicate, that bryophytes can be a useful indicator of the general biological diversity in areas of intensive agriculture. The amount of trees and shrubs, expressed as the number of species, number of specimens or total volume, is the factor of the greatest importance with regard to the number of bryophyte species.

The same relation was observed in vascular plant and bird communities, which clearly demonstrates, that removing the high vegetation significantly contributes to the decline of biodiversity in agricultural landscapes. Unfortunately, recently this practice is common in areas of intensive agriculture of Poland. We argue that linear marginal habitats should be managed in an environmentally friendly way, because of their unique position in keeping relatively high level of the biological richness in farmland. It relates especially for bryophytes which currently are not legally protected and have the only refuges it these landscape elements.

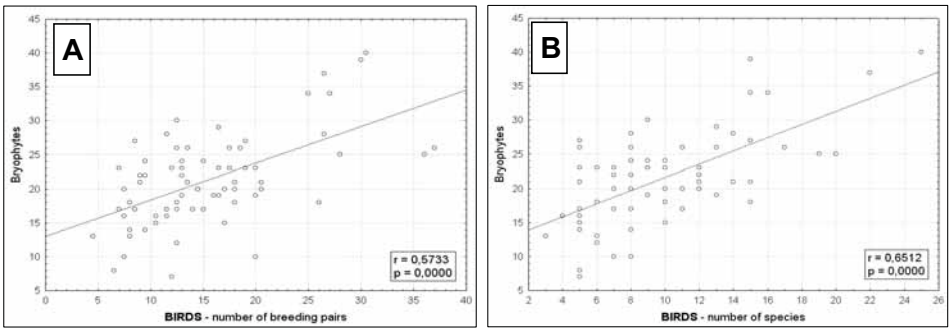

Fig.4. Relationships between the number of bryophyte species and breeding bird species richness (A) and number of pairs (B)

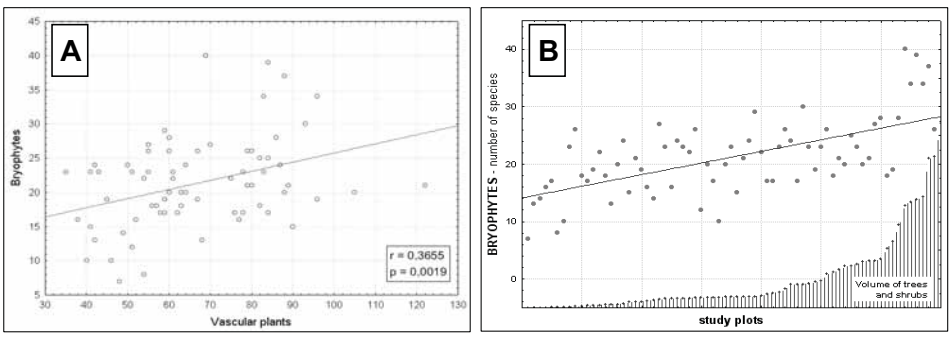

Fig.5. Relationships between the species richness of bryophytes and vascular plants (A) and the volume of trees and shrubs (B)

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