Role of green veining to sustain biodiversity in agricultural landscapes

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Role of green veining to sustain biodiversity in agricultural landscapes

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Abstract

Influence of land use intensification and green veining reduction on biodiversity (birds, small mammals, carabid beetles) was investigated in three agricultural landscapes of Western France. Land use intensification induced a fragmentation of green veining but it was not associated to a loss of habitat heterogeneity. There was no simple response of species to such modifications. Passerine birds and small mammals were mainly sensitive to the total amount of green veining, that a shift from forest specialist to open habitats species for birds and a growing disequilibria of small mammal communities. Carabid beetles seemed to respond to the decrease of green veining heterogeneity, which induced a replacement of woody species by more common open field species. Our results show that both amount and diversity of green veining should be considered in management plans for the conservation of biodiversity in agricultural landscapes.

Introduction

Agricultural landscapes are a mosaic of arable fields and uncultivated elements. Non-productive areas, like hedgerows, woodlots, fallow lands and permanent grasslands are essential for species survival as they constitute a "green veining" that acts as habitat (Forman and Baudry, 1984), refuge (Dennis and Fry, 1992) and corridor (Duelli *et al.*, 1990) for many species. However, land use intensification has led to dramatic changes in agricultural landscapes of Western Europe (Agger and Brandt, 1988) that have been assumed to be responsible for a major decline of biodiversity (Wilson *et al*., 1999). Semi-natural habitats have been fragmented, their surface decreased, distances between habitat patches increased and there has been a loss of habitat diversity. All these factors were assumed to explain species extinction (Andren, 1994). Few studies considered simultaneously effects of such changes on different groups of species (Burel *et al.*, 1998). However, different taxonomic or functional groups may perceive differently landscape changes depending on their ecological requirements (Burel, 1991). Therefore, various biological groups and consequently the whole diversity of permanent elements should be considered for a global and functional approach of biodiversity in agricultural landscapes.

This paper deals with the characterisation of biodiversity (passerine birds, small mammals and carabid beetles) along a gradient of land use intensification and green veining removal. Two hypothesis were tested : (i) land use intensification would induce a reduction of the amount and the diversity of green veining (ii) land use intensification and green veining removal would influence biodiversity in different ways according to the group considered.

Methods

Study sites

The study was conducted in Brittany, Western France, in three 1-km² areas that are representative for fine grain, heterogeneous hedgerow network landscapes ("bocage") (figure 1). The study areas differ in term of type of agriculture (cow production in site 1 and 2, and pig production in site 3) and they are distributed along a gradient of land use intensification defined by a strong increase in the total cultivated area from site 1 (0,54 ha) to site 3 (0,86 ha) and growing values of animal husbandry (from 2,58 to 6,34 animals/ha). Study sites are also contrasted in term of landscape structure, site 2 being characterized by the more open and homogeneous mosaic.

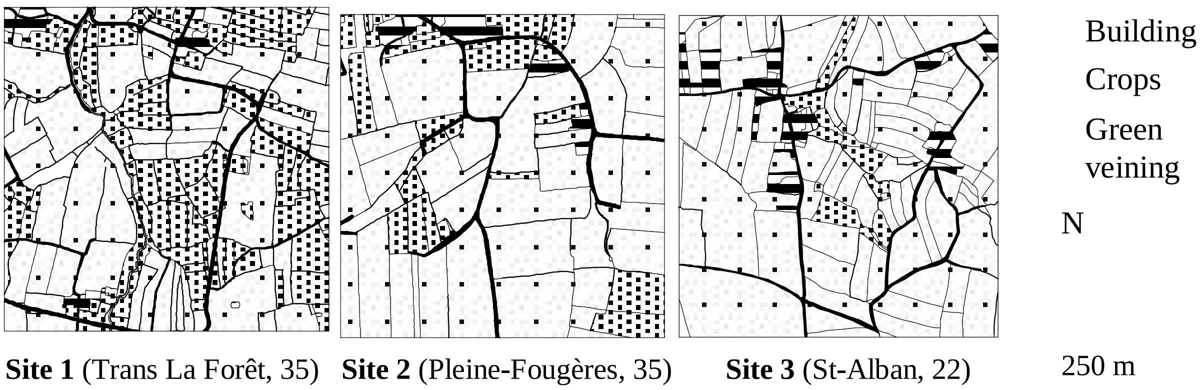

Figure 1: Study sites (site 1: Trans La Forêt; site 2: Pleine Fougères; site 3: Saint-Alban).

Characterisation of green veining composition and structure

The green veining was assessed in each site by its total surface area, the proportion of the surface area covered by each type of uncultivated element (hedge, wood & fallow land, permanent meadow). Heterogeneity of the green veining and the total number of connections between hedges were computed as measures of green veining structural complexity.

Biodiversity characterisation

Passerine birds, small mammals and carabid beetles have been chosen to evaluate biodiversity. Data on passerine birds were collected according to the ‘IPA’ method in site 1 and 2 (Dubs, 1997) and to the fixed strip transect method in site 3 (Le Du *et al.*, 2000). Because of evident dissimilarities between these two methods, we did not use relative abundances of bird species for the analysis, but presence/absence data only. Small mammals communities were characterised by analysing pellets of *Tyto alba* (the Barn owl) (site 1 and 2: Paillat, 2000; site 3: Le Du *et al.*, 2000). No resting site of the Barn owl was found in site 2 but we used data from a resting site situated in a larger area that encompassed site 2. Carabid beetles communities were surveyed by using interception traps (Le Du *et al.*, 2000). The number of sampled hedges and traps per hedge varied between sites but the trapping pressure (number of traps per length unit of hedge) was similar in the three sites.

Data analysis

Several indexes were used to compare species assemblages between sites. Species richness (S), Shannon's diversity index (H') and evenness index (J) were calculated for the comparison of species numbers and relative abundances between sites. Sorensen's similarity index was also used as it allows to account for differences in species composition. Comparisons of S and H' between sites were performed with a t test.

Results

Effects of land use intensification on green veining

The total surface area covered by green veining decreases sharply from site 1 to site 3. Density of hedges and surface of permanent meadows decrease following the intensification-gradient (table 1). Permanent meadows constitute the major part of the green veining in all sites, but sites 1 and 3 are characterised by a higher proportion of hedges and woods than in site 2. Land use intensification induces a decrease of the total number of connections between hedges, but green veining heterogeneity varies non-linearly along this gradient (highest values in sites 1 and 3) (table 1).

Table 1: Characteristics of green veining composition and structure in the three sites.

	Site 1	Site 2	Site 3
Hedge density (m/ha)	252.46	96.63	68.78
Wood & fallow land (ha)	0.04	0.003	0.007
Permanent meadow (ha)	0.33	0.16	0.04
Total GV area (ha)	**0.37**	**0.16**	**0.05**
% Hedges	25	23	41
% Wood & fallow land	10	1	8
% Permanent meadow	65	75	51
GV heterogeneity	**0.52**	**0.36**	**0.41**
Number of connections	291	112	89

Biodiversity characterisation along the intensification-gradient

Species richness, diversity and evenness are given in table 2. These indexes vary differently along the gradient of land use intensification and green veining reduction, depending on species groups.

Table 2: Species richness (S), Shannon’s diversity index (H’), evenness index (J) and Sorensen’s similarity index (I) for the studied groups in the three sites.

	S			H’			J			I		
	1	2	3	1	2	3	1	2	3	1/2	1/3	2/3
Passerine birds	17	19	17		-			-		0,66	0,64	**0,72**
Small mammals	10	10	**8**	2,89	2,84	**2,31**	0,87	0,86	**0,77**	**1,00**	0,87	0,87
Carabid beetles	26	**22**	28	3,85	**2,94**	4,16	0,82	**0,66**	0,86	0,44	**0,55**	0,35

The three sites exhibit similar value of birds species richness ($p>0{,}005$). The species assemblages of passerine bird communities differ between sites as shown by Sorensen's index values, site 1 and 3 being the more contrasted in term of species composition. These differences are mainly explained by a progressive increase of common and open field species and a decrease of the number of woody species (figure 2).

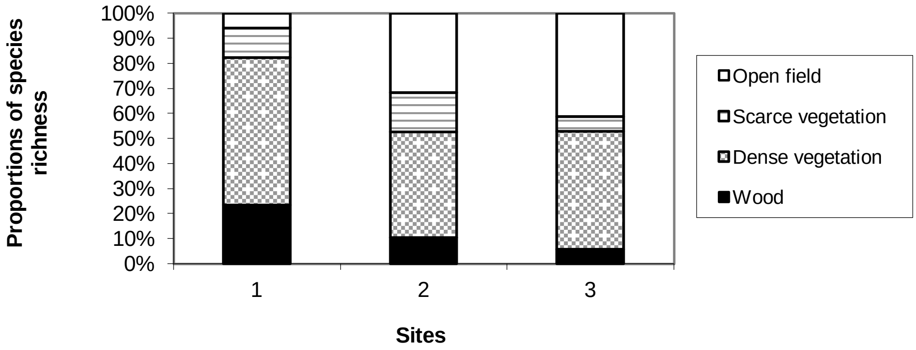

Figure 2: Proportion of species associated to woods, dense vegetation, scarce vegetation and open fields in the three sites (classification according to Dubs, 1997).

Species richness of small mammals differs significantly only between site 1 and 3, where a loss of two species is noticed ($p_{1/3}=0{,}047$). Site 3 is characterised by the lowest species diversity ($p_{1/3}$ and $p_{2/3}<0{,}001$) and is the less balanced. Site 1 and site 2 show similar values of Shannon's diversity ($p_{1/2}=0{,}655$) and evenness indexes. The composition of small mammal communities is similar for site 1 and 2. Species assemblage in site 3 differs slightly from those in other sites as it is mainly dominated by *Apodemus sylvaticus* (the wood mice) that represents more than 40 % of the species encountered in this site (figure 3).

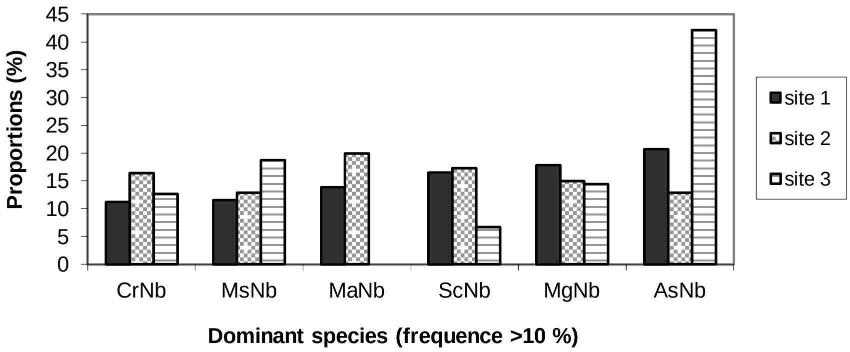

Figure 3: Distribution of small mammal species in the three sites (only species with occurrence > 10 % are represented ; Cr: *Crossidura russula*; Ms: *Microtus subterraneus*; Ma: *Microtus arvalis*; Sc: *Sorex coronatus*; Mg: *Microtus agrestis*; As: *Apodemus sylvaticus*).

The number of carabid species is approximately identical in site 1 and 3, but significantly lower in site 2 ($p_{1/2}=0{,}0036$; $p_{3/2}<0{,}001$). Carabid communities in the three sites show strong differences in their value of Shannon's diversity index ($p<0{,}001$). The highest diversity is observed in site 3, whereas it remains low in site 2 and intermediary in site 1. Evenness index follows the same pattern, the community in site 3 being the more balanced. Sorensen's index values show that carabid community in site 3 differ the most from those in other sites in term of species assemblage, with a predominance of common species adapted to open habitats (figure 4). Carabid communities in site 1 and 3 mainly differ from those in site 2 by the notable presence of forest specialist species, like *Abax ater* and *Carabus nemoralis* that are absent or occur with a frequency less than 1% in site 2 (figure 4).

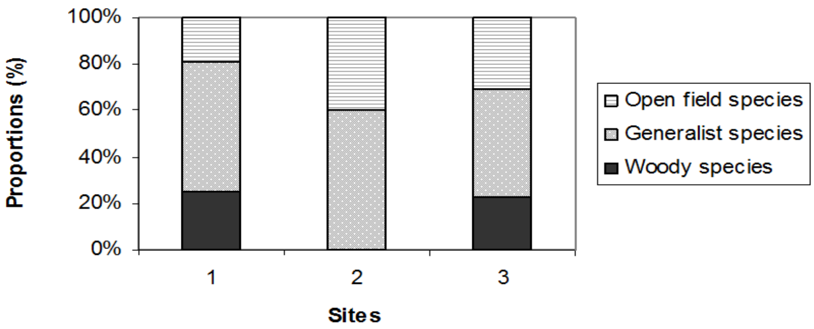

Figure 4: Proportions of woody, generalist and open field carabid species in the three sites.

Discussion

Effect of land use intensification on the green veining

Land use intensification causes major changes in agricultural landscapes. In our study, it was obviously correlated with a sharp reduction of green veining. Permanent meadows and hedges were highly reduced, as well as number of connections between hedges. These changes reflect a growing fragmentation of permanent habitats along this gradient, that may be a critical factor for determining species survival. Land use intensification has been the more often associated to a loss of habitat diversity and landscape heterogeneity (Meeus *et al.*, 1990), but we could not relate reduction of green veining diversity or heterogeneity to the intensification gradient as it remained high in the more intensively used site. This underscores the difficulty of characterising land use intensity in an adequate way. Other factors should be considered to assess more accurately interactions between land use intensification and green veining changes.

Effects of land use intensification and green veining removal on biodiversity

Our results show that there is no simple response of species to the gradient of land use intensification and green veining removal. Depending on the group of species, the total uncultivated area or green veining heterogeneity alternatively influenced biodiversity. Passerine birds and small mammals seemed to be sensitive mainly to the reduction of the amount of uncultivated habitats. Small mammals exhibited a loss of species diversity and a growing disequilibria of communities, illustrated by the dominance of the wood mice in the more intensively used site. Green veining reduction induced changes in the species assemblage of passerine birds, with a shift from forest specialist species to less demanding species associated to open landscapes and habitations. This results should be however considered carefully. Small mammals data in the second site could be not representative for the real community as the resting was not situated in our 1-km² area. Moreover, only presence/absence data were used for characterising birds communities and further analysis with abundance data is needed. Habitat diversity and landscape heterogeneity has been shown to influence the diversity of invertebrates and vertebrates (Freemark and Merriam, 1986;

Jonsen and Fahrig, 1997). In our study, only carabid beetles seemed to respond to the reduction of green veining heterogeneity which corresponded to a decrease in the proportion of woods and hedges in green veining, but they seemed not to respond to green veining reduction. These changes induced a loss of species diversity and a shift in species assemblages, as species associated to dense vegetation and woods tend to be replaced by more common open field species. This results could be reliable to the ecological traits of species. Species associated to stable habitats, such as forest species, are usually large-sized and characterised by a limited capacity of locomotion (Den Boer, 1969). The persistence of such species in the more intensively used landscape could be due to its relative fine grain size, which may promote movements of individuals. It can be concluded from our results that both amount and diversity of green veining interact with biodiversity in agricultural landscapes and these two factors should be considered in the elaboration of conservation plans.

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