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Grassy strips in their landscape context, their role as new habitat for biodiversity

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ABSTRACT

In the context of rapid and severe biodiversity decline in agroecosystems, the European Union has introduced agri-environmental schemes. However, these schemes require evaluation to estimate their efficiency, for further consolidation and improvement. The establishment of grassy strips along watercourses represents a measure of cross-compliance introduced in France in 2005. In this study, we analyzed the benefits of these new landscape elements for biodiversity, by (i) exploring the plant community composition of grassy strips in relation to their landscape context, (ii) analyzing the faunal communities of three major functional groups (i.e., small mammals, syrphids, and carabid beetles) present in grassy strips of agroecosystems, (iii) comparing the faunal biodiversity to that observed in other habitats of agroecosystems, such as fields and hedgerows, and (iv) investigating the relationships between faunal community indices and grassy strip properties. The results of our study showed that the plant community of grassy strips is mainly influenced by semi-natural habitats that are present within a landscape context, i.e., at a scale >500 m. We found that grassy strips do not necessarily present areas of particularly high animal biodiversity compared to other habitats (i.e., fields and hedgerows). However, the properties of these strips (i.e., length, width and plant biodiversity) influence the structure of faunal communities.

Two years after the establishment of grassy strips, their role as ecotones between previous field margins (mostly hedgerows in our study site) is illustrated through the response of the fauna. Hence, grassy strips, being more stable than cultivated fields, contribute to a new refuge within the agroecosystem landscape.

1. Introduction

In recent decades, modern farming practices and policies have led to an increase in production, consequently causing a dramatic change to the agricultural landscape. For example, the biodiversity of European arable farmland has severely declined (Butchart et al., 2010), due to the expansion of the area of cropped land (inducing changes to landscape structure and the loss of semi-natural habitats) and the intensity of agricultural production, in terms of input use and farming practices (Denys and Tscharntke, 2002; Robinson and Sutherland, 2002). The negative impact of agriculture is caused by factors operating at different scales, from the field to the landscape and regional scales (Baessler and Klotz, 2006; Pacha and Petit, 2008). At the landscape scale, overall heterogeneity and the importance of semi-natural habitats have been shown to have a positive influence on biodiversity (Tscharntke et al., 2005; Holzschuh et al., 2010). Connectivity among semi-natural elements is also crucial for biodiversity (Schweiger et al., 2005). Hence, one of the roles of agri-environmental schemes is to increase the amount of semi-natural areas, which enhance biodiversity and associated ecological services (Aviron et al., 2009; Holzschuh et al., 2009).

In Europe, one of the objectives of the Common Agricultural Policy (CAP) reform in 2003 was to maintain and improve the state of the environment and associated biodiversity. As a result, "Good Agricultural and Environmental Conditions" (GAEC) were defined as cross compliance measures. The GAEC refers to a range of standards aimed at protecting against soil erosion, maintaining soil organic matter and structure, avoiding the deterioration of habitats, and managing water. The establishment of grassy strips along watercourses is one such measure, which was introduced in France in 2005 (EU regulation 1290/2005). Grassy strips must be 5–10 m wide and must be established on up to 3% of the farmland. The expected benefits of these grassy strips were (i) the improvement of water quality and stream protection and (ii) habitat enhancement, for example by providing food sources, nesting cover and shelter for many wildlife species (Ovenden et al., 1998). Moreover, it may potentially provide connecting corridors in agricultural landscapes. Existing studies have shown that

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grassy field margins have an overall positive effect on biodiversity (Grashof-Bokdam and Van Langevelde, 2005; Herzog et al., 2005). As cross compliance measures, strips are implemented over the whole territory, whereas they would have been restricted to only some voluntary farms if part of a traditional agri-environmental scheme.

Agriculture both provides and benefits from ecosystem services. For example, carabid beetles are potentially important natural pest-control agents, because of their predatory polyphagous diet. The abundance and species richness of this group of beetles in agricultural landscapes are enhanced by the presence of semi-natural elements (Schweiger et al., 2005). Several authors have stressed the importance of grassy field margins as overwintering refuges for carabids and other polyphagous predators (e.g. Desender et al., 1989; Asteraki et al., 1995) that disperse from these areas into the fields the following spring (Dennis and Fry, 1992).

Another example is syrphid hover flies (Dipterous, Syrphidae), which are also an important group of beneficial insects in agroecosystems, for two reasons. First, syrphids have been shown to provide significant pollination services to wild flowers and crops (Fontaine et al., 2006; Jauker and Wolters, 2008). Second, some species are aphidophagous at the larval stage; hence, they are able to prevent outbreaks of aphids on crops (Schmidt et al., 2003; Brewer and Elliott, 2004). In the present context of the pollinator crisis and the overhaul of the agricultural paradigm, these flies represent important functional biodiversity that provides services in agricultural ecosystems. Some landscape features may also be particularly important, such as forest edges that facilitate the survival of syrphid in winter (Arrignon et al., 2007), or grassy field strips that offer complementary flower resources to syrphids (Pontin et al., 2006). However, various syrphid species show different preferences in terms of botanical families (Speight et al., 2008). Consequently, the way in which grassy field strips favor syrphid populations (and associated agricultural services) may depend on their vegetation structure and habitat characteristics.

Small mammals are not often addressed in biodiversity studies because they are generally considered as pests that cause damage to agricultural products (Millymaki, 1977). This is mainly the case for some microtine (i.e., rodent) species that exhibit cyclic population outbreaks (Delattre et al., 1996). Aside from rodents, shrew species may be useful, due to their effect on soil invertebrates and litter decomposition (Shvarts et al., 1997). Moreover, small mammals are now often considered as a key factor in food web complexity and predator species diversity, due to their role as main primary prey biomass (Salamolard et al., 2000; Butet et al., 2010). As a new habitat in the agricultural landscape, grassy strips may act as a complementary habitat to other semi-natural systems, such as hedgerows and meadows (Tattersall et al., 2002; Macdonald et al., 2007).

This study tested how grassy strips may contribute towards maintaining and improving biodiversity in agricultural landscapes, by examining the plant community of grassy strips and the assemblages of three key faunal taxa of the agroecosystem. Specifically, we explored: (i) the plant composition of grassy strips in relation to their landscape context, and hypothesized the strong dependence of this habitat on the landscape context, which provides a species pool of propagules; and (ii) the composition of faunal communities in the grassy strips in comparison to that observed in other agroecosystem habitats, such as fields (for carabid beetles and syrphids) and hedgerows (for carabid beetles and small mammals). We subsequently investigated the relationships between faunal community indices and the characteristics of grassy strips. We hypothesized that plant diversity should enhance the diversity of syrphids, while grassy strip structure should impact carabid and small mammal communities. We apply the results of this study towards suggesting improvements to enhance the biodiversity of grassy strips which should be incorporated into existing European Union guidelines.

2. Materials and methods

2.1. Study area

The study site was located in Brittany (south of the Mont Saint-Michel: 48°36′N, 1°32′W), France, at an Long-Term Ecosystem Research (LTER) site.

In the study site, 68 grassy strips were identified in 2007. As some owners did not agree to the sampling of their grassy strips, only 54 grassy strips were sampled: all were established in 2005, located along watercourses, and adjacent to cereal fields (wheat or maize) (Fig. 1a). These strips were sown with the same seed mixture (*Lolium perenne*, *Trifolium repens*). For 19 of the field margins no information was available on the seed mixtures used in their establishment, although vegetation composition suggests it was similar to that of the other margins. According to CAP cross compliance rules, the grassy strips were mown between mid July and mid August. Some strips were inaccessible to mowing machinery (mainly because they were adjacent to maize) and were mown in autumn, after maize harvest. This late mowing implies that the strips supplied flowers likely to be visited by the syrphids, in particular yellow flowers such as *Lotus corniculatus* (Fabaceae), *Sonchus asper asper* (Asteraceae) or *Ranunculus* sp. (Ranunculaceae). Neither nutrients nor pesticides, including herbicides, were used on any of the grassy strips.

2.2. Grassy strip vegetation in the landscape context

2.2.1. Vegetation sampling

A survey of herbaceous vegetation was conducted on all 54 grassy strips in June 2007 (Fig. 1c). Vegetation cover was assessed within 2 m × 0.5 m rectangular quadrates placed along three transects. These transects were positioned 50 m from each other, perpendicularly to the field margin. For each transect, three quadrates were set up: one 50 cm from the edge of the field, one in the middle of the grassy strip, and one 50 cm from the hedgerow. In each quadrate, the cover of all species was recorded using the Braun–Blanquet method. Richness (Sveg), Shannon's diversity (Hveg), evenness (Jveg), and species composition were used to characterize the plant community observed in the grassy strips.

2.2.2. Landscape descriptors

In 2007, land use characteristics were surveyed from aerial photographs, and stored on ArcGIS version 9.2 (ESRI Inc. 1999–2005). Eight categories of land use were identified: annual crops, grasslands, hedgerows, woods, buildings, roads, grassy strips and stretches of water.

Environmental descriptors of grassy strips were extracted using buffer tools in geographical information system. Buffers were 100 m, 250 m, 400 m, and 550 m radii around each grassy strip (Fig. 1b). These different spatial scales were tested in order to determine the most pertinent scale influencing the vegetation structure. Previous studies have shown that these radii are sufficient to describe the landscape adequately in terms of the capacity for plant dispersal (Ozinga et al., 2004; Ma, 2008)

Twelve variables were calculated for each spatial scale (i.e., buffer radii): they belong to four groups of landscape descriptors (Table 1). The first group of variables accounts for the composition of the agricultural mosaic and is well known to influence biodiversity (Thies et al., 2003; Fischer and Lindenmayer, 2006). These composition descriptors were: the area of grasslands, the area of