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# Farming system and landscape characteristics differentially affect two dominant taxa of predatory arthropods

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ABSTRACT

Despite the role generalist predators may play in biological regulation, the influence of landscape composition in shaping their assemblages remains little studied, especially when landscape interacts with local factors. In this study, we investigated the effects of farming systems along gradients in landscape elements on the structure and composition of carabid and spider assemblages. Twenty pairs of organic vs. conventional spatially-matched fields were sampled in 2013 along increasing percentage covers of organic farming and semi-natural habitats in the landscape. A total of 24241 spiders and 27767 carabids belonging to 120 and 75 species respectively were collected by pitfall traps. Farming systems locally had a strong influence on the community structure (activity-density and species richness) and composition for both spiders and carabids. Structure of spider assemblages was mostly affected by local and landscape factors, whereas that of carabids was more driven by landscape variables and the interaction of the two levels. Spider and carabid community compositions were mostly determined by field farming systems and wood percentage around the field. Our study underlines the importance of landscape context in shaping assemblages of predatory arthropods, and suggests that mechanisms behind the distribution of individual species strongly differ between spiders and carabids.

## 1. Introduction

During the second half of the 20th century, agriculture experienced widespread industrialization worldwide, resulting in a strong increase in crop yield and in an intensification of farming practices (Stoate et al., 2001). Semi-natural habitats (SNH), such as woodlots, hedgerows covered by perennial vegetation had especially suffered from the mechanization and fields' expansion (Tscharntke et al., 2005). Agricultural practices such as the use of chemical fertilizers and pesticides had devastating effects, both direct and indirect, on not-target animal and plant species (Stoate et al., 2001). Indeed the intensification of farming practices and landscapes simplification have been identified as the main drivers of biodiversity loss in arable lands (Schmidt and Tscharntke, 2005), with strong consequences for agroecosystem functioning (Tscharntke et al., 2005).

Biodiversity provides many ecosystem services crucial for agroecosystem functioning (Tscharntke et al., 2012a), biological regulation of pests by predatory arthropods being one of the most important (Benton et al., 2003; Tscharntke et al., 2005). At the field or farm scale, it has been shown that organic farming positively affects the abundance and species richness of predatory arthropods, but this depends on the studied taxa (Bengtsson et al., 2005; Gabriel et al., 2010). Recent studies have also shown a positive effect of the proportion of organic farming in the landscape for beneficial arthropods (Rundlöf et al., 2008; Gabriel et al., 2010). The landscape heterogeneity, related to the composition and spatial configuration of SNH around the cropland, further influences both the structure (abundance and species richness) and species composition of beneficial arthropods' communities (Batáry et al., 2011). The effect of field farming system might also strongly vary depending on the heterogeneity of surrounding landscapes. Indeed, according to "*the intermediate landscape-complexity hypothesis*" (Tscharntke et al., 2012b), fields in moderately complex landscapes often host higher species diversity compared to homogeneous landscapes where croplands dominate (Rundlöf and Smith, 2006),. However, SNH may also constitute barriers to long-distance dispersal for arthropods (Larrivée and Buddle, 2009; Gauffre et al., 2015). Overall, the effects of interactions between field farming system at local and landscape scales and landscape heterogeneity on beneficial arthropods' communities

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remain little studied (but see Rundlöf and Smith, 2006; Flohre et al., 2011; Winqvist et al., 2011).

The effects of predator diversity on pest regulation are usually enhanced when they act at different spatiotemporal scales (Schmidt et al., 2003; Straub et al., 2008). The effectiveness of biological control is strongly influenced by the structure and composition of predator communities (Riechert and Lawrence, 1997; Menalled et al., 1999; Griffin et al., 2013; Rusch et al., 2015). In addition, investigating both community structure and species composition allows to better understand agroecosystem functioning (Bommarco et al., 2013), which argues to use these parameters as key response variables.

This study investigated the relative effects of farming systems and other environmental characteristics perceived to operate at the local (field) and landscape scales on ground-dwelling arthropod predators in agroecosystems. Indeed, these generalist and polyphagous predators strongly contribute to biological regulation (Thies et al., 2011; Cardinale et al., 2012). Among them, spiders and carabid beetles received special attention because i) they are abundant arthropods largely contributing to the local diversity of agroecosystems and ii) they have recognized bio-indicator values in the way they quickly react to changes in habitat structure (for spiders see Bell et al., 2001; for carabid beetles see Luff, 1998). We were more specifically interested in assessing the influence of field farming systems at both local and landscape scales (Organic Farming vs. Conventional Farming further abbreviated as OF and CF respectively), habitat and landscape characteristics and their interactions on the structure and species composition of spider and carabid assemblages. We tested the following hypotheses:

i) Field farming systems (OF vs. CF) locally drive the structure and composition of arthropod communities. We expect that both abundance and species richness of arthropods are significantly higher in OF fields (Bengtsson et al., 2005), mainly because of less disturbing agricultural practices (e.g. compared to the use of pesticides and chemical inputs in CF). We also expect clear differences in species composition between farming systems for both spiders and carabids. Large species and higher diversity of diets are expected in OF fields and more open habitat and carnivorous species are expected in CF, because of differences in local habitat conditions like vegetation structure and density (including weeds) (Tuck et al., 2014; Henckel et al., 2015) and prey availability (Roubinet et al., 2017).
ii) At the landscape scale, elements surrounding fields modulate the structure and composition of predator communities for both spiders and carabids. We expect a positive effect of the proportion of SNH and organic farming in the landscape on arthropod abundance and species richness (Tscharntke et al., 2012b). We also expect species composition to be influenced by the proportion of SNH only because they provide refuges, habitat for overwintering and alternative food resources (Holland et al., 2009).
iii) There are interacting effects of local, field farming system and landscape elements on the structure and composition of predator communities. We expect the effects of SNH to depend on farming system (Tscharntke et al., 2012b), because a high proportion of SNH can buffer the impact of farming practices (e.g. pesticides in CF) acting as source habitats from which individuals disperse in arable fields (Chaplin-Kramer et al., 2011).

## 2. Material and methods

### 2.1. Study site

The study site was located in Brittany, Western France (48° 06′ 53″ N, 1° 40′ 46″ O). It is characterized by a dense hedgerow network and dominated by mixed crop-livestock farming systems. The landscape is dominated by meadow (~40%) followed by corn (30%) and wheat (20%).

Forty fields (twenty pairs of organic and conventional fields) cultivated with winter wheat (*Triticum aestivum*) were selected in an area of about 200,000 ha along two landscape gradients: the first was made up by the proportion of OF around the sampled fields (radius of 500m; ranging from 3.5 to 30%) and the second by the proportion of SNH around the sampled fields (from 6.5 to 65.5%). A Moran's I test showed that the sites and gradients in landscape elements were not spatially auto-correlated (see Puech et al. (2015) for details in sites selection).

### 2.2. Characterization of local and landscape variables

In each field, vegetation height, wheat density, and percentage of wheat and weeds cover (using the Braun-Blanquet index) were measured in four quadrats (1 $m^2$) at a 3 m distance from pitfall traps in June 2013. Landscape metrics were computed to characterize the composition and spatial organization of land covers in the surrounding of each focal field. The landscape was characterized in a radius of 500 m around each field (Table 1). This distance was chosen because it is relevant to describe landscape for both spiders (Schmidt and Tscharntke, 2005) and carabids (Batáry et al., 2007). In total sixteen variables were

**Table 1**
Complete list of local and landscape variables measured in the study, with their type (qualitative vs. quantitative), unit, min-max and mean (together with the standard error).

| Scale | Variable Name | Description | Variable type | Unit/class | Min-Max | Mean (± SE) |
|---|---|---|---|---|---|---|
| ***Field scale*** | | | | | | |
| | Far_Syst | Field farming system (organic *vs* conventional) | qualitative | OF *vs* CF | – | – |
| | Moy_ble | Ground covered by wheat | qualitative | Braun-Blanquet index | 1–3 | 2.28 (± 0.11) |
| | Moy_adv | Ground covered by weeds | qualitative | Braun-Blanquet index | 1–5 | 1.94 (± 0.19) |
| | AH_veg | Average vegetation height | quantitative | cm | 63.75–142.5 | 88.1 (± 2.5) |
| | Moy_nbplt | Wheat density | quantitative | number of stems per $m^2$ | 6.75–33 | 19.3 (± 0.92) |
| ***Landscape scale (500 m radius)*** | | | | | | |
| | OF_landscape | Proportion of organic farming | quantitative | % of cover | 3.49–29.22 | 18.22 (± 1.4) |
| | CF_landscape | Proportion of conventional farming | quantitative | % of cover | 42.48–86.5 | 66.24 (± 1.7) |
| | NR | Proportion of missing data regarding farming type | quantitative | % of cover | 5.64–31.47 | 15.53 (± 1.1) |
| | Farm_anl | Annual crops | quantitative | % of cover | 25.53–84.05 | 56.5 (± 2) |
| | Farm_inter | Perinnial crops | quantitative | % of cover | 6.27–45.57 | 28.5 (± 1.7) |
| | Wood | Proportion of Wood | quantitative | % of cover | 0.001–23.89 | 3.9 (± 0.96) |
| | Grass_strips | Proportion of Grass strips | quantitative | % of cover | 0.001–2.17 | 0.5 (± 0.08) |
| | Meadow | Proportion of Meadow | quantitative | % of cover | 6.03–45.27 | 28 (± 1.7) |
| | Road_Frame | Proportion of built areas | quantitative | % of cover | 2.36–20.35 | 9.3 (± 0.73) |
| | Water | Proportion of water elements | quantitative | % of cover | 0.001–4.31 | 0.7 (± 0.16) |
| | Hedge | Hedgerow lengh | quantitative | m | 3692.63–11134.3 | 6933.21 (± 317) |