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Pollinator community response to vegetation of semi-natural habitats around arable fields

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Abstract: Semi-natural habitats (SNH) might develop a role in agricultural landscapes supporting pollinators in some or all of their life stages. Six types of SNH were assessed regarding their floral composition and pollinator's presence. Woody linear elements attracted most of the *Bombus* species while herbaceous ones hosted most of the wild/solitary bees. Hoverflies and butterflies were widely present in both types of SNH. Alfalfa fields seemed to play a role as periodic feed resources for *Apis mellifera* and *Bombus terrestris*.

Key words: agricultural landscapes, ecosystem services, pollination, vegetation composition, floral abundances

Introduction

Effective animal pollination can be considered as a crucial ecosystem service: about 84% of European crops and 35% of global production depend, at least to some extent, upon animal pollination (Klein *et al.*, 2007); it is also a key process for the sexual reproduction of most wild extant flowering plants (Aguilar *et al.*, 2006). Prior evidences prove that solitary bee abundance and species richness are positively correlated with the amount of natural vegetation in the surrounding landscape (Kremen *et al.*, 2007) and habitat-specialist butterfly abundance is also associated to nearby forest cover (Korpela *et al.*, 2013). Presence of wild pollinators -even when honey bees are abundant- seems to increase efficiency, stability and quality of pollination as well as crop productivity and stability (Greenleaf & Kremen, 2006).

Intensively managed agricultural landscapes usually tend to lack species-rich floras and continuity of floral resources. Maintaining patches of semi-natural vegetation within the agricultural matrix can be a good solution for these temporal food shortages while providing some resources necessary to sustain resident bee populations (Banaszak, 1992). Previous studies also state that the value of pollination services from these patches outweighs the expected revenues of devoting that land to productive purposes (Ricketts *et al.*, 2004). The objective of this preliminary research is to identify whether the predefined types of SNHs entail different levels of attractiveness for pollinators, and if so, how they shape pollinator communities.

Material and methods

Study area

The study area was located in the plain of Pisa, region of Tuscany (43°43′0″ N, 10°24′0″ E), covering an area of 460 km^2 with agricultural land dominated by annual cropping systems.

Vegetation and pollinator surveys

We surveyed 50 SNHs in 15 landscape sectors of one km radius scattered along the study area following a gradient of landscape complexity. For simplicity, landscape complexity was estimated as the total coverage of SNH based on aerial photographs. Each SNH was allocated to one of the five predefined categories: Woody areal (WA), Woody linear (WL), Herbaceous areal (HA), Herbaceous linear (HL) and In-field (FA). Any sampled element had a minimum surface of 150 m^2 to guarantee a minimum impact on beneficials and ecosystem service delivery. In each landscape sector one SNH type for each category was selected, if present. The minimum distance between SNH was 200 m to ensure independence of measurements. In addition, three *Medicago sativa* fields (MSF) for hay present in three of the 15 selected landscape sectors were also surveyed to assess their potential as recurring food resources for pollinators in Mediterranean regions.

For each SNH, two transects of 1.5 m by 50 m were placed running parallel at the external (E) and internal (I) part of the element. In narrow elements where this was not possible both were located consecutively in line along the main axis of the element. Species floral abundances (number of inflorescences/m^2) were measured within each transect in 10 randomly distributed plots of 1 m^2 for flowers at 0-2 m height.

Simultaneously to vegetation surveys, pollinator community was assessed using standardized transect walks (Dafni *et al.*, 2005) in accordance with the vegetation ones. Pollinators and flower abundances were sampled in early June, late July and mid September. During a maximum of 10 minutes per transect unit the observer walked slowly and at a constant pace while recording all individuals of the following insect groups: bees (Hymenoptera: Apoidea: honey bees, bumble bees, other wild bees/solitary bees), hoverflies (Diptera: Syrphidae) and Lepidoptera. Honey bees and bumble bees were identified to species level and the remaining Apoidea were classified as “other wild bees/solitary bees”; hoverflies and butterflies were classified at family and order level respectively (Syrphidae and Lepidoptera). Transect walks were carried out following weather standards established by Pollard & Yates (1993).

The sampling protocols used for this study are part of the common protocols developed in the FP7 project QuESSA (www.quessa.eu).

Data analysis

Species floral abundances were grouped by family. Vegetation and pollinator data were averaged over the three sampling times and analyzed using Canonical Correspondence Analysis (CCA) performed with the CANOCO 5.03 package (Ter Braak & Šmilauer, 2012).

Results and discussion

Floral abundances

CCA confirmed the expected differences in species composition among the predefined types of SNH. WL-I plots did not contain any flower and thus were excluded from the analysis. Polygonaceae, Convolvulaceae, Verbenaceae and Fabaceae were almost exclusive for herbaceous elements, while Lamiaceae, Rosaceae and Rubiaceae for woody ones. Apiaceae and Asteraceae were present in both types of elements denoting a broader level of dispersion and adaptability. Figure 1 shows distribution of flowering families across plots aggregated by "SNH type & Sampling Position". Explanatory variable [SNH type-Position (E/I)] accounted for 19.8% of the total variation. Permutation Test Results: On 1st Axis, pseudo-F = 4.3, P = 0.036; On All Axes, pseudo-F = 1.6, P = 0.004.

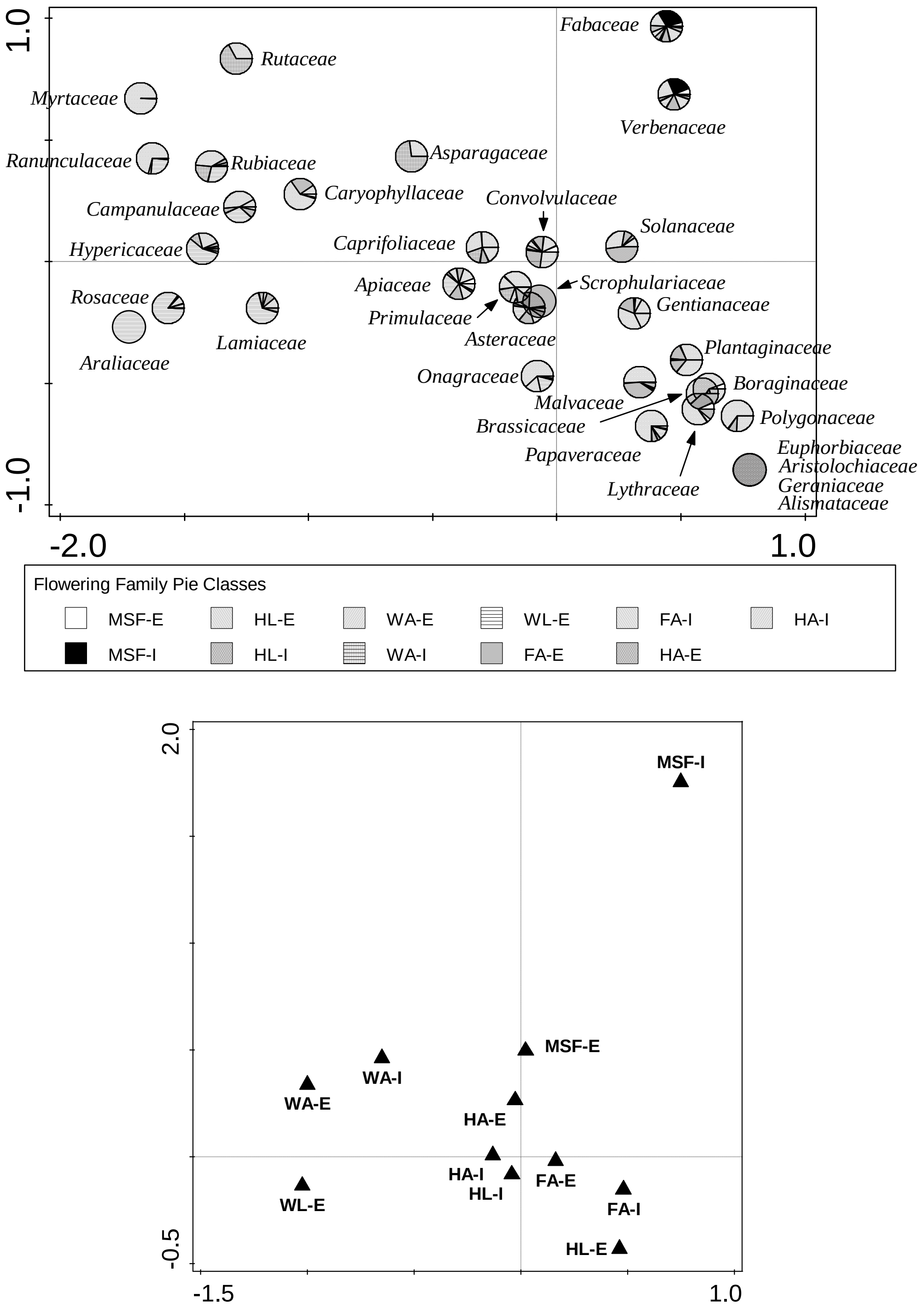

Figure 1. Distribution of flowering families across "SNH type-Position" aggregated plots (top). Dissimilarity of flower composition among "SNH type-Position" aggregated plots (bottom).

E = external, I = internal; for full names of Semi-Natural Habitats see Material & methods.

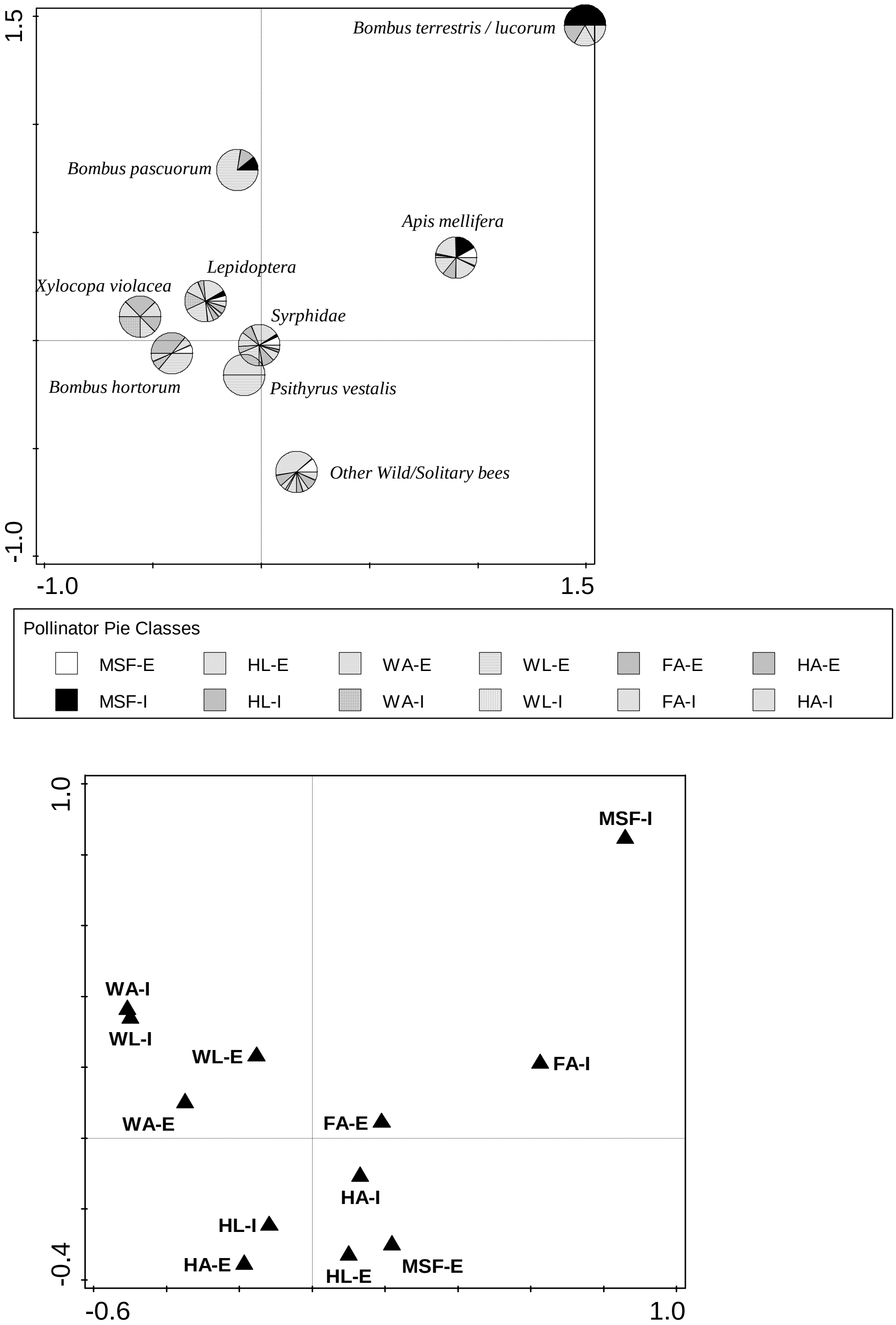

Figure 2. Distribution of pollinator groups across "SNH type-Position" aggregated plots (left). Dissimilarity of pollinator community composition among "SNH type-Position" aggregated plots (right).
E = external, I = internal; for full names of Semi-Natural Habitats see Material & methods.

Pollinator abundances

Assessment of pollinator community showed that *Lepidoptera* and *Syrphidae* were quite ubiquitous among SNHs, while *B. pascuorum* was almost exclusively found in WL-E plots.

Most of the "*B. terrestris/lucorum*" group specimens were recorded in flowering alfalfa fields, suggesting that these fields can act as feed stepping stone for big pollinators between periods of mass flowering crops. *A. mellifera* foraged in different SNH types but had a preference for herbaceous elements. Half of the "Other solitary/wild bees" group was found in the HL plots. An overview of pollinator community across SNH types is given in Figure 2: CCA of number of individuals by pollinator group with "SNH type-Position (E/I)" as explanatory variable accounting for 23.5% of the total variation. Permutation Test Results: On 1^{st} Axis, pseudo-F = 7.4, P = 0.06; On All Axes, pseudo-F = 2.0, P = 0.012.

Overall data showed that majority of *B. hortorum* and *B. pascuorum* were found in WL-E plots, with a floral community characterized by Lamiaceae and Rosaceae and dominated by Apiaceae, Asteraceae and Rosaceae. *B. terrestris/lucorum* group was highly attracted to alfalfa flowering fields, with half of their presences recorded there. "Other wild bees/solitary bees" group showed preference to HL elements, where floral resources were mostly dominated by Polygonaceae, Apiaceae and Asteraceae, and Malvaceae as characteristic one. Syrphids and butterflies were quite omnipresent, suggesting that they are related to families as Apiaceae and Asteraceae that are homogenously distributed in the SNHs. For *X. violacea*, woody elements seem to play an important role, since 25% of the specimens were found in WA-I plots. *A. mellifera* was present mostly in herbaceous elements but also in woody ones at flowering period of *Rubus* spp. suggesting its high dispersal ability and generalist behaviour. Comparison of the SNH classification based on vegetation composition and on pollinator community resulted in very similar clustering, indicating that SNH types have a consistent plant community hosting specific pollinators. However, further research is needed to disentangle plant-pollinator interactions with practical implementations.

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