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Role of floral resources in the conservation of pollinator communities in cider-apple orchards

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ABSTRACT

Pollinators are generally assumed to be in decline but a proper habitat management could help to conserve pollination services. In 2012 we surveyed the groundcover in nine cider-apple orchards to (I) identify the floral and faunal communities present in the ground floor, (II) assess the attractiveness of the local spontaneous flowers to insects and (III) determine the role that the flower community may play for the conservation of the associated arthropods in general and of pollinators in particular. The apple orchards provided a continuous succession of floral resources in the groundcover with differences among orchards in the abundance, richness and diversity of flowers. Flowering plant species were visited by a wide variety of insects, mostly from the orders Hymenoptera (70%) and Diptera (25%). Wild bees accounted for 27% of hymenopterans and hoverflies for 30% of dipterans. Flowering plants differed in the number of taxa they attracted and in their attractiveness for particular insect groups and for insects as a whole. A total of 16,159 arthropods were collected from the groundcover, and 2064 individuals belonged to taxa involved in the pollination. Pollinators and arthropods (exemplified by hemipterans and coleopterans) differed between orchards and periods and were affected by the plant community. Plant species richness and the abundance of some plant species favored the presence of both pollinators and arthropod assemblages while flower abundance had only a marginal effect on those communities. Pollinators were also affected by plant diversity. Among-orchard differences in the plant community suggest that management recommendations must be site-specific to ensure the permanent availability of diverse floral resources for the arthropod community and for pollinators in particular. Therefore, a proper groundcover management could provide benefits for apple growers by improving pollination services.

1. Introduction

The dramatic decrease of pollinating insects, which provide vital ecosystem services to crops and wild plants (e.g. Potts et al., 2010), has generated a general concern because they are crucial for global food production and biodiversity conservation. Around 88% of plants are pollinated by animals (Ollerton et al., 2011) and 35% of global food production relays on animal pollination (Klein et al., 2007). Honeybees, bumblebees, solitary bees, butterflies or some beetles and flies highlight within insect pollinators although only a few (mainly honeybees, but also some bumblebees or solitary bees) have been actively managed for food production (Vicens and Bosch, 2000; Tepedino et al., 2007). However, wild insect pollinator communities account for a substantially greater proportion of pollination services than previously thought and might provide an insurance policy in the future (e.g. Tepedino et al., 2007; Breeze et al., 2011; Aebi et al., 2012; Christmann and Aw-Hassan, 2012). Agriculture intensification, mediated by habitat destruction, pesticide abuse or loss of floral resources, is a major threat for native pollinators (Inouye, 2007; Marini et al., 2012; Wratten et al., 2012) whereas their conservation relays on proper management strategies, both on the crops and their surroundings (Wratten et al., 2012).

Apple is an excellent example of pollination-dependent crop as it greatly relays on the services provided by flower-visiting insects (Vicens and Bosch, 2000; Tepedino et al., 2007; Marini et al., 2012). This crop covers more than 10,000 ha in Asturias (NW Spain) and focuses on the production of cider-apples for an important cider production industry.

Vegetation in those orchards needs to be removed in the tree row to reduce competition for water and nutrients, whereas vegetation is maintained in the alleys between tree rows, as it reduces mud and debris on fruit, and helps to protect the soil from erosion or compaction due to machinery traffic (Merwin, 2003). Such vegetation develops spontaneously in Asturian orchards forming a groundcover of autochthonous species including a wide variety of flowering plants.

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Flowering plants provide critical sources of nectar and pollen for the reproduction and survival of many beneficial insect groups, such as pollinators and pest natural enemies (Wäckers, 2004; Kraemer and Favi, 2005; Laubertie et al., 2012). Identifying the native flowering plants in spontaneous and permanent perennial crops, such as fruit orchards, and understanding their role in conserving agriculturally-functional insect groups (e.g. pollinators or pest controllers) is of great relevance and might contribute to develop proper conservation strategies (Wäckers, 2004; Fiedler and Landis, 2007; Sivinski et al., 2011; Dib et al., 2012). Therefore, the aims of this study were to: (I) identify the floral and faunal communities present in the floor of organic apple orchards, (II) assess the attractiveness of the local spontaneous flowers to beneficial insects development and (III) determine the role that the flower community may play for the conservation of the associated arthropod fauna, especially of pollinators.

2. Materials and methods

2.1. Site description

The investigations took place from April to September 2012 in nine semi-intensive cider-apple orchards subjected to organic guidelines and located in Asturias (NW Spain; 43°30′N, 5°30′W). Asturias has a temperate oceanic climate with a fairly evenly spread rainfall over the year which exceeds 1100 mm. Five different locations were considered to cover a wide range of common growing situations in the region: Nava (N1), Oles (O1, O2), Priesca (P1), Sariego (S1, S2) and Villaviciosa (V1, V2 and V3). The orchard surface ranged from 0.4 to 2.1 ha, tree age from 1 to 15 years, and altitude from 10 m to 365 m a.s.l. Finally, the type of soil varied from clay to sandy. The trees were planted on semi-dwarfing rootstocks, and the distance between adjacent trees was 2.5–3 m in the tree row and 5.5–6 m in the alley (space separating tree rows). The groundcover in the tree row was managed by mowing or shallow tillage, and alleys were periodically cut with a shredder in all the orchards.

2.2. Inventory methods for flowering plants

Visual observations were conducted fortnightly from mid-April (coinciding with apple bloom) to mid-September (just before fruit harvest) to assess the composition of the flowering plant community and the period of inflorescence in the orchard floor. During each sampling event, the presence of plants-in-flower in the orchard floor was recorded on a 200-m transect line along the center of the alleys. At 10-m intervals, the observer stopped and searched visually for the presence of flowers in a circle (1 m radius) which covered a 3.15 m^2 area. The occurrence of flowers was recorded in 20 intervals during each sampling event (total of 10 events). In order to get representative data from the orchard, the observer moved to another alley after performing five intervals. For each plant species, “peak bloom” refers to the specific date of maximum number of flowers, “full bloom” to the dates with more than 10% of the total flowers recorded, and “in bloom” to those dates with presence of flowers below 10%.

2.3. Inventory methods for arthropod fauna

2.3.1. Fauna visits to flowers

The attractiveness of flowering plants to insects was estimated by visual observation. The observation of all the plant species is almost impossible in practice, so the most representative ones was selected attending to their blooming period and abundance. After the arbitrary selection of an open flower, the number of insects which visited it over 3 min was recorded. Insects were counted when they stopped on the flower to feed, as well as when they flew in front of the flower. During the sampling, the observer remained motionless and a minimum of 1 meter apart to avoid any disturbance. Observations occurred on clear windless days at times close to midday.

2.3.2. Fauna community in the herbaceous layer

Sweep net transects were used to collect the arthropod fauna from the herbaceous layer once a month from May to September 2012. Sweep net collections provide a rapid, inexpensive, and easily standardized protocol. At each site, four random 25 × 2 m belt transects were chosen, yielding a total of 100 sweeps per site each month. Transects were located at least 10 m from the edges and were nonintersecting. Sampling occurred between 9:30 a.m. and 4.30 p.m. on sunny and wind calmed days above 18 °C. In each transect, each sample included the arthropods collected from 25 pendulum sweeps (triangular-shaped net, diameter 30.5 cm wide). The specimens were preserved in labeled zip-top bags and stored in a −20 °C freezer until identified. All the arthropods were identified to Order level and, within the Coleoptera and Hemiptera, to family level. Both orders hold taxa from a wide variety of trophic groups and habitat requirements providing a good representation of the arthropod community. We estimated the contribution of insect fauna to the pollination of flowering plants by identifying all the taxa which are recognized as direct or incidental pollinators (Roubik, 1995).

2.4. Statistical methods

Analysis of variance (ANOVA) with repeated measures was used to assess the changes in the number of flowers and in the abundance of fauna (total and for pollinators) along time and among orchards. Community structure of the flowering plants was described by species richness (S) and Shannon-Wiener’ diversity index (H'). The same indexes were calculated for the fauna at family level. The orchard and period effect on all these community parameters were estimated with the same procedure. Flora data was calculated for each sampling interval (20) at each orchard (9) and period (10). Fauna records were calculated for four random samples per orchard (9) and period (5). The data was $\log_{10}(x+1)$ transformed when necessary to meet the assumptions of variance homogeneity and sphericity. The Greenhouse–Geisser correction was used when the sphericity was not met. Treatment means were compared using Bonferroni multiple-comparison test. Correlation analyses were performed to study the relationships between the plant species and the plant diversity parameters. All these analyses were performed using SPSS (IBM SPSS statistics version 19.0.0).

Multivariate analyses based on constrained ordination were used to calculate the variability in fauna abundance [$\log_{10}(x+1)$ transformed] accounted for the environmental (vegetation) variables including all the families of Coleoptera and Hemiptera as well as the assemblages of pollinators. The Redundancy analyses (RDA) were chosen on the basis of the short gradient lengths (<3SD for Axis 1) determined from preliminary detrended correspondence analysis (DCA). The RDA were performed on a insect taxa × plots matrix, including the full set of environmental (vegetation) variables. Fauna data were pooled for each month while vegetation data were averaged. The variation due to the month was subtracted by entering the period as a covariate. As not all the variables could have a significant influence on the species data matrix, a reduced model with the most explicative ones was generated using a forward stepwise selection on the environmental data. The statistical significance of the model after the inclusion of each environmental variable during forward selection, was evaluated by the F-ratio based on the trace and 4999 unrestricted Monte Carlo permutations. All ordinations were carried out using the software for canonical community