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Organic versus conventional systems in viticulture: Comparative effects on spiders and carabids in vineyards and adjacent forests

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ABSTRACT

Farming systems and management regimes of vineyards may affect local biodiversity of plants and invertebrates. While most studies have focused on the overall biodiversity of vineyards, there has been little consideration of the response of different ecological guilds to vineyard management, or to how vineyard management affects communities of adjacent semi-natural habitats.

We study here two functional guilds of carabids and five of spiders in Langa Astigiana (NW-Italy) with the following aims: (i) to assess the comparative effects of organic and conventional farming systems, along with associated habitat and landscape variables, on species richness and abundance in vineyards; and (ii) to compare the same within forest patches *surrounding* organic and conventional vineyards.

The different guilds exhibited distinct preferences for habitat characteristics (i.e. grass cover), landscape context and farming systems. Generalized Linear Mixed Models showed that spider preferences mostly depended upon habitat variables, while carabid preferences depended on small-scale landscape variables. In general, organic farming increased biodiversity and abundance of arthropod predators, even though different guilds of carabids and spiders responded differently. Brachypterous carabids, ambush spiders, ground-hunter spiders and other hunters preferred organic vineyards, whereas macropterous carabids, specialist spiders (mostly ant-eating spiders) and sheet web weavers selected conventional vineyards. The research we report here shows that preferences for vineyards with different farming systems has been driven not only by farming systems *per se* (i.e. omission of synthetic pesticides), but also by habitat characteristics and small-scale landscape structure. Arthropod diversity was greater in the forest patches adjacent to organic vineyards than to conventional ones. This suggests that organic systems may sustain a higher diversity of carabids and spiders both in vineyards and in the adjacent forest patches as well. We conclude that although conventional systems may promote the diversity of some guilds, organic systems should take priority.

1. Introduction

Agroecosystems are characterized by diverse inputs, such as human labour and petrochemical energy and products, which replace and supplement the functioning of many ecosystems. While such substitutions may buffer some of these functions, they also run the risk of damaging others. For instance, the use of pesticides may control diseases that have negative impact on crops, but these may also kill non-target organisms with other positive functions such as pollination or soil fertility enhancement (Power, 2010; Swift et al., 2004).

The current intensification of agriculture is leading to growing concern about the sustainability of farming systems, since farmland biodiversity has severely declined (Kleijn et al., 2011; Vickery et al., 2004). Biodiversity is certainly important to the functioning of ecosystems: insights from Biodiversity and Ecosystem Function (BEF) experiments are likely to underestimate, rather than overestimate, the importance of biodiversity to ecosystem functioning and the provision of ecosystem services (Duffy, 2008). One of the major threats to farmland biodiversity is the simplification of landscape structure, with diminution of non-crop habitat deriving from the expansion of intensive arable crops (Benton et al., 2003; Stoate et al., 2001). Organisms at higher trophic levels seem to be more vulnerable to disturbance than those at the lower trophic levels (Kruess and Tscharntke, 1994), suffering decreases both in their diversity and abundance. Disturbance affects predatory arthropods both directly and indirectly through reduced densities of their prey and hosts. This process in turn decreases the *natural* control of important crop pests (Riechert and Lawrence, 1997; Schmidt et al., 2003). Considering that many ecosystem services of particular importance for agriculture such as pollination and natural pest control

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often depend on the number of species in an ecosystem (Cardinale et al., 2012; Tilman et al., 2002), the impoverishment of natural communities by agriculture should be minimized to avoid negative feedbacks on production (Díaz et al., 2007).

Organic systems have been shown to support higher biodiversity than conventional ones across many different taxa (Bengtsson et al., 2005; Fuller et al., 2005). These systems aim to promote beneficial organisms by prohibiting the use of synthetic pesticides, herbicides and mineral fertilizers. Moreover, they minimize tillage in order to reduce soil erosion. Studies on organic farming in vineyards are particularly prominent because these agroecosystems are important not just for agriculture, but for conservation as well. In temperate Europe, vineyards (which typically occupy sites with particularly warm and dry climates) may host rare and endangered species of plants and invertebrates. General biodiversity is also typically high (Costello and Daane, 1998; Gliessman, 2000; Isaia et al., 2006).

Vineyards are an ancient crop of Mediterranean mountain environments, cultivated on steep slopes or terraces probably since the early middle ages (Aldighieri et al., 2006; Cots-Folch et al., 2006; Wicherek, 1991). Predicted northward shifts in the climate of European viticultural regions over the coming decades (Kenny and Shao, 1992; Maracchi et al., 2005) may alter both the spectrum and the distribution of grape varieties currently used (Metzger et al., 2008; Schultz, 2000). Several studies have shown that farming systems and regimes of vineyards are important factors determining biodiversity of plants and invertebrates (Bruggisser et al., 2010; Costello and Daane, 2003; Di Giulio et al., 2001; Thomson and Hoffmann, 2007; Trivellone et al., 2012). Carabids and spiders are important components of the vineyards. They are potentially important natural agents of pest-control because of their predatory polyphagous habits, and they may be helpful to maintain ecosystem functions and services and promote sustainable agriculture (Kromp, 1999).

Vineyard landscapes of north-western Italy represent peculiar agroecosystems which deserve high conservation priority because of ecological, historical and economic importance (high quality wine production). The research we report here investigated how species richness and abundance of spiders and carabids respond to organic and conventional farming systems in the context of habitat and landscape variables. We also studied the effects of these systems on spider and carabid diversity in the forest patches surrounding the vineyards because, to our knowledge, little attention has been addressed to study the effect of management on surrounding habitats while more consideration has been addressed to analyse how landscape context influences arthropod communities in organic and conventional farms.

Furthermore, while most studies have focused on the overall biodiversity of vineyards, less attention has addressed the effect of organic versus conventional systems on the different ecological guilds (Krauss et al., 2011). Accordingly, we considered functional guild identity of carabids and spiders instead of the overall community, since species with varying ecological requirements may respond differently to different farming systems.

2. Materials and methods

2.1. Study area and sampling design

The study was carried out in the Langa Astigiana (NW Italy which ranges for about 28,000 ha), a rural region where vineyards cover 19% of the territory (5,343 ha). The present landscape is the result of centuries of historically documented activities. Other main land uses include oak (*Quercus robur*), chestnut (*Castanea sativa*) and black locust (*Robinia pseudoacacia*) groves/forests (28%, 7873 ha), hazelnut orchard areas and other fruit crops (21%, 5905 ha), arable lands (16%, 4499 ha), grasslands and pastures (9.5%, 2671 ha), shrub lands (3%, 843 ha), urban areas (3%, 843 ha), and uncultivated lands (0.11%, 31 ha). The climate belongs to type Cfa (temperate, without dry season and with hot summer), in terms of Köppen–Geiger's classification (Peel et al., 2007). During the last five years, annual precipitation ranged from 567 to 894 mm with minimum values in July, January and February and with a maximum peak in April and November. Total annual rainfall averaged 757.4 mm, while the mean annual temperature was 11.9 °C (Loazzolo climatic station, 600 m a.s.l.). We investigated 12 vineyards, of which 6 were certified for organic production whereby no chemical treatments except sulphur and copper sulphate spraying were used. In some cases pyrethrum was sprayed against the principal vector (*Scaphoideus titanus*) of flavescence dorèe (*Candidatus Phytoplasma vitis* IRPCM, 2004), which is a bacterial disease of the vine. The other 6 vineyards were cultivated according to conventional production methods. These involved chemical treatments with pre- and post-emergence herbicides, insecticides (mostly against flavescence dorèe), anti-rot compounds, sulphur, copper and zinc spraying, products with esaconazol and copper oxiclorur sulphate against oidium and rots, carbamate pesticides and fungicide, and the use of mineral fertilizers with average concentration of P, K and N at 6.5 q/ha. In particular, during the study period, conventional vineyards were treated with 1.5 l/ha of chlorpyrifos-ethyl and 1.5 l/ha of chlorpyrifos-methyl against bacterial infection (flavescence dorèe) in the months of June and July respectively. Treatment against downy mildew consisted of three treatments of copper oxychloride (40%) and Dimetomorf 6% (3.5 kg/ha) in June and three treatments of Bordeaux mixture (6 kg/ha). Treatment against *Oidium* consisted of powdered sulphur (50 kg/ha), one treatment of Trifloxystrobin (125 g/ha), and two treatments of wettable sulphur powder (3 kg/ha) in June and two in July.

We placed five pitfall traps in the core of each vineyard and five in the last row of the vines at the edge of the vineyards. For each vineyard, we selected the closest, possibly adjacent, broad leaved forest patch (mixed black locust-oak forest in each site), where we placed five traps as well. Traps were arranged 10 m apart along line transects. Pitfall traps were 7.5 cm in diameter and 9 cm deep, filled with 150 ml of a standard mixture of wine vinegar and saturated sodium chloride solution, designed to preserve individuals. They were placed at the beginning of July 2009 and emptied three times at two-week intervals. Trapped arthropods were sorted and identified, whenever possible, to the species level using updated standard keys or specialist works. For spiders, only adults were considered. Nomenclature follows Platnick (2014) for spiders and Vigna Taglianti (2005) for carabids.

Three habitat variables were recorded in vineyards around each pitfall in a circular area of 5 metre radius: the percentage of grass cover, leaf litter cover (estimated by eye), and the mean grass height (ten random measurements, in centimetres). Five habitat variables were recorded in the forests close to the vineyards around each pitfall in a circular area of 5 metre radius: the percentage of grass cover, leaf litter cover, bare ground cover and dead wood cover (estimated by eye), and the mean grass height (ten random measurements, in centimetres).

2.2. Data analysis

We used land cover data digitized from 1:10000 aerial photographs to describe the landscape composition and structure. We considered a small scale (focused on the vineyard and forest patches) and a large scale (focused on the landscape, i.e. vineyard and adjacent land uses). At the small scale, we created a buffer of 200 m of radius with the centre coincident with the third trap (i.e. in the middle of the transect) of each transect. At the large scale, we created a buffer of 1500 m of radius with the centre coincident with the centroid of the triangle whose vertices coincided with the third trap