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Research paper

Does organic farming enhance biodiversity in Mediterranean vineyards? A case study with bats and arachnids

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ABSTRACT

The effectiveness of organic farming for promoting biodiversity has been widely documented, yet most studies have been undertaken in temperate agroecosystems with a focus on birds, insects and plants. Despite the Mediterranean basin being a biodiversity hotspot for conservation priorities, the potential benefits of organic farming for biodiversity there has received little attention. Here, we assessed the effect of farming system, landscape characteristics and habitat structure on biodiversity in Mediterranean vineyards using two taxa with different functional traits (in terms of mobility, dispersal ability and home range size): bats and arachnids. We also tested the "intermediate landscape-complexity" hypothesis, which predicts that local conservation measures have greatest success in landscapes of intermediate complexity. Our study design involved pairs of matched organic and conventional vineyard plots in the south of France situated along a landscape complexity gradient. Abundance of arachnids were higher in organic vineyards, although arachnid species richness was positively associated with the amount of ground vegetation cover. Organic farming was ineffective on its own to enhance bat activity and species richness regardless of the landscape context. Rather, our results suggested that landscape features were more important for bats than vineyard management, with significantly higher bat activity recorded on vineyard plots located at close proximity to hedgerows and rivers. When designing conservation strategies in Mediterranean farmlands, we strongly recommend the implementation of a multi-scale approach to assure benefits for a wide range of species.

1. Introduction

Over the last 30 years, policies of the European Union (EU) have progressively evolved to try halting the dramatic loss of biodiversity that was associated to agricultural expansion and intensification (Henle et al., 2008; Pe'er et al., 2014). While the EU – with its Common Agricultural Policy (CAP) – has encouraged intensive and productive farming to ensure food security, problems of declining biodiversity were first addressed by the EU in 1985 by providing several measures for environmental protection to member states, and then during the 1992 CAP reform by developing and promoting Agri-Environmental Schemes (AESs) (Kleijn and Sutherland, 2003). This incentive system aims to counteract the negative effects of intensive agriculture by providing financial compensation to farmers that adopt environmentally-friendly farming approaches. AESs have become a key EU policy which aim to enhance biodiversity and ecosystem services in farmland (Whittingham, 2011) and represent the most expensive conservation programme implemented in Europe (Batáry et al., 2015): the EU will have allocated nearly 23 billion euros to AESs between 2014 and 2020 (European Parliament, 2016).

Support for conversion to organic farming is one of the main agri-environment schemes proposed to farmers. In 2015, farmlands under organic management represented 6.2% of utilised agricultural area in Europe (EU-28), comprising 11.1 million hectares, compared with 9.2 million hectares in 2010 (Eurostat, 2016). Due to the wildlife-friendly management implemented in organic farming (e.g., non-use of synthetic chemical pesticides and input fertilizers, low pressure on land-use) and its positive influence on landscape heterogeneity and complexity (Norton et al., 2009), organic farming would seem to be favourable for a range of taxa (Hole et al., 2005). However, several studies emphasize that the effects of organic farming on biodiversity are species-specific (Fuller et al., 2005) and most importantly, are dependent on the scale considered (Gabriel et al., 2010) and the landscape context (Batáry et al., 2011; Bengtsson et al., 2005; Tuck et al., 2014). Regarding the latter, the "intermediate landscape-complexity" hypothesis has been proposed to explain this pattern (Tscharntke et al., 2005; Tscharntke et al., 2012; Concepción et al., 2008). It stipulates that the effectiveness of organic farming would be higher in landscapes

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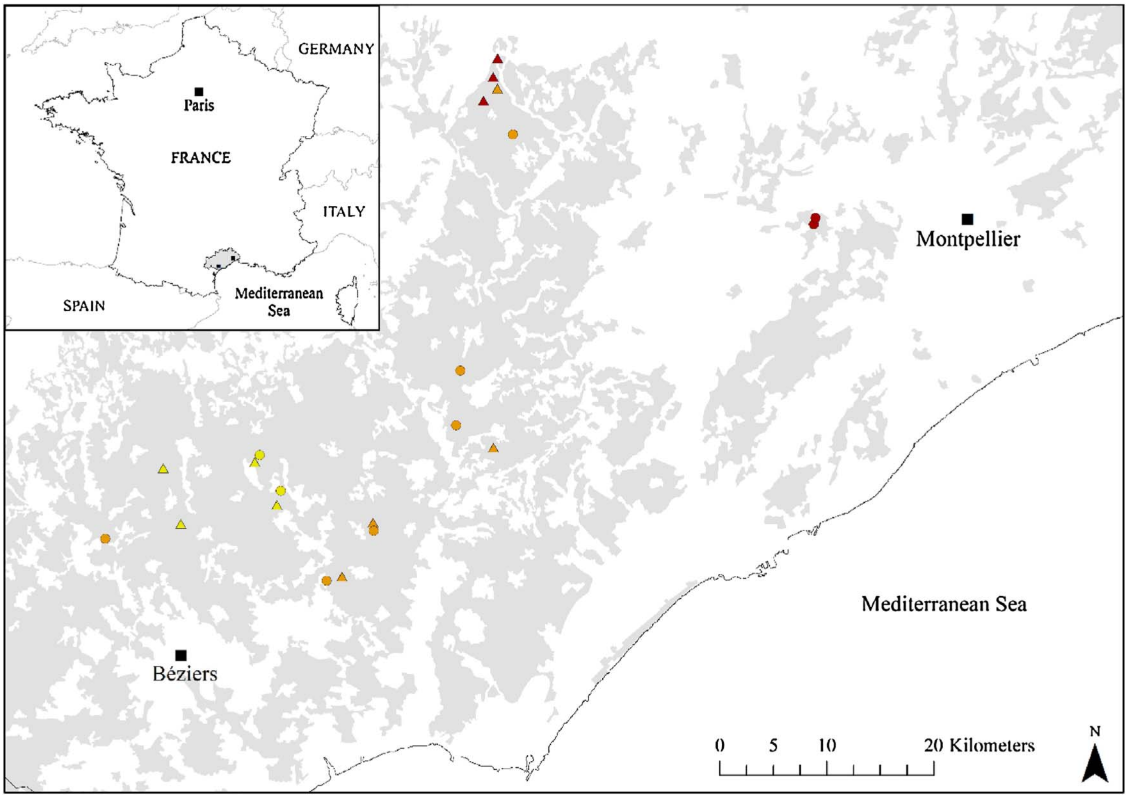

Fig. 1. Location of the 21 paired sites in South of France (Hérault County). Each symbol represents a pair. Arachnids were sampled in 11 pairs (triangles) while acoustic sampling of bats took place in each pair (circles and triangles) situated along a landscape complexity gradient. Cleared landscapes (yellow symbols): extremely simplified landscape with < 1% of forest and semi-natural areas; Simple landscapes (orange symbols): 1–20% of forest and semi-natural areas; Complex landscapes (red symbols): > 20% of forest and semi-natural areas (Tscharntke et al., 2012). Vineyard areas are represented in grey (© CORINE Land Cover 2006, code 221). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

with intermediate level of complexity given that (i) extremely simplified landscapes are devoid of population sources and therefore do not allow possible re-colonisation; and (ii) the implementation of local conservation measure in more complex landscapes does not increase the species pool which is already high because of the complexity of the landscape (but see Allouche et al., 2012).

The effects of organic farming system on biodiversity have been, however, mainly investigated on birds, plants and insects in temperate grasslands and crops. Consequently, general results and ensuing recommendations may be not applicable to other taxa and other agricultural systems, especially those located in different bioclimatic regions (Tuck et al., 2014). Thus, there is a crucial need to re-assess the effectiveness of organic farming in non-temperate agroecosystems, especially in those located within biodiversity hotspots for conservation priorities (Myers et al., 2000), and to investigate the role of landscape characteristics in such systems.

Despite their roles as bioindicators and in pest suppression in agricultural areas (Jones et al., 2009; Boyles et al., 2011), insectivorous bats have been overlooked in studies assessing the effects of different agricultural management practices (Park, 2015). In Europe, little information is available for the Mediterranean basin, yet the area supports the highest bat species richness (Rebelo et al., 2010). In fact, only two studies reported the benefit of low-intensive management on bat activity and richness and these were restricted to olive groves (Davy et al., 2007; Herrera et al., 2015). While vineyards represent one of the main crop systems in several parts of the Mediterranean basin (e.g., in France 10.4% of lands located in the Mediterranean bioclimatic area are covered by vineyards), evidence on how bats may be affected by farm and landscape management in vineyard-dominated landscapes is lacking. At the farm scale, we could expect that organic farming would harbour more insect prey (Wickramasinghe et al., 2004), thus enhancing bat activity and species richness over organic fields (Wickramasinghe et al., 2003). At a broader scale, the presence of other foraging habitats (e.g., water bodies, forests) and roost sites (e.g., trees with cavities, man-made structures) are very likely to influence bat habitat use in vineyards (Rainho and Palmeirim, 2011). Given that populations of bats showed substantial declines during the second part of the 20th century partly due to the loss of foraging and commuting habitats within the agricultural matrix (Hutson and Mickleburgh, 2001), it is important to better understand bat-habitat relationships in vineyards to provide evidence-based conservation actions in these extensive habitats.

In this study, we aimed to determine whether organic farming is an efficient measure for enhancing bat activity and richness in Mediterranean vineyards. Our first objective was to disentangle the effect of landscape characteristics, farming system (organic vs. conventional) and vineyard structure on bat activity and species richness in order to provide adequate management recommendations. Given that bats are highly mobile and therefore capable to move across the landscape, we tested whether landscape features would be the main driver of bat activity and species richness in comparison to species with low-mobility which we hypothesized would be mainly affected by local management (Gonthier et al., 2014). We therefore used arachnids in addition to bats as biological models to test these hypotheses. Arachnids have a lower dispersal ability and home range size but like bats they occupy high trophic levels and may play a role in the suppression of pest populations (Marc et al., 1999), especially in vineyards (Emerit, 2011a; Drieu and Rusch, 2017). Furthermore, they may also be a good bioindicator taxon given their sensitivity to ecological change (Pearce and Venier, 2006; Gerlach et al., 2013). Our second objective was to investigate to role of landscape complexity in moderating the effect of organic farming on bats. We tested the "intermediate landscape-complexity" hypothesis (Tscharntke et al., 2012) using bat activity and