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Local and landscape drivers of butterfly richness and abundance in a human-dominated area

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ABSTRACT

In Europe, butterflies have declined over the last decades mainly because of the increasing urbanization and the agricultural intensification occurred in lowlands areas. Drivers of butterfly decline were identified in changes of both local scale habitat characteristics and landscape-scale land-use coverage. Thus, to counteract the negative trend of butterfly populations, management actions that simultaneously have an effect on local and landscape scale environments are needed.

The present research was performed in northern Italy, in a human-dominated area of about 170 km^2. From April to September 2014 and 2015, we surveyed butterflies in 494 50-m sections, grouped into 44 line transects. First, using a multi-scale GAMM, we analysed the simultaneous effect of local (nectar index, crop type, presence of woodlands and hedgerows and degree of shelter) and landscape (fractional cover in 500-m buffer of arable lands, meadows, woodlands and artificial surfaces) variables on butterfly richness and abundance. We evaluated the contribution of local and landscape variables by a variation partitioning approach. Second, we performed a GAMM to investigate the effect of specific management practices adopted in meadows, hedgerows and field margins on butterfly communities. Our results showed that the evaluation of the effect of local scale characteristics on butterfly communities definitely cannot disregard the landscape context. We thus suggest maintaining urban and agricultural areas alternated by a mosaic of nectar-rich land-covers, such as meadows and alfalfa, forest patches and hedgerows.

Our study also allowed to formulate management guidelines of specific habitats. Accordingly, meadows should be managed by reducing the number of cuts, while wide herbaceous margins, characterised by a high grass layer rich in dicots, should be maintained in arable lands. To avoid a barrier effect and to guarantee the presence of a well-developed shrub layer, which provides high nectar resources, it is also necessary to avoid an excessive growth in hedgerows height. Results evidence that the adoption of these management guidelines and of a proper landscape planning strategy, can lead to play an important role in butterfly conservation even within human dominated areas.

1. Introduction

Human activities are by far the most important cause of landscape changes, especially in areas originally dominated by forests (Bengtsson et al., 2000). However, not all human-induced changes have had a negative effect on habitats and wildlife. For instance, many species have taken advantage of the diversification generated by human exploitation of natural habitats, which has created many open areas at the expense of woodlands (Foster and Motzkin, 1998; Navarro and Pereira, 2015). This is particularly true for several taxa of invertebrates (Bignal and McCracken, 2000; Loos et al., 2014), which easily profit by the new landscape pattern because of their fast-responding ability to habitat changes (Kremen et al., 1993).

Anthropogenic impact has drastically worsened in Europe during the last century, and especially in the last decades. In lowland areas, urban sprawl and intensification of agricultural practices have generated a new kind of landscape, increasingly poor in natural elements, and dominated by the human footprint (Stoate et al., 2009, 2001). In these contexts, the natural and semi-natural elements that act as a refuge for invertebrates (Bubová et al., 2015; Öckinger et al., 2009; Samnegård et al., 2011; Wood and Pullin, 2002) and many other taxa (Ambrosini et al., 2011; Bani et al., 2017, 2009; Benton et al., 2002; Dondina et al., 2017b) have decreased. Therefore, even those taxa that formerly benefitted from human modifications of the original forest landscapes are now under threat (Benton et al., 2003; Van Dyck et al., 2009).

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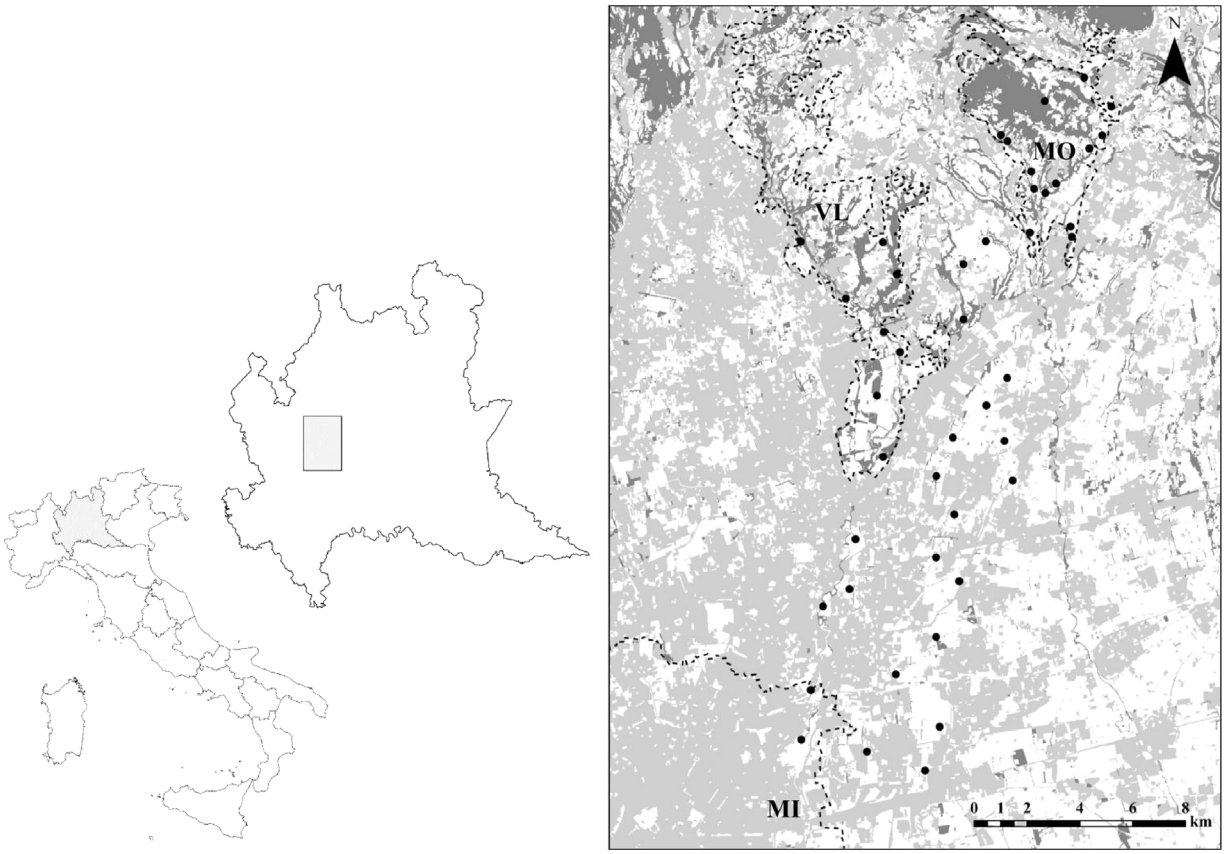

Fig. 1. Study area. From left to right: the location of the study area in Northern Italy and in the Lombardy region (45°37'N 9°19'E). Black dots: location of the survey transects. Background: land cover map (light grey: artificial surfaces; dark grey: forests; white: all other cover types). Black dashed lines: boundaries of the municipality of Milan (MI) and of the protected areas (VL: Valle del Lambro Regional Park; MO: Montevecchia e Valle del Curone Regional Park).

The degree of suitability of human-dominated landscapes for invertebrates depends on the amount and the spatial arrangement of the residual natural or semi-natural habitats, such as urban green spaces in built-up areas or meadows and hedgerows in intensive agricultural areas (Thomas and Hanski, 1997). In this context, the suitability of residual natural or semi-natural habitats largely depends on their correct management by humans. Indeed, inadequate management practices (e.g. frequent mowing and trampling of meadows) often lead to the decline in quality of refuges that could be potentially suitable for several species (Bubová et al., 2015; Garratt et al., 2017).

Among invertebrates, butterflies are one of the taxa most sensitive to the intensification of the human impact on ecosystems (Gross, 2016; Van Swaay et al., 2016). Many studies have showed how butterflies are negatively affected by the alteration of specific local conditions, such as nectar resources and host plants (Clausen et al., 2001; Curtis et al., 2015; Dover et al., 2000; Pywell et al., 2004; Sparks and Parish, 1995), while other studies highlighted that the composition of butterfly communities can also be strongly affected by landscape characteristics, such as the overall amount of residual habitats (Bergerot et al., 2011; Dover and Settele, 2009; Öckinger and Smith, 2006; Öckinger et al., 2012, 2009).

For these reasons, among invertebrates, butterflies are good model organisms for identifying the correct habitat management and landscape planning guidelines to counteract the negative effect of anthropic modifications, acting simultaneously at different spatial scales (Marini et al., 2009; Olivier et al., 2016).

Although the importance of a multiscale approach is widely recognised in ecology, many studies did not used a multiscale analysis (McGarigal et al., 2016). Even in butterfly studies, only recently some authors started to adopt a multi-scale approach. For instance, Loos et al. (2014) and Olivier et al. (2016) performed single-level multi-scale analyses, evaluating the effect of the same variables at different spatial scales, in order to identify the one that best explains the observed distribution of butterflies.

In this research, we analysed butterfly communities in a human-dominated area with the purposes of identifying the spatial scale at which environmental characteristics mostly affect butterfly distribution and of suggesting the proper habitat management practices to guarantee butterflies long-term conservation. We adopted a multi-level approach by combining two different groups of environmental variables, each acting at a specific spatial scale (local or landscape), in a multivariable multi-scale model (*sensu* McGarigal et al., 2016) to explain the variability of butterfly species richness and abundance. In the first group of variables we included local habitat characteristics that could directly affect the complex life cycle of Lepidoptera by conditioning the availability of different plant species, exploited as host and/or nectar plants by butterflies (see Bubová et al., 2015; Curtis et al., 2015). In the second group, we considered the landscape cover of multiple land-use categories, which could play a critical role affecting dispersal processes, thus determining the composition of invertebrate communities (Di Giulio et al., 2001) and specifically of butterflies, (Dover and Settele, 2009; Öckinger and Smith, 2006)

Finally, we analysed the effect of the number of meadow cuts and of the composition and structure of herbaceous margins and hedgerows along crop fields, to provide, beyond the proper spatial scale, practical suggestions to manage agricultural areas in a butterflies-friendly way.

All the analyses were performed considering both the whole community of butterflies and homogeneous functional groups based on species-specific ecological traits, which are known to affect the response of animal communities to environmental modifications (e.g. Dondina et al., 2017a; Kuussaari et al., 2007; Melero et al., 2016).