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Review

Winners and losers of organic cereal farming in animal communities across Central and Northern Europe

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ABSTRACT

Organic farming is promoted as a sustainable alternative to conventional farming, with positive effects on the diversity of plants and selected animal taxa. Here, we used a literature survey to collect presence/absence data on the composition of farmland bird, ground beetle, spider as well as butterfly and moth communities from 28 independent studies to identify genera and (sub-)families that had either higher (winners) or lower (losers) species richness under organic farming. We further tested if the taxonomic breadth of communities and the number of species of conservation concern differed between farming systems and if climate or fertilization intensity altered responses of animal communities to organic farming. Our results suggest that there are both winners and losers of organic farming and that this effect depends on whether taxa are predaceous (losers) or exclusively feed on plant material (winners). Organic farming did not lead to a higher number of exclusive species, but significantly more species of conservation concern were observed under organic farming. Organic farming consistently led to a slightly higher taxonomic breadth of bird communities. Finally, we did not find support that local long-term climatic conditions or differences in fertilization rates between farming systems altered the effect of organic farming. Overall, we did not find strong support for general positive effects of organic farming on animal diversity in the analysed groups across Central and Northern Europe.

Contents

1. Introduction

Support for organic farming is one of the most well-established agri-environment schemes in the European Union that aims at contributing to a more sustainable agricultural production (e.g.

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Pimentel et al., 2005). In Europe, 10.6 million hectares of agricultural land were certified as organic agriculture in 2011, constituting 2.2% of the total agricultural area in the region (Willer et al., 2013). In terms of biodiversity conservation, the proposed advantages of organic farming are the prohibition of pesticide and synthetic fertilizer application, sympathetic management of non-crop elements in landscapes and more diverse crop rotation schemes (Hole et al., 2005). Several reviews have previously summarized effects of organic farming on species richness and abundance patterns of plants and animals (Bengtsson et al., 2005; Hole et al., 2005; Gomiero et al., 2011; Rahmann, 2011). Recently, Winqvist et al. (2012) added a first synthesis about the effects of organic farming on species richness in a landscape context (see also Batáry et al., 2011; Tuck et al., 2014). The overall conclusion of these reviews is that species richness benefits from organic farming in many taxa ("winners" of organic farming), with particularly strong effects on plant and pollinator species richness (Tuck et al., 2014). However, there are exceptions from these patterns in animal groups such as spiders (reviewed in Birkhofer et al., 2013) or ground beetles (reviewed in Birkhofer et al., 2012), which may even show higher species richness or abundance under conventional management ("losers" of organic farming). The claim that agri-environment schemes contribute to the conservation of biodiversity on farmland has been challenged (Henle et al., 2008; Kleijn et al., 2009, 2011). We suggest that addressing three additional aspects of the response of animal communities to organic farming may be relevant to better understand the role of this popular agri-environment scheme for biodiversity conservation.

First, studies that focus on species richness within higher levels of the taxonomic classification (e.g. species richness in the insect order Lepidoptera) may miss important details that could improve recommendations for the conservation of species (see also Kleijn et al., 2011). In contrast, measuring species richness within lower levels of the taxonomic hierarchy (e.g. species richness in individual Lepidoptera genera) may offer much more information on biodiversity effects of organic farming. In addition, whether organic farming increases the number of species of conservation concern is generally not well-documented (Kleijn et al., 2011). From a practical perspective, protection of all species at a high taxonomic level may not be a desired outcome of organic farming. The beetle family Carabidae and the insect order Lepidoptera for example include species for which conservation efforts may (e.g. carnivorous ground beetles as natural enemies, Kromp, 1999 or butterflies as pollinators, Proctor et al., 1996; see also Vessby et al., 2002) or may not (e.g. granivorous ground beetles as crop seed predators or moth species as agricultural pest, Alford, 2011) cause problems to agricultural production (Letourneau and Goldstein, 2001). Given the evidence for positive effects of organic farming on plant diversity and abundance (Gabriel et al., 2006; Ekroos et al., 2010; Klaus et al., 2013a), it seems plausible that animals respond to organic farming according to the strength of their reliance on plant species (Power and Stout, 2011), that are either utilized as food resource (Clough et al., 2007) or as structural elements (Diehl et al., 2012). This assumption is partly supported by the well-documented positive effect of organic farming on pollinator species richness (Tuck et al., 2014). Organic farming has been proposed to contribute to reducing the loss of biodiversity due to agricultural intensification (Gomiero et al., 2011) and may therefore particularly contribute to the conservation of species that are otherwise threatened by conventional management. It is important to understand if organic farming holds a high potential to conserve animal species compared to conventional farming and to better understand the functional role and the conservation status of winners.

Second, the degree of relatedness between species in a community is an additional aspect of diversity that is neglected in most biodiversity studies (Purvis and Hector, 2000). Communities with equal numbers of species can still differ in diversity if, for example, one community consists of taxonomically more closely related species than another (Clarke and Warwick, 1998).This is particularly true for groups with converging ecological traits (e.g. Beltrán et al., 2012), as the functional role of closely related species in these communities resembles each other and species may therefore show similar responses to organic farming. Web-building spiders for example show a high level of phylogenetic conservatism for web-types and more closely related species often have similar habitat needs in terms of structural properties for web attachment (Diehl et al., 2013). These species are therefore more likely to be affected by the same type of disturbance than more distantly related species. Even though our understanding of the meaning of taxonomically or phylogenetically broader communities in terms of their relationship to anthropogenic stress is still limited we may gain important insights from such comparisons (Polasky et al., 2001). Organically managed fields can be expected to be richer in terms of resources and structural properties compared to conventionally managed fields (Birkhofer et al., 2011). A higher availability of niches may increase diversity by increasing the taxonomic breadth of communities without an effect on species richness simply due to species turnover (e.g. Zintzen et al., 2011). The comparison of the taxonomic breadth of communities under organic and conventional management will therefore improve our understanding of whether or not the loss of species in response to stress depends on the relatedness between species. This aspect has implications for conservation strategies that also aim for the maintenance of ecosystem services, as more closely related species may also be functionally more redundant (e.g. Flynn et al., 2011).

Third, the effect strength of organic farming on diversity may be driven by differences between study regions (Winqvist et al., 2012). At least three non-exclusive explanations are available as to why effects of organic farming may vary with study location: (a) the size of the species pool or the composition of communities in a region may differ because of climatic differences (e.g. Entling et al., 2007; Heller and Zavaleta, 2009), (b) the size of the species pool and the composition of communities in a region may differ because of differences in landscape complexity (e.g. Roschewitz et al., 2005; Rundlöf and Smith, 2006) or land-use history (Klaus et al., 2013b) and (c) the contrast in management intensity between organic and conventional farming systems may differ between regions (e.g. Bengtsson et al., 2005; Rundlöf and Smith, 2006; Kleijn et al., 2011). In the first and second case, a larger species pool in a particular region may provide a higher chance to attract more species by less intensive farming, compared to a region with an overall smaller species pool. In the third case, studies in regions with a stronger contrast in intensity between organic and conventional farming may result in a more pronounced difference in diversity. Analysing the dependence of the effect of organic farming on species richness and taxonomic breadth across regions will therefore contribute to an improved planning of conservation efforts at larger spatial scales.

We analysed the community composition of farmland birds, ground beetles, spiders and butterflies and moths using species richness values at the genus and (sub-)family level from 28 independent studies that compared diversity under organic and conventional management. From these analyses we identified winners and losers of organic farming at a scale ranging from Central to Northern Europe with particular emphasize on the feeding ecology and the conservation status of species in these taxa. In addition to species richness, we analysed effects of organic farming on the taxonomic relatedness between species and analysed if differences in climate or land-use intensity alter the effect strength of organic farming. Our hypotheses were that organic farming: (a) leads to genera and (sub-)families with higher species richness (winners) and that more species occur exclusively under organic