Bridging the gap between scientific knowledge and practice: how can we assist organic farmers in sustaining wild bees and pollination on their farms?

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Abstract

Wild bees (bumblebees and solitary bees) are declining in Denmark as in the rest of Europe, resulting in reduced yield stability in insect pollinated crops and insufficient pollination of wild plants. Farmers are the most important actors influencing wild bee conditions in farmland, and organic farmers are especially attentive to pollination due to both production stability and biodiversity in general. Therefore the challenge is to provide farmers with tools to evaluate their farm for its quality for wild bees, thus offering an option to be proactive in improving on farm bee conditions. The tool proposed in this paper is a science based scoring system, based on an existing scientific model linking resources and wild bees on landscape level and modified to the Danish context. The tool guides farmers through an field estimation of nesting and flower resources on the farm during the season. Development of the tool is done in collaboration with organic red clover seed producers and apple growers, who test the tool and offer feedback on user friendliness to adjust the tool. Farmer use of the tool will increased trust and improve yield stability in insect pollinated crops.

Introduction

Wild bees (bumblebees and solitary bees) are two important groups of wild pollinators in temperate zones, delivering pollination services to crops and wild plants. It is well documented that wild bees are declining nationally and regionally in Europe (Biesmeijer et al., 2006) threatening crop pollination estimated to 14 mia. euro/year. Wild bees are dependent on presence of high quality flower resources and on suitable nesting and overwintering sites locally (Strandberg et al., 2011). In the agricultural landscape, availability of these resources depend on land use, i.e. distribution between arable land and uncropped areas, crop distribution and management as well as quantity and quality of permanent grasslands, hedgerows, road verges, etc. Although organic farms have the potential for harboring wild plants with high flower intensity due to absence of herbicides and crop distribution (Henriksen et al., 2013), organic farms in practice vary highly in availability of food and nesting resources temporally and spatially.

Establishing general measures to improve conditions for wild bees on organic farms is not simple. Wild bees use a range of floral resources including agricultural crops such as red clover, field bean, apple etc., in addition to wild flowers and ornamental plants. Foraging and nesting requirements are species specific which means that different species of bees are associated with different habitats and plant species. Although foraging distances vary from a few hundred meters to up to several kilometers, most wild bees forage on a local scale, often less than 300 m from the nest (Osborne et al., 2008). Flower resources and nesting sites are unevenly distributed spatially and temporally and resources in one year may affect populations the following year. However, for organic farmers with insect pollinated crops like seed crops, seed legumes and tree fruit pollination is a key issue and they face the risk of yield reduction due to insufficient pollination. In many agricultural contexts these high value crops form the economic base of organic arable farmers, and securing yield stability and decreasing risk is of outmost importance. For these crop types, the importance of wild bee pollination ranges from being vital (red clover seed, apples) to being supplementary to honey bee pollination (field beans) but in general yield stability and quality is improved by wild bee pollination (Garibaldi et al., 2013). Thus, farmers have a strong motivation to improve living conditions for wild bees. Farmers with insect pollinated crops often depend on managed honey bees for pollination. However a decline in honey bee keeping in Europe (Potts et al., 2010) and reports on Colony Collapse Disorder (Vejsnaes et al., 2010) indicate that pollination of crops by honey bees may become insufficient. Furthermore recently it has been shown that pollination by wild insects increase crop yield independent of honey bee abundances (Garibaldi et al., 2013).

Most available scientific knowledge on wild bees in agricultural landscapes has focused on certain species or groups in specific contexts and thus offers valuable pieces of knowledge to the picture. However making the existing knowledge operational for farmers and policy makers is difficult but nonetheless required, taking the

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urgency of the problem into account. In this paper we will present an example of the type of fragmented results which are available and discuss whether and how this type of scientific knowledge may be applied in practice and be brought into action. .

Material and methods

Two groups of wild pollinators of importance in temperate zones, bumblebees and solitary bees, were trapped (pan traps) in road verges bordering 14 organic (organic sites) and 14 conventional (conventional sites) winter wheat fields. Pairs of organic and conventional were located in agricultural landscapes with similar proportions of semi-natural habitats in a circle with radius 1 km around the sampling site, ranging from 10 to 42%. The quantity and quality of local flower resources in the road verge and adjacent field headland were estimated as overall density of dicotyledonous herbs in the flowering stage (quantity) and density of plants containing combined high pollen and nectar amounts (quality). Potential flower and nesting resources in the surrounding landscape were assessed using semi-natural habitats as a proxy at four different scales (for details see Henriksen,2013).

Results and discussion

As shown in many other studies the organic farming system had a positive effect on plant species richness and density of plants and thus on the overall flower resources for bees. Here, also the quality of the flower resource for bees were assessed, and the availability for bees of species evaluated as "high value bee plants" in the flowering stage were significantly higher in both wheat fields and road verges in organic sites compared with the conventional sites. This shows that organic farming practices not only enhance species richness and the quality of the flower resource (high value bee plants) in the arable field, but also contribute to creating a more diverse and higher flower quality in adjacent uncropped habitats (here road verges) compared with the conventional farming system. The more abundant flower resources in organic wheat fields, mostly originating from annual weeds, contributed to the greater numbers of individuals and species of solitary bees in the organic farming system, as solitary bees exploited the flower resources at short distances from the nest. In contrast bumblebees did not respond positively to organic compared with conventional farming, but higher numbers of individuals and species was seen with increasing proportion of semi-natural habitats in both organic and conventional sites at 1000 m scale (figure 1). The lack of response by bumblebees to organic management of arable fields was probably seen because bumblebees depend more on flowers of perennial plants found in semi-natural habitats and the flower resource of mostly annual plant species in organic arable fields play a minor role for this group. Also the solitary bees benefitted from a higher proportion of semi-natural habitats, as this resulted in increased number of individuals and number of species at smaller spatial scale than the bumblebees (250 m and 500 m scale) at both organic and conventional sites.

The results from our study exemplifies the type of data currently available on wild bee conditions and responses. They all offer a small piece of the picture but are difficult to make operational and use for targeted actions. If the goal is to provide organic farmers with practical tools, thus offering an option to be proactive in improving on farm bee conditions, one way to proceed is to attempt to develop an assessment tool. It must be science based but pragmatic, acknowledging that our knowledge is detailed, but fragmented. Recently existing knowledge has been integrated into a predictive model, which link land use on farm scale with pollinator requirements to predict pollinator abundance and pollination (Lonsdorf et al., 2009). In a planned project, we hope to modify this model to create a science based assessment tool for farmers. The tool would be made to guide farmers through a field estimation of nesting and flower resources on their farm during the season, and the development, user tests and validation will be done in collaboration with motivated organic farmers, e.g. clover seed producers, apple growers and field bean producers. If successful, such a tool could make the best available knowledge accessible for organic farmers in a robust form and facilitate improvements for wild bees, crop pollination and help document biodiversity benefits of organic farming practices.
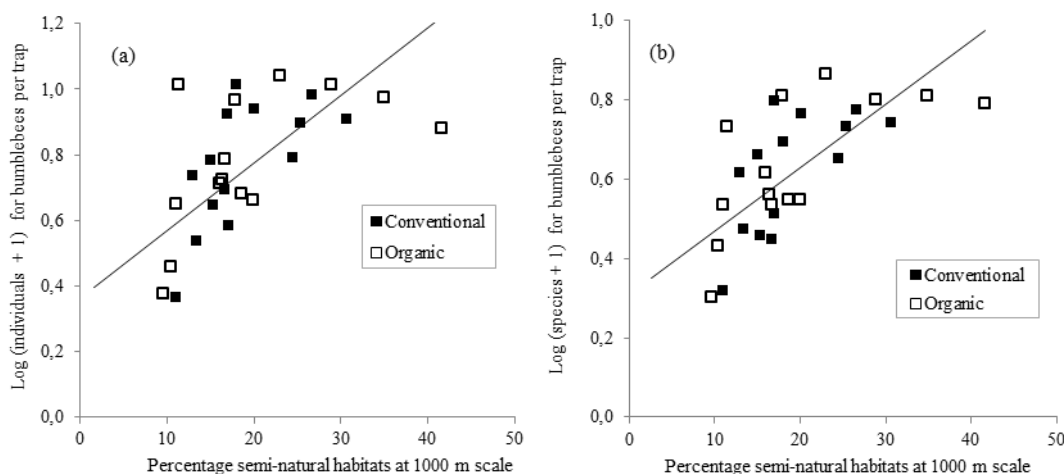
Fig. 1. Effect of semi-natural habitats at 1000 m scale on (a) number of individuals and (b) species of bumblebees.

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