Agriculture, Ecosystems and Environment 243 (2017) 55–66

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

The impact of crop parameters and surrounding habitats on different pollinator group abundance on agricultural fields

K. Brandt[a,b,e,*], M. Glemnitz[a], B. Schröder[c,d]

[a] Leibniz Centre for Agricultural Landscape Research (ZALF), Institute of Land Use Systems, Eberswalder Str. 84, D-15374 Müncheberg, Germany
[b] University of Potsdam, Institute of Earth and Environmental Sciences, Karl-Liebknecht-Str. 24/25, D-14476 Potsdam, Germany
[c] Technische Universität Braunschweig, Institute of Geoecology, Division of Landscape Ecology and Environmental Systems Analysis, Langer Kamp 19c, D-38106 Braunschweig, Germany
[d] Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, Germany
[e] Thünen Institute of Biodiversity, Bundesallee 50, D-38116 Braunschweig, Germany

ARTICLE INFO

Article history:
Received 12 September 2016
Received in revised form 2 March 2017
Accepted 8 March 2017
Available online xxx

Keywords:
Species distribution models
Generalized linear models (GLMs)
Environmental drivers
Habitat suitability
Pollinator conservation
Wild bees

ABSTRACT

Pollination is a key ecosystem service. Pollinators, however, are in decline and their service is increasingly threatened. The decline is driven by several factors, most of which are related to agricultural management. However, the complexity of the landscape system, consisting of both cropped and non-cropped areas, makes it difficult to address or even quantify the role of farming practices in pollinator abundance. Therefore, the aim of this paper is to improve our understanding of the relationships between pollinator abundance and their habitat use. We intend to identify and quantify the driving environmental factors that determine pollinator abundance in agricultural landscapes on the crop and landscape scale. These information helps us to design algorithms that can be used as a basis for predicting pollinator abundance on agricultural fields. To integrate varying environmental conditions data sampling was performed on farms in three different regions in Germany. Pollinators were classified into different groups with three aggregation levels. We observed crop parameters as well as landscape parameters in the areas surrounding fields in addition to temporal aspects. Generalized linear models (GLMs) were then calculated. Our results showed that both crop and landscape parameters affect pollinator abundance on agricultural fields. However, the explanatory power of the included parameters varied strongly among the particular pollinator groups and between aggregation levels. Furthermore, differentiation between species groups improves the explanatory power compared to models that are more aggregated. We also found that the temporal match between main activity periods of the particular pollinator groups and resource supply by the crop species is a key factor when analysing pollinator abundance. In conclusion, we demonstrated that the assessment and support of pollination services should be carried out with regard to individual pollinator groups. When studying pollinator abundance, the crop as well as the landscape scale should be addressed. A range of different habitat requirements and different activity periods of the pollinator groups must be covered to maintain pollination services, and therefore both diverse landscapes and diverse crop rotations are of crucial importance.

1. Introduction

Due to their strong impacts on pollination services, pollinators are prime examples for describing the role of biodiversity for human wellbeing (Kremen et al., 2007; Serna-Chavez et al., 2014). Pollination by wildlife insects has identified as serious impact on global crop production which was shown in general (Klein et al., 2007), for crops being restricted by pollinators (Schulp et al., 2014) and as factor impacting yield level of the crops (Garibaldi et al., 2013). Several studies have even calculated the economic benefit of pollination in terms of monetary value (Leonhardt et al., 2013; Gallai et al., 2008).

Substantial declines of honey bees (*Apis mellifera*) and wildlife pollinators of different taxa have been reported by numerous studies worldwide (e.g., Potts et al., 2010; Goulson et al., 2015; Cameron et al., 2011). The decline is driven by several factors, including agricultural intensification, land use change with

* Corresponding author at: Thünen Institute of Biodiversity, Bundesallee 50, D-38116 Braunschweig, Germany. Tel.: +49 531 596-2587
E-mail address: karoline.brandt@thuenen.de (K. Brandt).

http://dx.doi.org/10.1016/j.agee.2017.03.009
0167-8809/

resulting habitat loss and fragmentation, reduction of landscape structures, climate change (Potts et al., 2010; Mayer et al., 2011) and pressures from pests and pathogens such as *Varroa* mites and the microsporidia *Nosema* (Genersch, 2010; Cameron et al., 2011). The application of neonicotinoids, a class of insecticides, is also one of the major causal factors of bee declines (e.g., Goulson, 2013; Henry et al., 2012; Marzaro et al., 2011). Additional pressures on wildlife taxa arise from the continued loss of semi-natural refuge habitats (e.g. Banaszak et al., 2015; Öckinger and Smith, 2007), which serve as food resources or reproductive habitat for pollinators. Kremen et al. (2004) found a strong positive correlation between stability and predictability of crop pollination and increasing natural habitat area.

Whereas semi-natural habitats are known to be key features for high pollinator diversity and abundance in landscapes (Klein et al., 2012; Kohler et al., 2008), arable land was for a long time only regarded as space between the favoured habitats ("matrix") (McIntyre and Hobbs, 1999) or even as a barrier isolating communities in semi-natural-habitats (Steffan-Dewenter and Tscharntke, 1999). Within the last few years the "matrix quality" was discussed as determinant factor (Garibaldi et al., 2013; Kennedy et al., 2013) for pollinator abundance. Most investigations in this context resulted in interactions between landscape heterogeneity and farming practice (Andersson et al., 2013; Kennedy et al., 2013; Jauker et al., 2009) and/or differentiated effects of farming systems on single pollinator groups or genera (Stanley and Stout, 2013; Jauker et al., 2009). Investigations dealing with single pollinator groups or specific habitat features of crop species often yield contradictory results and conclusions. If grown with mass-flowering crops, arable fields may cause pollinator dilution that threatens wild flower pollination (Holzschuh et al., 2011). On the other hand, Westphal et al. (2003) recovered positive effects of mass flowering crops on bumblebees at the landscape scale. In addition, Sardiñas and Kremen (2015) detected vice versa a positive impact of adjacent hedgerows on pollination services in mass flowering crops.

Summarizing the current findings, it appears that it is difficult to assess or quantify the effects single factors like farming practices – as, e.g., crop species changes – on pollinator populations due to the interactions between cropped and non-cropped areas and taxon-specific responses. Andersson et al. (2013) suggested investigations beyond species richness to uncover the consequences of agricultural intensification. Stanley and Stout (2013) demonstrated that an assessment of the impact of different crops on the abundance of pollinators cannot be based on a small suite of taxonomic groups. Generalizations are difficult to obtain, and therefore it is important to include a range of taxa to generate overarching, general results. An improved understanding of the interdependencies of driving forces is essential for the development of meaningful strategies to halt pollinator losses and to exert influence on recent agricultural developments in Europe such as the promotion of energy cropping.

Bioenergy cropping is regarded as major recent threat to biodiversity in general (Leadley et al., 2010; Robertson et al., 2012), but also offers new options for the diversification of the agricultural practice (Pedroli et al., 2013). Overall, currently little empirical evidence is available on the effects of energy crops on biodiversity (Pedroli et al., 2013).

In this paper, we present a methodological approach that addresses the impact of crop selection and the design of crop rotations while considering variation due to the surrounding landscape context. For this purpose, we differentiate between the demands of different pollinator groups while comparing and quantifying both environmental parameters on the crop and on the landscape level. In our analysis we focused on hoverflies and bees, the most abundant groups with the most economic significance for pollination (Kremen et al., 2007). Butterflies, which are also a group of pollinators, were not considered in this study. Drivers for pollinator occurrence and abundance are usually assessed in an isolated way, but interactions between these drivers at different scales are mostly unknown (Mayer et al., 2011; Potts et al., 2010). We perform statistical modelling to overcome this shortage and to disentangle field- and landscape-level effects within one framework. Species distribution models estimate species occurrence and abundance probabilities from species distribution data and a set of environmental predictor variables (Elith and Leathwick, 2009). They allow us to identify and quantify the important environmental factors so that habitat requirements of species can be derived and can be used to predict occurrence probabilities and abundance patterns under certain circumstances (Schröder and Seppelt, 2006; Guisan and Thuiller, 2005). Thus, predictions of species abundance regarding changing conditions such as land use changes can be made. Our paper aims to design algorithms that can be used as a basis for predicting pollinator abundance and thus enable the comparison and assessment of different cultivation systems at both the crop and landscape scale with regard to their habitat quality for pollinators.

Little is currently known regarding how changes in land use and agricultural management at the plot scale affect pollinator populations and thus pollination services at larger scales, and a better understanding of the relationships between pollinator abundance and their habitat use is needed to assess these affects. This knowledge would help farmers respond to pollinator requirements and therefore help maintain their own economic basis (pollination). Therefore, the objective of this study was to identify and quantify environmental factors driving the abundance of pollinators in the agricultural landscape. We hypothesize the following:

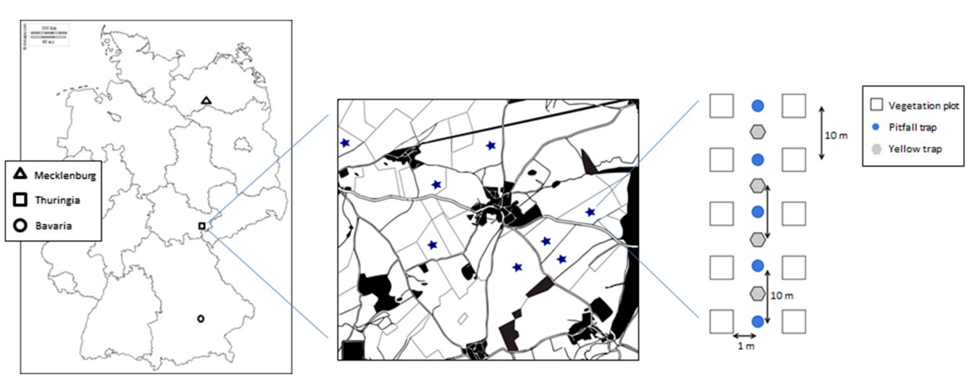

Fig. 1. Location of study sites and transect design example for the study area in Thuringia.