Agriculture, Ecosystems and Environment 229 (2016) 21–29

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

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

Spatiotemporal changes in flying insect abundance and their functional diversity as a function of distance to natural habitats in a mass flowering crop

Benoît Geslin[a,b,*], Melissa Oddie[c], Morgane Folschweiller[b,d], Gaëlle Legras[b,e], Colleen L. Seymour[f,g], F.J.Frank van Veen[c], Elisa Thébault[b]

[a] Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE), Aix Marseille Université, CNRS, IRD, Avignon Université, Faculté des Sciences et Techniques St-Jérôme, Avenue Escadrille Normandie Niémen, Case 421, F-13 397 Marseille Cedex 20, France
[b] CNRS, Sorbonne Universités, UPMC Univ Paris 06, INRA, IRD, Paris Diderot Univ Paris 07, UPEC, Institute of Ecology and Environmental Sciences of Paris (IEES Paris), 7 quai St Bernard, F-75252 Paris, France
[c] Centre of Ecology and Conservation, College of Life and Environmental Sciences, University of Exeter, Penryn Campus, Penryn, Cornwall, TR10 9FE, UK
[d] Laboratoire de Zoologie, University of Mons, Mons, Belgium
[e] University of French Polynesia – UMR-241 EIO (UPF, IRD, Ifremer, ILM) Papeete, French Polynesia
[f] South African National Biodiversity Institute, Kirstenbosch Gardens, PVT Bag X7, Claremont, 7735, South Africa
[g] DST/NRF Centre of Excellence at the Percy FitzPatrick Institute of African Ornithology, Department of Biological Sciences, University of Cape Town, Rondebosch 7701, South Africa

ARTICLE INFO

Article history:
Received 25 June 2015
Received in revised form 5 May 2016
Accepted 10 May 2016
Available online xxx

Keywords:
Body size
Flower-visitors
Functional diversity
Isolation from natural habitat
Mangoes
Morphological traits
Wing span

ABSTRACT

To meet the dietary requirements of a burgeoning human population, the demand for animal-dependent crops continues to grow. To meet the demand, intensive farming practices are used. The gains in food production associated with agricultural intensification may be offset by its detrimental effects on pollinator populations through natural habitat fragmentation and pesticide use. Abundance and species richness of pollinators have been found to decrease with increasing distance to natural habitat in agroecosystems, reducing crop yields. A key aspect of crop pollination lies in the diversity of functional traits (functional diversity, FD) of flower-visitor communities within crop fields. Higher FD allows improved pollination success through complementarity between flower-visitors' morphology, phenology and behaviour. Many studies reported negative effects of increasing distance to natural habitats on the abundance and richness of flower-visitor communities, but the link between FD and natural habitat isolation is less well understood. Also, a more complete understanding of the functional traits of flower-visitor communities within crops should consider potential variations through time. Differences in resources availability between seasons are important in tropical areas and could modify ecological responses of flower-visitor communities to isolation. In this study, we surveyed the Hymenoptera and Diptera communities within mango orchards of South Africa using pan traps at 100 m, 200 m and at the maximal distance possible from any natural habitat. We measured the response of insect abundance, wing span and body size as well as functional diversity to habitat isolation during mango flowering (dry season), and during the wet season (after mango fruit harvest). Flying insect abundance decreased with increasing distance to natural habitat during mango flowering, but no effect was detected during the wet season. FD of flying insects declined with increasing distance to natural habitat in both sampling periods. Insects captured during mango flowering were smaller but had higher wing length/body length ratios than those caught during the wet season. This study highlights that mango orchards are more inhospitable for flying insects during mango flowering. This effect might be due to low palatability of mango flowers, or pesticide use in mango fields. In order to maintain a high FD of flower-visiting species, and reduce the detrimental effects of habitat isolation to ultimately ensure better crop pollination, we propose establishment of patches of resource-rich habitats combined with judicious use of pesticides within orchards.

* Corresponding author at: Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE), Aix Marseille Université, CNRS, IRD, Avignon Université, Faculté des Sciences et Techniques St-Jérôme, Avenue Escadrille Normandie Niémen, Case 421, F-13 397 Marseille Cedex 20, France.
E-mail address: benoit.geslin@imbe.fr (B. Geslin).

http://dx.doi.org/10.1016/j.agee.2016.05.010

1. Introduction

To ensure nutritional security to a burgeoning human population, the demand for animal-pollinated crops is continually increasing (Eilers et al., 2011; Ehrlich and Harte, 2015). To meet this demand, agricultural production has intensified in recent decades through conversion of large areas to monocultures, with concomitant loss of natural and semi-natural areas, and increasing use of agrochemicals (Tscharntke et al., 2005; Kennedy et al., 2013). However, given the reported negative effects of agricultural intensification on pollinator populations (Kremen et al., 2002; Vanbergen et al., 2013), the benefits of intensification for animal-pollinated crop yield might be negated by ensuing pollinator loss (Garibaldi et al., 2011a; Leonhardt et al., 2013; Deguines et al., 2014). By pollinating crops, insects provide a critical ecosystem service estimated to be worth more than €153 billion worldwide (Klein et al., 2003; Gallai et al., 2008; Winfree 2008). The decline of pollinators owing to agricultural intensification therefore raises concerns for food security (Aizen et al., 2008; Garibaldi et al., 2011a) and highlights the need for sustainable agriculture that ensures agricultural production whilst conserving biodiversity (Garibaldi et al., 2015, 2016).

In agricultural landscapes, natural areas provide habitat for wild insects and constitute sources of flower-visitors for crops (Kennedy et al., 2013; Morandin and Kremen, 2013). Many flower-visitors, such as bees, are central place foragers and usually visit plants close to their nests (Cresswell, 2000). As distant resources are more energetically costly to visit than proximate resources, it is predicted that flowers isolated from natural areas will be less frequently visited (Schmid-Hempel et al., 1985; Schmid-Hempel and Schmid-Hempel, 1986; Steffan-Dewenter and Tscharntke, 1999). In croplands, species richness of flower-visitors, visitation rates, and pollination services all tend to decline with distance to natural areas (e.g. Ricketts et al., 2008; Carvalheiro et al., 2010; Garibaldi et al., 2011b). Whether or not flower-visitors disperse from natural habitats into the adjacent crop depends on many factors such as floral resource abundance, floral reward level or type of management (e.g., Kennedy et al., 2013). In this respect, pollinator functional traits can be key. Most studies on the effect of distance to natural patches of vegetation have not considered flower-visitor traits or their functional diversity (e.g. Ricketts et al., 2008; Farwig et al., 2009; Carvalheiro et al., 2010, 2012; Garibaldi et al., 2011b; but see Jauker et al., 2009; Williams et al., 2010; Benjamin et al., 2014). Yet traits such as flower-visitor body size are likely to affect pollination success as these traits can influence insect behaviour, foraging distances and pollen deposition (Hoehn et al., 2008). For example, foraging distance is primarily dictated by pollinator body size, and small flower-visitors will forage closer to their nests (Araújo et al., 2004; Greenleaf et al., 2007; Benjamin et al., 2014). Moreover, several studies have shown that functional diversity (FD) of flower-visitor communities enhances pollination by providing complementary pollination services, for example through niche partitioning of resource use in time and space (Fontaine et al., 2006; Hoehn et al., 2008; Albrecht et al., 2012; Fründ et al., 2013). Studying the effects of isolation from natural areas on traits and FD of flower-visitors can thus shed light on the factors which affect both crop pollination and the persistence of diverse flower-visitor communities in agro-ecosystems, informing effective land management strategies (Williams et al., 2010; Benjamin et al., 2014).

Temporal dynamics of agricultural landscapes are also important. Cultivated areas exhibit particularly large temporal variations in floral resources which could affect flower-visitor communities (Westphal et al., 2003). Mass flowering crops such as mangoes (*Mangifera indica* L., Anacardiaceae) constitute a super-abundant floral resource during a short period of time, representing a resource pulse for flower-visitors (Orford et al., 2015). The relationship between increasing distance to natural habitat and flower-visitor communities has been mostly explored during crop mass flowering (e.g. Holzschuh et al., 2011) but negative effects of distance on flower-visitors are likely to be stronger when the crop is not flowering, because only flowering weeds then provide resources in cultivated fields. Seasonal variation of wild floral resources and flower-visitor communities also contribute to temporal variation of agroecosystems. Spatiotemporal turnover in flower-visitor assemblages varies between and within years in temperate and tropical ecosystems (Oertli et al., 2005; Rollin et al., 2015; Samnegård et al., 2015), with temporal changes in abundance or even functional traits of flower-visitors varying because of food and nesting requirements (Tylianakis et al., 2005; Rollin et al., 2015). Flower-visitor assemblages might respond differently to agricultural perturbations in different seasons (Samnegård et al., 2015). For example, in tropical environments, resources are more scarce and patchily-distributed during the dry season relative to the wet season. Greater mobility may therefore be advantageous to crop flower-visitors during the dry season (see Samnegård et al., 2015).

To explore those questions, we studied the response of potential flower-visitors (hereafter referred to as “flying insects”) to increasing distance from natural vegetation in mango orchards in north-eastern South-Africa in two different seasons. Mango is one of the most important tropical fruits produced in the world, and is economically important for income and employment-creation in the region (FAO, 2010). Research conducted in our study area in the past has found clear effects of distance on pollination (Carvalheiro et al., 2010, 2012), pest control (Henri et al., 2015) and bird assemblages (Ehlers Smith et al., 2015).

We used pan-traps to survey flying insects during mango flowering in the dry season (winter), and during the wet season (summer, when mango is not flowering), along transects of increasing distance to natural habitat. We hypothesised that the number of flying insects caught in traps would decrease with distance to natural vegetation. If isolation from natural areas is the only cause of the decrease in flying insect abundance, the effect should be consistent between seasons. We also measured wing span and body length of each flying insect and investigated distance effects on flower-visitor functional-trait diversity. We hypothesised a decline of the FD with increasing distance from natural areas in both seasons, since species loss caused by isolation is likely to result in loss of trait diversity. Finally, given links between size and flight abilities, we predicted that average insect body size would be larger with increasing distance to natural area.

2. Materials and methods

2.1. Study site

Our study site was situated in the Kruger to Canyons Biosphere Region, Limpopo Province, South Africa. This region includes agricultural areas and also two large protected areas (Kruger National Park and Blyde River Canyon reserve; 24° 24′S 30°50′E). The entire area retains more than 50% of intact vegetation unaffected by anthropogenic perturbations (Coetzer et al., 2013).