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Supporting wild pollinators in a temperate agricultural landscape: Maintaining mosaics of natural features and production

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ABSTRACT

Pollination has received attention recently due to reported sharp declines of *Apis mellifera* in several locations, and it has been proposed that diverse native bee communities may be key for continued pollination of economically important crops. However, there is some inconsistency in the literature as to how these communities should best be managed. To address this issue, we collected bees from an intensively managed agricultural region in eastern Australia using blue vane traps. Both linear remnants of vegetation, which form part of a larger corridor network, and adjacent fields of native and exotic pastures, wheat, canola, and lucerne were sampled. A total of 3249 individual bees, representing four families and 36 species were collected. Highly modified environments of nectar-bearing crop supported the most species-rich bee assemblages, and the highest abundance of individual bee species. Distance from the remnants did not limit the body size of species occupying fields (up to 400 m). However, richness of bee assemblages also responded positively to the presence of conservation land in nearby areas, or the number of remnant native trees surrounding traps. Linear remnants of native vegetation contributed to assemblage heterogeneity by adding unique species to the regional pool. Our findings indicate that agricultural industries that currently rely on pollination by *A. mellifera* should ensure that intensive land use is complemented by untilled areas in the form of conservation land, or farm dams and scattered trees in fields, to support wild pollinators that may act as insurance against further future losses of managed hives.

1. Introduction

Bees (Hymenoptera: Apiformes) are the most important group of pollinators worldwide (Roubik, 1995; Kremen et al., 2004), and have been the centre of much recent debate (Ghazoul, 2005; Steffan-Dewenter et al., 2005). Given reported population declines of both *Apis mellifera* (European honey bee, De la Rua et al., 2009), and other pollinators (Potts et al., 2010), there has been growing concern for pollination services, and understanding how to best manage and boost populations of alternative wild pollinators has become a priority. Recent research has found that while agricultural fields provide an abundant source of forage for wild bees, they are also hostile nesting environments, with the proportion of untilled land in surrounding areas (Morandin and Winston, 2006; Morandin et al., 2007), diversity of weedy species (Winfree et al., 2008), and distance to natural areas (Ricketts et al., 2008; Krewenka et al., 2011) strongly influencing the diversity of wild bees in farmland. However, contrary lines of evidence suggest that under some circumstances, bees can readily persist in highly-modified anthropogenic habitats (Klein et al., 2002; Tommasi et al., 2004). For example, Winfree et al. (2007) found that in a mostly forested landscape, agricultural areas supported richer and more abundant bee assemblages than natural areas. In many cases, only the largest species are sampled a great distance from nesting sites (Steffan-Dewenter and Tscharntke, 1999; Gathmann and Tscharntke, 2002; Greenleaf et al., 2007), so many authors advise maintaining and building on networks of natural areas in the landscape to ensure continued visitation of bees to fields (Banaszak, 1992; Lagerlof et al., 1992; Morandin and Winston, 2005).

These recommendations are in line with increasing worldwide recognition that networks of natural areas can be beneficial to agricultural production (Tscharntke et al., 2005). Examples of linear networks can be found in many countries, and may take the form of hedgerows (Ernoult and Alard, 2011), agricultural drainage ditches (Herzon and Helenius, 2008), riparian corridors (Sekercioglu, 2009), and railway right-of-ways (Tikka et al., 2001). In Australia, networks of roadside remnant native vegetation (known locally as ‘stock routes’) now transect some of the country’s most extensively cleared and intensively managed agricultural regions (Lentini et al., 2011b). It has been suggested that some of these ‘stock route’ remnants be sold to private landholders, necessitating

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the assessment of which sections to sell, and which to retain for conservation and other purposes (Lentini et al., 2011b). These sorts of conservation planning decisions are often based on well-studied groups such as birds and other vertebrates, for which responses to landscape changes can be more easily predicted (Kremen et al., 1993). Other groups, such as bees, may be equally or more important from a functional and economic perspective. One of the causes underlying the declines of *A. mellifera* is the parasitic mite *Varroa destructor* (Varroa mite, Ellis et al., 2010), which has now spread to all continents other than Australia. It is being assumed that it will eventually invade (Department of Agriculture Fisheries and Forestry, 2011), the economic consequences of which will be great: the predicted losses to Australian agriculture are between AUD $21 and 51 million annually (Cook et al., 2007).

In the absence of managed *A. mellifera*, it is like likely that wild pollinator diversity will need to be maintained in order to fulfil pollination requirements (Kremen et al., 2002; Klein et al., 2003). Australia harbours approximately 1600 species of native bee, and the majority of these are solitary and nest in soil, hollow stems, or woody debris (Schwartz and Hogendoorn, 1999). However, the ecology of this group remains poorly understood (Batley and Hogendoorn, 2009). To inform the ongoing management of wild 'free' pollination in agricultural landscapes, we examined bee communities in linear remnants and in adjacent agricultural fields. Our study addressed two core questions:

(1) What factors shape bee communities at landscape and local scales?
(2) What management actions can be taken to encourage the persistence of wild bees in agricultural landscapes?

2. Materials and methods

2.1. Study area and design

Bees were surveyed across a 1400 ha area of the inland agricultural region of New South Wales, Australia (33–34°S and 147–148°E, Fig. 1). Once covered by grassy *Eucalyptus*-dominated woodlands, the study region has since been cleared extensively to make way for cereal and livestock production. Cultivated fields and pastures now form a mosaic interspersed with linear remnant and planted vegetation, and in many cases large scattered trees also persist within the fields. Larger tracts of remnant native vegetation, in the form of reserves, are sparsely distributed across the region.

We sampled 104 points at 32 sites across the study region. Twenty four sites contained a trapping point in a remnant, and three additional trapping points in adjacent agricultural fields located at 100, 200, and 400 m from the remnant (Fig. 1). The remaining eight sites consisted of a trapping point in the remnant only, because adjacent fields did not contain an adequate number of trees. The 32 remnant points were stratified to represent the spectrum of vegetation condition and remnant widths within the study area – eight sites each of narrow-intact, narrow-degraded, wide-intact, and wide-degraded (widths ranged from 38 to 570 m; see Lentini et al., 2011a for details on site selection). The 24 agricultural field sites consisted of five native pastures, five improved pastures dominated by exotic grasses, five fields sown with lucerne (*Medicago sativa*) and/or clover (*Trifolium* spp.), six fields of wheat (*Triticum* spp.), and three fields of canola (*Brassica* spp.) All of the fields had some trees retained within them, ranging from 1 tree ha^{-1} in crops to 75 trees ha^{-1} in native pasture (μ = 5.6 trees ha^{-1}, see Lentini et al., 2011a for details).

2.2. Bee and vegetation surveys

We used blue vane traps (SpringStar Inc., Woodinville, USA) to conduct our bee surveys (Fig. 1), which are an efficient means of surveying wild bees in the presence of flowering resources (Stephen and Rao, 2007). Surveys were conducted in spring/summer between November 2009 and February 2010. For each survey, a single trap was hung at each trapping point for 1 week, after which the contents were collected. Each trapping point was surveyed twice, approximately two months apart, and crops in cultivated fields were harvested between these periods (though this did not appear to affect species richness– see Fig. A.1, in Supplementary Material). At the 104 trapping points, traps were either hung from either (a) a tree branch (91 points); (b) a shelving bracket attached to a tree trunk (11 points); or (c) a shelving bracket attached to a post hammered into the ground (two points, both linear remnants). The average height of the hanging trap was 2.12 m (±0.6 SD).

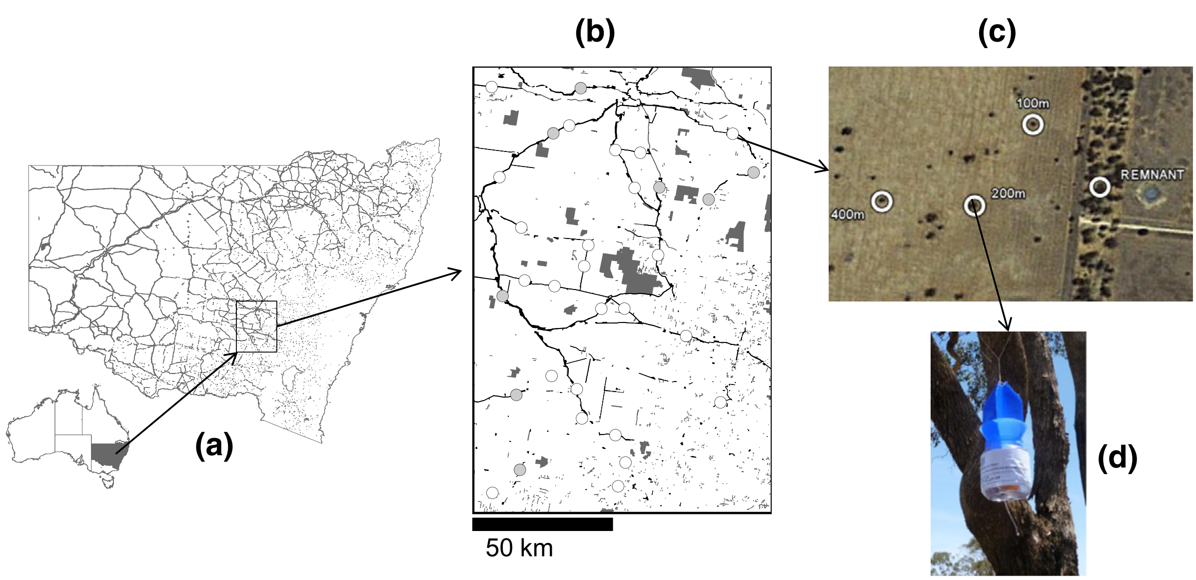

Fig. 1. Schematic showing (a) the extent of the linear remnant network across New South Wales, (b) the position of study sites within the landscape, with remnants shown in black. Light-grey circles indicate traps were placed only in the remnants, and white circles that traps were in both the remnant and the adjacent field. Conservation areas are dark grey, (c) study site showing trapping point in the remnant and at 100, 200 and 400 m into the field, (d) blue vane trap suspended from a tree branch.