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Vegetation increases the abundance of natural enemies in vineyards

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ABSTRACT

Non-crop areas can increase the abundance of natural invertebrate enemies on farmland and assist in invertebrate pest control, but the relative benefits of different types of vegetation are often unclear. Here, we investigated abundance of natural enemies in vineyards with edges consisting of different types of vegetation: remnant native forests, wooded margins planted after establishment of the crop (hereafter called shelterbelts), or pasture. Invertebrates were sampled four times using canopy sticky traps and ground level pitfall traps, replicated across two seasons at one of the sites. The distribution and abundance of natural enemies in relation to edges with adjacent vegetation or pasture were mapped by distance indices (SADIE) and compared with ANOVAs. There was a positive influence of adjacent wooded vegetation on staphylinids, predatory thrips, predatory mites, spiders, ladybird beetles and hymenopteran parasitoids including *Trichogramma* egg parasitoids in the canopy and/or at ground level, although there were significant differences among sites and groups of organisms. In contrast, pasture edges had no effect or a negative effect on numbers of natural enemies in vineyards. To directly assess potential beneficial effects of adjacent vegetation, predation and parasitism of eggs of a vineyard insect pest, *Epiphyas postvittana* Walker (Lepidoptera: Tortricidae), was measured. Parasitism by *Trichogramma* was higher adjacent to remnant vegetation while predation was not affected. These results indicate that the abundance and distribution of vineyard natural enemies and parasitism of pest moth eggs is increased adjacent to edges with wooded vegetation, leading to beneficial effects for pest control. The conservation of remnant woodland and planting of shelterbelts around vineyards may therefore have direct economic benefits in terms of pest control, whereas non-crop pasture may not produce such benefits.

1. Introduction

As more arable land comes under cultivation, there are potential consequences for agricultural pest control, because a decrease in non-crop habitat in a landscape can reduce the abundance and effectiveness of natural enemies of pests (Bianchi et al., 2006). Many studies have demonstrated that the activity of natural enemies and other beneficial invertebrates in agricultural ecosystems is reduced as diverse habitat is lost (Schmidt et al., 2004). These effects have been detected for a variety of enemies including parasitoids, spiders, beetles and predatory mites (Symondson et al., 2002; Thorbek and Bilde, 2004; Tsitsilas et al., 2006). Non-crop vegetation may provide resources for enemies not found in crops such as shelter, overwintering sites and food sources particularly for a wide range of arthropods with primarily carnivorous feeding habits that need plants for pollen or nectar to complement prey. However, maintaining or even increasing non-crop habitat comes at a cost to farmers in terms of a reduction in the area available for production.

By understanding characteristics of vegetation that promote natural enemies, this potential cost could be decreased (Gurr et al., 2004). For instance, vegetation that provides nectar resources can increase activity of predators and parasitoids (Landis et al., 2000; Hooks et al., 2006; Winkler et al., 2006). This increased activity at field edges can translate into decreased crop damage in adjacent crops and therefore could provide direct benefits to offset costs (Landis et al., 2000; Tscharntke et al., 2002; Bianchi et al., 2006; Tsitsilas et al., 2006). However the connection between natural enemy activity and pest control is not always clear (Gurr et al., 2000). For instance Olson and Wäckers (2007) found no change in cotton boll damage with decreasing distance from a field margin, despite an increased abundance of natural enemies. Pest damage can even be higher at the edge of fields bordered by trees despite an increase in natural enemies (Holland and Fahrig, 2000).

Sustainable pest control usually involves many enemy species that have an impact on a particular prey and whose importance may change over time (Rosenheim, 1998; Memmott et al., 2000; Symondson et al., 2002; Cardinale et al., 2003). For instance, control of aphids involves different natural enemies in particular years and regions (Thies et al., 2005) and the key controlling agent might switch between different groups (Schmidt et al., 2003). When assessing the overall benefits of adjacent vegetation on decreasing

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crop damage, the impact of a range of host/parasitoid and predator/prey interactions therefore needs to be assessed.

In this study, we evaluate the impact of vegetation adjacent to vineyards in south-eastern Australia on natural enemy abundance. The most significant insect pest in Australian vineyards is light brown apple moth, *Epiphyas postvittana* Walker (Lepidoptera: Tortricidae) (LBAM). LBAM is known to be parasitised by 25 species of Hymenoptera (Paull and Austin, 2006) and attacked by predators including spiders, predatory Hemiptera and neuropteran larvae (Thomson and Hoffmann, 2006a). A host of pests other than LBAM also attack vines including eriophyoid mites, weevils, scale, mealybugs and Rutherglen bugs (Buchanan and Amos, 1992). These vary in importance depending on region and season, and are all potentially controlled by natural enemies including parasitoids and predatory mites.

In many parts of Australia, there is increasing interest in understanding the impact of non-crop vegetation within agricultural landscapes on production. The vegetation might consist of remnant woodland that has never been used for cropping, or new plantings aimed at providing shelter from wind or chemical drift, corridors for wildlife, removal of waste water or meeting regulatory requirements. At present, vegetation is not specifically maintained or planted for promoting invertebrate natural enemies, and we are unaware of studies that investigate this issue within a vineyard context.

To address the potential impact of vegetation on pest control in vineyards, data were collected over two grape growing seasons using two trapping methods (canopy and ground level) at multiple sites. Spatially explicit sampling and mapping techniques were used to establish patterns of natural enemy abundance throughout one vineyard with two wooded and two pasture edges. At other sites we examined invertebrate diversity and abundance in different types of vegetation and within the adjacent vineyards. Finally, we investigated whether spatial patterns in natural enemies could be linked to predation and parasitism of eggs near adjacent vegetation.

2. Materials and methods

2.1. Sites

Sampling was undertaken at 10 sites in commercial vineyards at Yarra Glen (37°43′S, 145°24′E) in two grape growing seasons, 2004–2005 and 2005–2006. Each site consisted of a block of the same grape variety (Chardonnay) with 3 m between rows, and rows consisting of vines 2 m apart planted to trellis with poles 5 m apart and of similar size (5–8 ha). Vine size and vigour were similar throughout the blocks. Undervine and interrow management practices were similar: soil under the vines was bare earth following application of herbicides, and between the vines was mown grass (mainly perennial rye grass *Lolium perenne* and phalaris *Phalaris* sp., with varying amounts of capeweed *Arctotheca calendula* and clover *Trifolium repens*). Only chemicals of low toxicity to beneficials (based on IOBC ratings – http://www.koppert.nl – and related data – see Thomson and Hoffmann, 2006b) were used, including sulphur (Thiovit®) (at 200 g/100L) and tebufenozide (Mimic®). We selected vineyards with three different edges: remnant, complex shelterbelts (*sensu* Tsitsilas et al., 2006) or cleared (pasture). Remnant refers to vegetation which is presumed to predate the establishment of agriculture in the region and thus may be representative of the original landscape. There was only limited remnant vegetation with a complex understory in the region considered. The term shelterbelt refers to planted trees with an understory consisting of shrubs and grasses.

In the first season (2004–2005), intensive sampling was carried out throughout an entire vineyard (site 1) with remnant (REM1), shelterbelt (SB1) and pasture edges for spatial analysis of the distribution of natural enemies relative to the edges. Sampling points were established at 100 points located randomly throughout the vineyard. In the second season (2005–2006), sampling was repeated at site 1 in woody vegetation and in the vines 5 and 50 m into the vineyard at both woody (e.g., SB and REM) vegetation edges to compare consistency between seasons. We also sampled at five additional vineyards with adjacent SB vegetation, one site with REM vegetation and two sites with pasture edges.

At each site with woody vegetation we sampled in the vegetation and in vine rows 5 and 50 m from vegetation (REM1–2 and SB1–6), again with five replicate sampling points at each distance. Vegetation at each site is given in Appendix A. We also further assessed the effects of edges at two other sites where the vines had pasture edges, sampling points extended at 10 m intervals from the center of each vineyard to the pasture edges. Sampling points for pasture edges extended 50 m into the vineyard, again with five replicate sampling points at each distance.

2.2. Sampling

At each sampling point we placed a pitfall trap to sample ground level invertebrates and a yellow sticky trap to sample canopy invertebrates. Pitfall traps consisted of an outer sleeve and an inner container with 4 cm of ethylene glycol. For the spatial collection, pitfall traps consisted of two plastic cups (Charnol Australia), 70 mm diameter × 80 mm deep. For all other collections each pitfall trap consisted of a glass test tube, 20 mm diameter × 150 mm inserted into a plastic sleeve, 22 mm diameter × 150 mm deep, inserted so that the top was flush with the surface. The yellow sticky traps were 240 mm × 100 mm (Agrisense) sheets suspended from the lower wire of a vertical two-wire trellis system 1 m above the ground. Sampling in both seasons was repeated over 4 months (November–February), with traps placed and collected the first week of each month. Previous work has shown the importance of repeated temporal sampling to obtain a range of organisms in vineyards (Thomson et al., 2004). Invertebrates collected on yellow sticky traps were assessed *in situ*, the contents of pitfall traps were sieved and transferred to a 10 cm Petri dish. Collections were sorted using a microscope (Leica MS5) at magnification 20× to 100×: insects (CSIRO, 1991), spiders (Hawkeswood, 2003) and parasitoids (Stevens et al., 2007) were sorted to family and mites to functional group (Krantz, 1978).

Yellow sticky traps collected Araneae, Hemiptera, Diptera, Coleoptera, Hymenoptera, Neuroptera, Odonata, Thysanoptera and Lepidoptera. Pitfall traps collected Coleoptera, Araneae, Hymenoptera, Diptera, Dermaptera, Acarina, Neuroptera, Isopoda, Lepidoptera and Hemiptera. Lacewings were predominantly brown *Micromus tasmaniae* (Walker) (Neuroptera: Hemerobiidae). Three families of predatory Hemiptera were found (Reduviidae, Nabidae and Anthocoridae) and numbers combined. The Diptera were sorted to family, the large number of Syrphidae analyzed separately and the other predatory/parasitic families (Empididae, Tachinidae and Cecidomyiidae) combined. There were 10 families of Hymenoptera: Formicidae, Braconidae, Ichneumonidae, Chalcididae, Encyrtidae, Pteromalidae, Aphelinidae, Mymaridae, Scelionidae and Trichogrammatidae. The last group was considered separately as it represents important egg parasitoids of LBAM (Glenn et al., 1997). Numbers of the other Hymenoptera, excluding Formicidae, were combined as 'parasitoids'. The role of ants in our vineyards is not fully known so their numbers were included in community analysis but not as predators.

Twelve families of Coleoptera were recorded: Carabidae, Staphylinidae, Anthicidae, Scarabidae, Curculionidae, Coccinellidae, Elateridae, Corylophidae, Byrrhidae, Bostrichidae, Lathrididae and Tenebrionidae. Seven families were sufficiently numerous to be in-