Biological Control 64 (2013) 57–65

Contents lists available at SciVerse ScienceDirect

Biological Control

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

Spatial scale of benefits from adjacent woody vegetation on natural enemies within vineyards

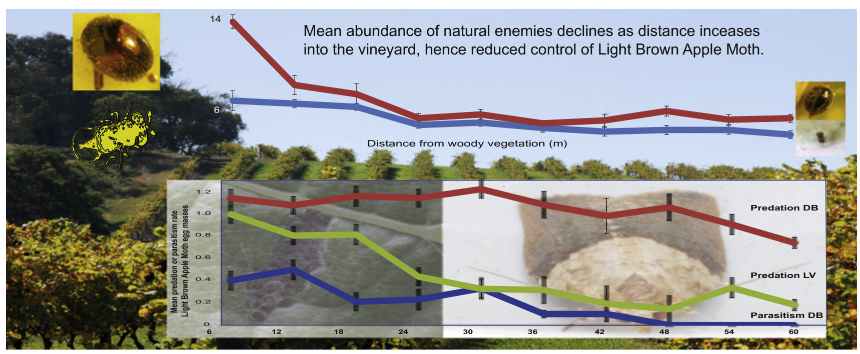
Linda J. Thomson *, Ary A. Hoffmann

Department of Zoology, Bio21, University of Melbourne, 30 Flemington Road, Parkville 3010, Australia

HIGHLIGHTS

- ▶ Adjacent woody vegetation enhances conservation biological control.
- ▶ To provide useful guidelines, effective distances of adjacent vegetation need to be established.
- ▶ We tested abundance of natural enemies and impact on an economically important vineyard pest.
- ▶ Results indicate 50 m spacing increases abundance and predation/parasitism.
- ▶ These results provide guidelines for landscape changes to enhance pest control.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 12 April 2012
Accepted 24 September 2012
Available online 16 October 2012

Keywords:
Coleoptera
Parasitoids
Vineyard insect distributions
Field margin
Patch
SADIE
Spatial dynamics

ABSTRACT

Abundance of predators in crops can be increased by augmenting the adjacent non-crop vegetation, with associated environmental benefits from reduced chemical inputs and landscape conservation. Fine-scale spatial analysis is required to assess the extent to which non-crop benefits extend into farmed areas. We used explicit spatial mapping to investigate benefits of woody vegetation in two vineyards. The abundance of canopy-dwelling predators and predation/parasitism rates was measured at two vineyards with woody vegetation on one margin. Grids were sampled monthly across two summer growing seasons and stability of spatial patterns determined for consecutive months for each season and between seasons. At these two locations small parasitoids and several species of ladybird beetles from the vine canopy exhibited spatial patterning, with regions of high and low abundance and activity, aggregated in rows near to woody vegetation. Aggregations varied in temporal stability, with some persisting throughout the season. When predation and parasitism of sentinel eggs of a moth pest were non-randomly distributed, levels were higher in vine rows closer to the woody vegetation and significantly associated with a known egg parasitoid and ladybird beetles. This study demonstrated predators and parasitoids had non random and stable distributions at two vineyards. Increased abundance of both Coccinellidae and parasitoids was seen over similar distances: extending approximately 40 m from the vegetated edge. Increase in parasitism and predation extended a similar distance in from the vegetation. These results suggest management of vineyards where non-crop vegetation can be used to increase numbers and impact of beneficials, with recommendations for planting woody vegetation a minimum of 50 m from vineyard edges.

1. Introduction

Ecosystem services such as natural pest control can reduce agrochemical use and associated environmental costs (Bianchi

* Corresponding author. Fax: +61 3 83442279.
E-mail addresses: lthom@unimelb.edu.au (L.J. Thomson), ary@unimelb.edu.au (A.A. Hoffmann).

1049-9644/$ - see front matter
http://dx.doi.org/10.1016/j.biocontrol.2012.09.019

et al., 2006) without reductions in pest control and plant productivity (Bengtsson et al., 2005). Increased abundance of natural enemies within croplands can decrease pest abundance in the crop, increasing crop yield (Sunderland et al., 1986; Mansour, 1987; Nyffeler et al., 1992; Hooks et al., 2003). This has led to research identifying factors that enhance natural enemy abundance. In particular, their abundance can be increased by changes in pesticide applications (Stark and Banks, 2003; Isaia et al., 2006; Thomson and Hoffmann, 2006), with applications of lower toxicity chemicals resulting in more parasitoids, predatory mites, coccinellids, carabids, spiders and other natural enemies (e.g. Epstein et al., 2001; Manzano et al., 2003; Prischmann et al., 2005; Thomson and Hoffmann, 2006; Nash et al., 2008, 2010).

For some groups of natural enemies, especially those benefitting from nectar resources, their abundance within crops can be increased by adjacent non-crop vegetation (Landis et al., 2000; Gurr et al., 2003; Bianchi et al., 2006; Winkler et al., 2006). This vegetation may consist of hedgerow networks, remnant native vegetation that has not been cleared for agriculture or that has been redeveloped, and/or areas of grassland that are currently not farmed (Bianchi et al., 2006; Geiger et al., 2009). Diverse parasitoids and ladybird beetles particularly benefit from adjacent woody vegetation (Nicholls et al., 2001; Thomson and Hoffmann, 2010a), increasing in abundance within crops especially when compared to grassland or pasture adjacent to vineyards (Thomson and Hoffmann, 2009; Thomson et al., 2010). Vegetation within the broader landscape can be important as well as vegetation directly adjacent to fields (Tscharntke et al., 2007), although the relative importance of these components is rarely evaluated (Thomson et al., 2010).

Benefits of non crop vegetation need to be considered within a spatial context, to determine how far they extend into the field. This can be evaluated both by focusing on one or a few sampling points within an agricultural field and comparing multiple landscapes rather than multiple field sites (Schmidt et al., 2008; Scheid et al., 2011) or by determining the spatial scale within a field over which an increase in natural enemy abundance occurs (Thomas et al., 2001; Pearce and Zalucki, 2006; Thomson and Hoffmann, 2009). Typically the abundance of natural enemies decreases as they are sampled at points away from non-crop habitat (Olson and Wäckers, 2007; Hogg and Daane, 2010; Roume et al., 2011). However there are relatively few published data sets on this issue, despite its importance for developing management advice to growers and estimating the economic benefits of non-crop vegetation (Zhang and Swinton, 2009). Spatial information may facilitate the localized management of pests within a field. For instance, chemical sprays may then be targeted only at areas where control through natural enemies is expected to be poor.

In this paper we consider the spatial context of the effects of non-crop vegetation on control of the Australian vineyard pest, light brown apple moth *Epiphyas postvittana* Walker (Lepidoptera: Tortricidae). This species is the principal insect pest of grapevines in Australia. A range of parasitoids of different life stages have been identified, including several species of egg parasitoids (Hymenoptera: Trichogrammatidae) (Glenn et al., 1997) and 26 larval or pupal parasitoids (Paull and Austin, 2006). While entomophagous lady beetles are well-known natural enemies of Hemiptera (Sternorrhyncha) (Hodek, 1973), they are also known to prey on a variety of other insects including Lepidopteran eggs (Hagler and Naranjo, 1994; Pfannenstiel and Yeargan, 2002; Evans, 2009).

In previous research we have reported abundance of four commonly occurring species of ladybird beetle (Thomson and Hoffmann, 2010a; Thomson et al., 2010). At least one of these, *Diomus notescens* Blackburn (Coleoptera: Coccinellidae), is known to prey on light brown apple moth eggs (MacLellan, 1973). Previously we have shown increases in abundance of natural enemies, accompanied by enhanced predation and parasitism of light brown apple moth eggs, in vineyards in south eastern Australia with ground covers including mid row cover crops, mulch under vines and woody vegetation at the local scale (Thomson and Hoffmann, 2007, 2009, 2010a; Danne et al., 2010). At the same time, we found limited effect of non-crop vegetation at the landscape scale for a range of natural enemies (Thomson et al., 2010; D'Alberto et al., 2012) suggesting that adjacent vegetation and within vineyard factors are more important than the broader landscape. This system provides an opportunity to examine the spatial context of benefits arising from adjacent vegetation.

Here spatial and temporal sampling was used to examine within vineyard variation in the numbers and activity of natural enemies of light brown apple moth. Two vineyards from two regions, with similar amounts of vegetation at the landscape scale, differing in rainfall, temperature with shelterbelts consisting of small trees with a shrub understory and grass ground cover on one boundary were selected to answer a series of questions. (i) Do predators or parasitoids aggregate in patches within vineyards? (ii) How consistent are these patterns across a season and in different vineyards? (iii) Is their distribution within vineyards influenced by adjacent woody vegetation? (iv) How far do vegetation effects on the abundance of natural enemies extend into the vineyard?

2. Materials and methods

2.1. Sites

To examine the within vineyard distribution of predators and parasitoids, intensive sampling was undertaken in two commercial vineyards from two regions: De Bortoli in the Yarra Valley (37°39′S, 145°21′E) in Victoria, and Lyndoch in the Barossa Valley (34°38′S, 138°53′E) in South Australia. Barossa Valley has an annual mean rainfall of 501 mm and mean maximum and minimum temperatures of 20.9 °C and 8.7 °C, respectively. Yarra Valley is a little cooler and wetter with an annual mean rainfall of 697 mm, and mean maximum/minimum temperatures of 20.2 °C/7.1 °C (http://www.bom.gov.au/climate/averages/tables/cw_023321.shtml). Woody vegetation in the landscape surrounding both vineyards was similar with approximately 24% woody vegetation in a circle of radius 250 m centred on each site. Each site had woody vegetation on one margin. At Lyndoch, woodland consisted of a mixture of *Allocasuarina* and *Eucalyptus* trees interspersed with grasses on the western edge while De Bortoli was similarly flanked by woody vegetation consisting of grasses, flowering shrubs, heath teatree, *Acacia* and *Eucalyptus* trees on the northern boundary. At both locations vines formed two boundaries and mown grass fields the fourth.

Both sites consisted of a vineyard block of similar size (about 20,000 m^2) with 3 m between rows of vines 2 m apart planted to trellis with poles 5 m apart. Undervine and inter-row management practices were similar: herbicide applications undervine, although patches of weeds remained. Between the vines was mown grass (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, 2006) were used, including sulfur (Thiovit®) (at 200 g/100 L) and tebufenozide (Mimic®) applied a single time at each site (December).

2.2. Sampling

Sites had 100 trap points, each consisting of a yellow sticky trap (240 mm × 100 mm) (Agrisense) suspended from the lower wire of