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ScienceDirect
Biological Control 41 (2007) 230–236
Biological Control
www.elsevier.com/locate/ybcon

Video analysis to determine how habitat strata affects predator diversity and predation of *Epiphyas postvittana* (Lepidoptera: Tortricidae) in a vineyard

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Received 23 September 2006; accepted 24 January 2007
Available online 6 February 2007

Abstract

Preserving arthropod predator abundance and diversity in agricultural ecosystems may reduce pest populations and subsequent loss in yield. However, since natural enemy species vary in their impact on pest populations, it is crucial to identify which predators are effective at reducing pest abundance. Leafrollers spend part of their life on the ground and part in the canopy of vineyards. In this experiment, predation of tethered leafrollers on the ground and in the vine canopy was compared in a New Zealand vineyard. Leafrollers in each stratum were recorded using video equipment to identify predators that were consuming leafrollers. A separate experiment investigated the behavior of *Epiphyas postvittana* larvae when encountered by earwigs on vines or concealed within leaf shelters. Predation rates of leafrollers did not differ between the ground and canopy strata. However, predator activity, attack rate, and species richness were higher on the ground. Six predator taxa consumed leafrollers on the ground whereas only earwigs consumed leafrollers in the canopy. Earwigs were more active, and killed significantly more leafrollers in the canopy than on the ground, compensating for the relatively low activity and diversity of other predators in that stratum. This research demonstrates the value of video recording in biological control research, as it permits identification of the predators contributing to pest reduction. In addition, it highlights the need to understand the contributions of individual predator taxa to biological control to better conserve the 'right diversity' in agricultural systems and benefit from this ecosystem service.

Keywords: Biological control; Habitat structure; Predator activity; Leafroller behavior; Dermaptera; *Forficula auricularia*; Video recording

1. Introduction

Preserving and enhancing arthropod predator abundance and diversity in agricultural ecosystems can reduce pest populations, subsequent loss in yield, and the need for insecticide applications (Landis et al., 2000; Gurr et al., 2004). However, simply increasing predator abundance (Prasad and Snyder, 2004) or diversity (Snyder and Ives, 2001; Snyder and Wise, 2001; Wilby et al., 2005) does not always result in greater control of target pests. In addition, since natural enemy species vary in their impact on pest populations, the identity of predators in an assemblage may have more influence on prey populations than species richness or abundance (Chalcraft and Resetarits, 2003; Finke and Denno, 2005; Straub and Snyder, 2006). Therefore, in agro-ecosystems it is crucial to identify which predators consume focal pests so that efforts to enhance and preserve natural enemies can focus on the most important taxa. This targeted approach may lead to more efficient development of conservation biological control tactics and more effective pest control.

Leafroller (Lepidoptera: Tortricidae) larvae are important pests in commercial vineyards throughout the world. The light brown apple moth, *Epiphyas postvittana*

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1049-9644/$ - see front matter
doi:10.1016/j.biocontrol.2007.01.012

(Walker), is a common leafroller species in New Zealand and Australian vineyards. This pest consumes grape leaves, flowers, and fruit. Leafroller feeding damage can predispose berries to bunch rot, *Botrytis cinerea* (Nair et al., 1988), while contaminated larvae can transmit this disease from one bunch to another (Bailey et al., 1997). Direct consumption of plant tissue and the subsequent infection by bunch rot can result in a lower grape yield and economic loss for growers (Lo and Murrell, 2000).

Leafroller pests of vineyards are generally managed with broad-spectrum insecticides such as organophosphates and carbamates which have detrimental effects on resident natural enemies and other non-target organisms (Epstein et al., 2000; Lo et al., 2000; Nagarkatti et al., 2002). In addition, some leafroller species, including *E. postvittana*, have begun to develop insecticide resistance (Suckling et al., 1984; Lo et al., 2000; Nagarkatti et al., 2002). For these reasons, there is increasing interest in attracting and conserving arthropod natural enemies in vineyards to help reduce leafroller abundance and damage.

Leafrollers spend much of their life inside shelters made by webbing leaves together with silk which may give protection from natural enemies. Leafrollers will leave their shelters to forage on nearby foliage, to search for a new shelter or pupation site, or to move from the foliage to fruit (MacLellan, 1973). Movement within the canopy may render them more vulnerable to predation than when they are in shelters. *E. postvittana* overwinters as larvae on the vineyard floor feeding on the vegetation there (Danthanarayana, 1975). Leafrollers on the vineyard floor may encounter a different assemblage of predators, relative to that of the canopy, which may differentially affect their survival. Late instar leafrollers and codling moth larvae in orchards suffer high levels of predation if they drop from the canopy or venture to the ground in search of pupation sites (Glenn and Milsom, 1978; Epstein et al., 2001). Research on the natural enemies and biological control of leafrollers in vineyards has been dominated by work on parasitoids (Danthanarayana, 1980a,b; Glenn et al., 1997; Berndt et al., 2002). However, little is known about the frequency or consequence of leafroller exposure to the predator fauna of vineyards or the behavior of leafrollers when they are encountered by a predator.

The objective of this study was to determine the identity, activity, and species richness of predators in the canopy and on the ground of a vineyard and their ability to successfully kill leafrollers. We use time-lapse video monitoring to test the hypothesis that predator activity and diversity will be greater on the vineyard floor than in the canopy. Based on this expectation our second hypothesis is that predation of sentinel leafrollers will be greater on the vineyard floor than canopy. Using information from the video recordings we also compare the rate of attack and successful predation of *E. postvittana* by the different predator taxa to identify the predators most important in reducing leafroller abundance. To further understand the vulnerability of *E. postvittana*, we compare their escape and defensive behaviors while exposed on grape vines or concealed in leaf shelters. The use of time-lapse video in this research will increase our understanding of which predators contribute to leafroller predation and in which strata leafrollers are most susceptible. It will also demonstrates the value of video technologies to ecological study. Understanding the role of predator taxa in pest suppression increases our ability to benefit from this ecosystem service (Gurr et al., 2004).

2. Materials and methods

The study site was a 2 ha Riesling vineyard in the Horticultural Research Area of Lincoln University, Canterbury, New Zealand. Herbicide was applied periodically to reduce weeds beneath the vines and fungicide was applied to manage botrytis disease. However, no insecticide had been used in the 2004/2005 season. At the time of this experiment the vegetation beneath the vines was approximately 10 cm high and consisted primarily of white clover, *Trifolium repens* (L.). The area between vine rows was planted with orchard grass *Dactylis glomerata* (L.) mowed to 5 cm high. The entire vineyard was surrounded by a windbreak of *Populus* spp.

2.1. Predation of sentinel leafrollers

Sentinel leafroller larvae were used to evaluate ambient rates of predation in the canopy and floor of the vineyard. The experiment was conducted in a different area of the vineyard on each of five nights, between 11 and 20 January 2005. Each night was a replicate. On each night 20 fifth instar leafroller larvae (2 cm long) were positioned on the ground below the grape vines and 20 in the grape vine canopy (= 2 treatments). Larvae were obtained from HortResearch, Auckland, New Zealand. All leafrollers were secured in their respective positions using size '0' insect pins (Frank and Shrewsbury 2004). Leafrollers were pinned through their penultimate abdominal segment. Preliminary trials ensured that *E. postvittana* larvae survived at least 12 h after pinning and that they did not escape from the pins.

On each night half of the length (i.e. from one end of the rows to the center) of two adjacent rows of vines was used in the experiment. Leafrollers in the ground treatment were pinned to the ground directly below the vines in both vine rows. Larvae in the vine treatment were pinned to the base of a leaf petiole 10–20 cm above a vine trunk in both vine rows. All larvae were at least 2 m apart. Leafrollers were placed in the vineyard at 18:00 h on each night. The following morning at 06:00 h, the leafrollers were counted and classified as either eaten or not eaten.

2.1.1. Statistical analysis

The number of leafrollers (of 20) eaten in each treatment per night (five replicates) was compared using a *t*-test.