Why are some parasitoids of light brown apple moth so uncommon in vineyards?

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Dedicated to my dear wife Yan Ma and our daughter Luyu Feng

ABSTRACT

The light brown apple moth, *Epiphyas postvittana* (Walker) (Lepidoptera: Tortricidae), is a key insect pest that belongs to one of the largest families of Lepidoptera, the Tortricidae, which has over 10,000 described species. This family includes numerous major pests of crops, forests, and ornamental plants. Hence an understanding of factors that affect parasitism of *E. postvittana* is potentially relevant to many other pest species and agroecosystems. Although a number of species are known to parasitise *E. postvittana*, only few of them were recorded attack *E. postvittana* in vineyards. Moreover, little is known about the interactions between *E. postvittana* and the parasitoids that are associated with it in crop and non-crop habitats. Therefore，this study addressed the question, “why are some parasitoids that attack light brown apple moth so uncommon in vineyards?” My thesis presents an investigation of the activities of parasitoids in vineyards and adjacent native vegetation in the Adelaide Hills wine region, and provides insights into the contribution they make towards natural biological control of the light brown apple moth.

This project aimed to investigate: (1) parasitism rates of *E. postvittana* in vineyards and adjacent native vegetation; (2) competitive interactions between parasitoids that attack *E. postvittana*; (3) the influence of host plants on foraging behavior and parasitism by parasitoids that attack *E. postvittana*; and (4) temperature dependent development of *Therophilus unimaculatus* (Turner) (Hymenoptera: Braconidae), a common parasitoid species that attacks *E. postvittana*.

Field experiments showed that *T. unimaculatus* was most active in non-crop native vegetation, whereas *Dolichogenidea tasmanica* (Cameron) (Hymenoptera: Braconidae) was the most common parasitoid of larval *E. postvittana* in vineyards. Molecular identification of larval tortricids that were parasitised by either of the two parasitoids species indicated these two parasitoids share a range of tortricid hosts in both vineyards and natural habitats. These results indicated that the two key parasitoids have different patterns of habitat use between vineyard and adjacent fields.

In order to investigate why parasitoids are not equally distributed between vineyards and native vegetation, two further series of studies were conducted. The first investigated the extent of interspecific differences in host discrimination and the outcome of interspecific competition between *D. tasmanica* and *T. unimaculatus*. Both wasp species did not show differential behavioural responses to un-parasitised hosts or those that were parasitised by the other species. But immature *D. tasmanica* out-competed immature *T. unimaculatus*, irrespective of the order or interval between attacks by the two species.

The second series of experiments examined the effects of host plants on the behaviour of *D. tasmanica* and *T. unimaculatus*. The effects of selected native and non-native host plants on the foraging preferences and efficiency of the two parasitoids were investigated through behavioural observations in a wind tunnel, and an experiment in the field. The results indicated that plants play a role that affects the habitat preferences of the two parasitoid species by influencing their foraging behaviour, and contribute to their distributions among habitats.

By studying the temperature dependent development of *T. unimaculatus* under constant temperatures, its mean developmental time from egg to adult emergence was found to be shortest at 24.4 days at 28.9 ℃. The data were fitted to a non-linear model, which showed that the number of generations of *T. unimaculatus* is equal or greater than *E. postvittana* in three out of four locations in Australia, and the development of *T. unimaculatus* is faster when the temperature is above 16.0 ℃. Thus temperature affects the extent of synchronization between populations of *T. unimaculatus* and *E. postvittana*.

Overall, this research contributes to understand the contributions that parasitoids make to natural biological control of *E. postvittana*. I concluded that native vegetation adjacent to vineyards is not always a reliable source of natural enemies for control of *E. postvittana* in vineyards and, more generally, that native vegetation is not always a reliable source of natural enemies in crops. Based on the results, the different habitat preference of the two parasitoid species is likely to be influenced by different degrees of host-species and habitat preferences, including responses to plants, and possibly specific life history differences between the two parasitoid species. The results of this research are also expected to be useful for understanding natural biological control of many other pest species.

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PREFACE

The research discussed in this thesis has led to the generation of four journal manuscripts that will be published in journal papers and four conference papers

Journal papers

Yi Feng, Olena Kravchuk, Harpinder Sandhu, Stephen D. Wratten, Michael A. Keller. The activities of generalist parasitoids are segregated between crop and adjacent non-crop habitats. For submit to: Biocontrol.

Yi Feng, Stephen Wratten, Harpinder Sandhu, Michael Keller. Interspecific competition between two generalist parasitoids that attack *Epiphyas postvittana* (Lepidoptera: Tortricidae). Accepted for publication: Bulletin of Entomological Research.

Yi Feng, Stephen Wratten, Harpinder Sandhu, Michael A. Keller. Plants affect the foraging success of two parasitoids that attack *Epiphyas Postvittana*. Submitted for publication: PLoS ONE.

Yi Feng, Michael A. Keller. Temperature dependent development of *Therophilus unimaculatus* on *Epiphyas postvittana.* For submit to: Austral Entomology.

Conferences papers

15-16 Nov. 2012, Australian Grape and Wine Research Symposium 'Crush 2012', *oral presentation* 'Biological control of light brown apple moth in vineyards: What affects the diversity of parasitic wasps?'

13-18 Jul 2013,15th Australian Wine Industry Technical Conference in Sydney, *poster presentation* 'Parasitic wasps that attack light brown apple moth: why do some species occur in vineyards and not others?'

29 Sept.-2 Oct. 2013, Australian Entomological Society Conference 2013 in Adelaide, *oral presentation* 'Interspecific competition between two generalist parasitoids that attack *Epiphyas postvittana* (Lepidoptera: Tortricidae)'.

28 Sept.-1 Oct. 2014, Australian Entomological Society Conference 2013 in Canberra, *oral presentation* 'Towards biological control of a generalist insect herbivore: the activities of generalist parasitoids are segregated between crop and adjacent non-crop habitats'.

References for chapter 1 and 6 are included in the References section; references for chapter 2-5 are included within each of those chapters