Factsheet 27/12 (Project PC 295b)

Protected Edibles

An introduction to hyperparasitism

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This factsheet provides an introduction to the biology, behaviour and recognition of the main groups of hyperparasitoids which commonly attack the primary parasitoids used for biological control of aphids in UK crops. These studies have been done in commercial pepper crops but the problems are far more wide-ranging. Hyperparasitism is a threat wherever primary parasitoids are used to control aphids.

Introduction

British pepper growers lead the world with the implementation of integrated pest management (IPM). The techniques are largely based on biological control agents and there are often several control measures used against each pest species. The overall programme would be very successful but for the break-down in control of aphids which can occur in summer.

Aphidius colemani, Aphidius ervi and *Aphelinus abdominalis* are the three most effective primary parasitoids released against aphids in peppers. In addition, *Praon volucre* usually invade naturally and become rapidly established without the need to purchase commercial products. All these species establish well in the early season and usually suppress aphid population growth without the need for supplementary insecticidal treatments. However, control with the primary parasitoids often falters in May and may fail completely in mid-summer (Figure 1).

Hyperparasitoids are secondary insect parasitoids which attack the biological control agents and thereby threaten the success of IPM programmes. Their existence has been known for many years but recent work in UK pepper crops has greatly improved our understanding of their biology and behaviour. It has become clear that their impact on primary parasitoids must be reduced to optimise the efficacy of the IPM programme.

1. Sticky leaves and fruit due to aphid damage

A total of ten different species of hyperparasitoids were found at trials sites in Essex and Somerset. They belong to four different genera; *Asaphes, Alloxysta, Dendrocerus* and *Pachyneuron.* They may be grouped into two categories based on adult egg laying and larval feeding behaviour:

- **Ectophagous:** The female deposits her egg on the surface of the primary parasitic larva after the aphid is killed and mummified. The hyperparasitic larva feeds externally on the primary host while both are still inside the mummified aphid. This category includes species of *Asaphes, Dendrocerus* and *Pachyneuron* (Figure 2).
- **Endophagus:** The female deposits her egg inside the developing primary parasitoid larva inside the live aphid but before the aphid is mummified. The egg does not hatch until after the mummy is formed and then the hyperparasitic larva feeds in the primary larval host. This category includes *Alloxysta.*

2. Female 'ectophagous' hyperparasitoid depositing an egg

Hyperparasitism in peppers

Table 1 shows which of the 10 species of hyperparasitoids were associated with each of the six different combinations of aphids and primary parasitoids. Only *Asaphes suspensus* was found in every type of mummified aphid. This was also the most numerous species overall.

Table 1. Hyperparasitoids associated with different combinations of aphid and primary parasitoids (y = positive record)

	Glasshouse potato aphid (*Aulacorthum solani*)			Peach-potato aphid (*Myzus persicae*)		Potato aphid (*Macrosiphum euphorbiae*)
	Aphidius	*Praon*	*Aphelinus*	*Aphidius*	*Praon*	*Aphelinus*
Alloxysta brevis	y			y		
Alloxysta brachyptera	y		y	y		
Alloxysta fulviceps				y		
Alloxysta victrix	y			y		
Asaphes suspensus	y	y	y	y	y	y
Asaphes vulgaris				y		
Pachyneuron aphidis			y	y		
Dendrocerus aphidum	y					
Dendrocerus laticeps	y	y				
Dendrocerus serricornis				y		

The first indication of the presence of hyperparasitoids is usually characteristic emergence holes in the mummified aphids. For example, *Asaphes* spp. emergence holes have irregular edges (Figure 3), while *Aphidius* spp. emergence holes have a neater edge and usually retain a distinct 'lid' (Figure 4).

The adult female *Asaphes* creates holes in the mummified aphid to both host feed and lay eggs. There may be several holes in a single mummy (Figure 5). The developing primary parasitoid is paralysed. The hyperparasitoid may feed without laying an egg. When this happens, the developing primary parasitoid dies. The remaining contents of the mummy often become colonised by saprophytic fungi and mycelium can be seen growing out of the feeding hole (Figure 6).

3. *Asaphes* spp. emergence hole typified by irregular edges

4. *Aphidius* spp. emergence holes have neater edges and usually retain a distinct 'lid'

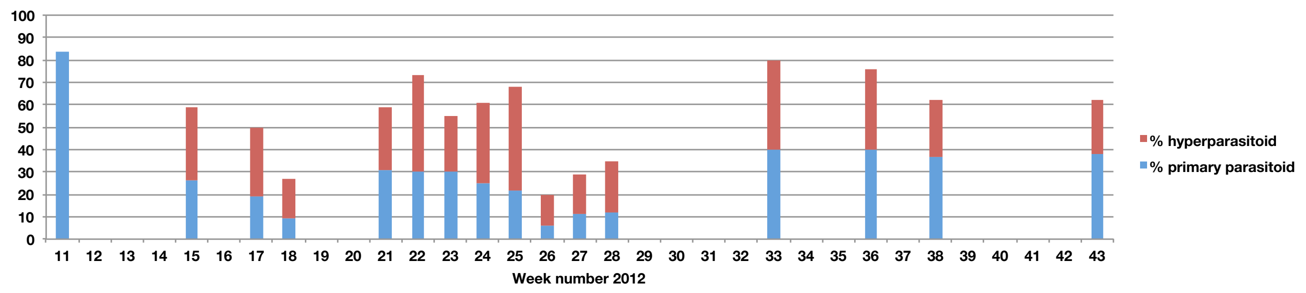
5. Multiple holes on mummified aphid due to *Asaphes* spp. Some may be feeding holes

6. Saprophytic fungi growing out of feeding holes

The percentage of adult primary parasitoids and hyperparasitoids emergent from all mummies collected from the Somerset nursery in 2011 are shown below (Figure 7).

From week 15, the proportion of primary parasitoids to hyperparasitoids fluctuated between 60:40 and 30:70 with an overall mean marginally in favour of the hyperparasitoids (44:56).

This indicated that the hyperparasitoids were coexisting with their primary parasitoid hosts rather than eliminating them. The shortfall in overall emergence of adult parasitoids is due to adult hyperparasitoids host feeding without laying eggs.



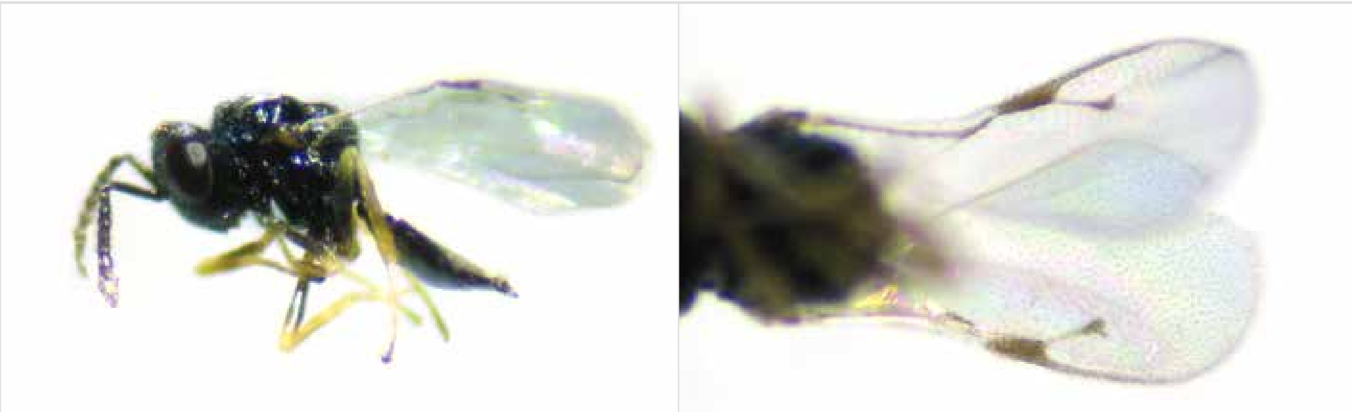
7. Percentage of adult primary parasitoids and hyperparasitoids emergent from all mummies collected at the Somerset nursery

Recognition of adult hyperparasitoids

The identification of parasitoids to species is a very specialised field. However, the four genera found in UK pepper crops may be distinguished from one another by their general body shape, antennae and wing venation. The size varies enormously and is not a reliable feature. Nor is the shape of the abdomen which may collapse in some situations (e.g. as in the image of *Pachyneuron* below). The key identification features are shown in Figures 8 to 11:

8. *Dendrocerus* spp.

9. *Asaphes* spp.

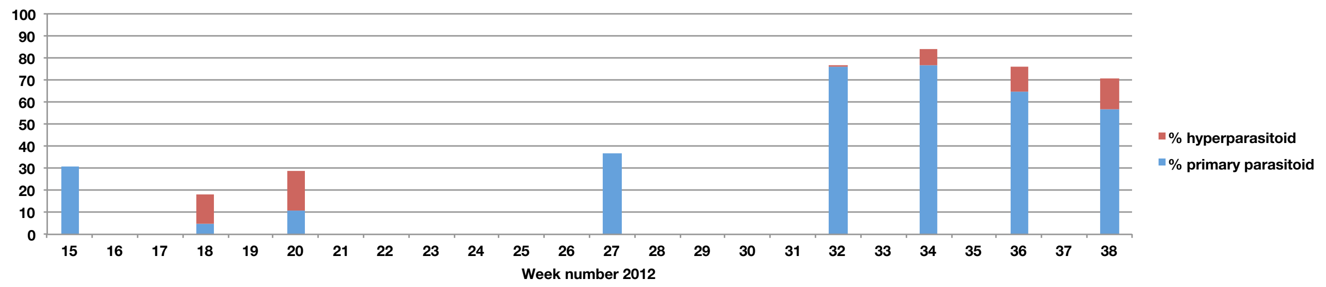


10. *Pachyneuron* spp.

11. *Alloxysta* spp. The short-winged species (left) is *A. brachyptera* and the longer-winged species (right) is *A. brevis.*

Alleviating the problem

At the Essex nursery in 2011, aphid populations required supplementary treatment with Chess (pymetrozine) and/or Aphox (pirimicarb) around week 24 (mid-June). These treatments were very effective and numbers of aphids, primary parasitoids and hyperparasitoids all declined to a very low level. Aphids rapidly recolonised the crop as did the primary parasitoids which were being released on a weekly basis. However, the hyperparasitoids were slower to recolonise and did not make a serious impact on the biological control programme for the rest of the season. This is illustrated in Figure 12 below which shows the percentage of adult primary parasitoids and hyperparasitoids emergent from all mummies collected:



12. Percentage of adult primary parasitoids and hyperparasitoids emergent from all mummies collected at the Essex trial site

Financial implications

The cost of routine control measures applied against aphids in conventional pepper crops is about £5.8k per ha per season. In one case, where severe aphid infestations persisted in organic crops, the overall cost of additional biocontrols, sprays, labour to wash fruit and loss of marketable yield exceeded £100k per ha per season. It is estimated that successful control measures developed by this project and subsequent work could ultimately save growers between £0.8k and £95k per ha per season depending on the severity of the existing problems. In addition, the work paves the way for further studies aimed at providing more sustainable biologically-based solutions. This in turn will help growers to satisfy the standards sought by major food retailers and thus improve competitiveness of the UK industry (Figure 13).

Hyperparasitism is not unique to pepper crops. Aphids are serious pests of a wide range of protected and outdoor crops and continuous control with primary parasitoids has proved to be very difficult in most situations. A thorough understanding of hyperparasitoid foraging behaviour could enable us to interrupt the process and thereby reduce their commercial impact. The results of a spin-off project by an Imperial College student demonstrated the existence of a semiochemical released by mummified aphids which acted as an attractant to *A. suspensis.* This attractant could be incorporated into hyperparasitoid traps.

13. Retailers demand high quality fruit

Acknowledgements

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