Project title:	Increasing hoverfly populations in apple orchards for control of apple aphids
Project number:	TF 218
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Report:	Year 2 report 2016
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Key staff:	Chantelle Jay
Location of project:	NIAB EMR
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Dr Chantelle Jay

Research entomologist

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Prof Jerry Cross

Head of PPESCM

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CONTENTS

GROWER SUMMARY

Headline

- The plant volatiles methyl salicylate, phenyl ethanol and (E)-β-farnesene in combination increased the number of hoverflies caught in baited traps indicating adult attraction.

Background and expected deliverables

Apple aphids are ongoing pest problems and biological control can help to reduce the severity of attack or eliminate the pest altogether. Hoverfly larvae are voracious predators of aphids and if adults can be attracted into the orchard early in the season, and/or encouraged to overwinter in or close to orchards (hoverflies overwinter either as adults or pupae depending on the species), this increase in predators would be an important component of an IPM strategy. Biocontrol is particularly effective where ants are discouraged from protecting the aphids. Hoverfly adults respond to plant produced volatiles and to components specific to aphid feeding.

This project aims to determine whether volatiles can be used to attract hoverflies into orchards and whether they then act as effective predators of aphids, reducing aphid populations in the orchard.

Summary of the project and main conclusions

Experiments have been done at East Malling Research to determine a blend of chemicals that will attract hoverflies and to examine the use of colour cues to assess if these will increase the attraction to hoverflies

The results, which are set out fully in the Science Section of this report, clearly show that hoverflies can be attracted to specific volatiles, and in these experiments a combination of the volatiles phenyl ethanol, methyl salicylate plus (E)-β- farnesene had the greatest catches when blends were compared. Given that (E)-β- farnesene is expensive to purchase, it may not be a cost effective addition to a dispenser. However, a combined blend of farnesene isomers may still give an increased catch and is worth exploring given that the cost of production is far cheaper. A combined phenyl ethanol and methyl salicylate dispenser may have a use in attracting other orchard beneficials such as lacewings, the combined blend being more effective than the single compounds alone.

Work in 2016 will concentrate on the blend required for hoverfly attraction and the economics of scale. With the withdrawal of commercially available aphicides this year such

as chlorpyrifos, alternative control options will be essential to develop an effective IPM system.

Financial benefits

Apple trees are subject to a number of aphid pests including the rosy apple aphid (*Dysaphis plantaginea* (Passerini)), the rosy leaf curling aphid (*Dysaphis devecta* (Walker)) and the green apple aphid, (*Aphis pomi* (De Geer)). When conditions are favourable pest numbers can increase rapidly. The rosy apple aphid is the most damaging of these and high numbers result in curled leaves and misshapen fruits, which can lead to economic losses. The Assured Produce threshold for RAA suggests that crop protection product application is justified if one aphid is found in the orchard pre-blossom. Some organic orchards see 100% crop loss from rosy apple aphid.

- Integrated pest management (IPM) strategies reduce crop protection product inputs, residues on the fruit and the risk of development of pest resistance to products.
- The use of plant volatiles to attract beneficial species is compatible with IPM and organic control programmes in apple orchards.
- If successful we will be able to manipulate beneficial species numbers in orchards with the aim of ultimately reducing pest numbers.
- Attraction of hoverflies into orchards would also be economically favourable as the adults are important pollinators. They are reported to be the most important pollinator group after wild bees.

Action points for growers

- At this stage there are no specific recommendations for growers.

SCIENCE SECTION

Introduction

Aphids can be serious pests of apple and pear trees. Many naturally occurring predators attack aphids and other pests in apple orchards, but often migrate into orchards as pest populations increase, and thus too late in the season to prevent damaging populations of the pest from occurring. Hoverflies (Family: Syrphidae) are important predators of aphids early in the season; adults have a high fecundity and the larvae are voracious predators. One of the most common species early in the season is *Episyrphus balteatus* which is a migratory hoverfly with larvae that feed on a range of aphid species, but which can overwinter in UK orchards. Therefore a possible control strategy would be to encourage hoverflies into the orchards before pest numbers increase on the trees.

Predation by hoverflies and other beneficial species is more effective when the ants that have a mutualistic relationship with the aphids are excluded from the system. Tree-banding and supplementary sugar feeding have been shown to reduce ant attendance which has led to an increase in control by beneficial insects and a reduction in aphid numbers (Stewart-Jones et al., 2008; Nagy et al., 2013; Nagy et al., 2015). Whilst the main hoverfly species have some defence strategies against ant attack, especially the third instar larvae, in the early larval stages in the early season they are more vulnerable to ant attack (Nagy, pers comm.).

Many plants respond to herbivore feeding by producing volatiles that act to reduce herbivore colonisation. These herbivore induced plant volatiles (HIPVs) have been shown to be attractive to some beneficial insects (Scutareanu et al., 1997; James, 2005). One volatile, methyl salicylate, has been used to encourage beneficial insects into grapes and hops (James and Price, 2004), and following this James (2005) tested a range of HIPVs in grassland and hop gardens as attractants for beneficial insects. Mallinger et al. (2011) also used methyl salicylate as an attractant in soybean. Methyl salicylate dispensers are commercially available in the US as PredaLure sachets™. As part of a Defra HORTLink project (TF 181, HL 0194) to develop novel control strategies for pear psylla, in experiments monitoring beneficials by using delta traps holding dispensers containing plant volatiles, we

found that methyl salicylate and phenyl ethanol were more effective at trapping hoverflies than control traps with no volatiles. Volatile components of aphid honeydew and aphid pheromones may also be attractive to hoverflies (Stökl et al., 2011). Hoverflies are thought to use host and plant volatiles in the penultimate stage of short range prey detection (Almohamad et al., 2009). These volatiles may not have an effect on the final searching behaviour (Joachim and Weisser, 2015).

Visual stimuli may also be important in attracting hoverflies. A blue colouration with a peak reflectance within the blue-violet region (400-520 nm) has been shown to be more effective at trapping hoverflies in plum orchards (Hartfield, PhD thesis 1998). Higher catches were also found on blue sticky traps in pear orchards (Defra HORTLink project, TF 181, HL 0194). Yellow is also known to be an attractive colour; hoverflies are also known to visit white and yellow flowers such as sweet alyssum (Gontijo et al., 2013).

The use of volatiles and visual stimuli to attract hoverflies should be transferable to apple orchards in the UK. In this project, replicated experiments were carried out to assess the effects of the use of volatiles alone and in combination to encourage hoverflies into orchards either early in the season or in the autumn. If an appropriate species can be attracted into the orchard when pest numbers are still low in spring this could offset the use of an early season insecticide application. As increased numbers of hoverflies are found in the orchards in autumn, and we have found an attraction to volatile compounds at this time, we have explored the possibility of attracting species that overwinter, leading to populations of adults in the spring and an earlier production of the larvae.

Materials and methods

Replicated field experiments aimed to use synthetic volatiles to attract hoverflies into apple orchards.

Orchards at EMR were mainly used for the experiments: EMR Wiseman orchard is further separated by windbreaks to give twelve sub-orchards, each of 0.1 ha and with 12 trees per row and 12 rows. Each row is planted with one of eight different cultivars. The distance between trees within the row was 1.8 m and between the rows was 3.5 m. EMR GE186 is an organic orchard of 1.39 ha which has double row plantings of three varieties. Planting spacing is 3.5 x 1.83 m. EMR VF225 is an organic orchard with the with 3.5 x 1 m spacing. Orchards at Broadwater farm were also used for the overwintering experiments by kind permission of Peter Checkley.

Experiment 1 – Spring volatiles 2015

This experiment aimed to determine a blend of chemicals to attract hoverflies. This was set up in the spring 2015 in EMR GE186 in a randomised block design, with 5 replicates of 4 treatments. Each block was a single row of cv. Rajka. Traps were at least 18 m apart within and 19.5 m apart between the rows.

Treatments were dispensers containing:

1. methyl salicylate (Sigma-Aldrich, UK) + phenyl ethanol (Sigma-Aldrich, UK),
2. methyl salicylate (Sigma-Aldrich, UK) + phenyl ethanol (Sigma-Aldrich, UK) + e β farnesene (Bedoukian research, Danbury, CT 06810, US),
3. phenylacetaldehyde (Sigma-Aldrich, UK) and methyl salicylaldehyde (Sigma-Aldrich, UK)
4. untreated control.

Dispensers were produced at the Natural Resources Institute (NRI), University of Greenwich. Each dispenser had a 0.5 ml loading of each chemical onto dental roll. As in year 1, the dispensers were hung inside a white delta trap with a sticky insert (size 15 cm x 15 cm). Treatments were put out on 22 April 2015. Hoverfly catches in the traps were checked every two weeks, on 28 April, 5, 12, 22 and 29 May, 2, and 12 June, and hoverflies were removed for identification and the sticky bases were replaced as required. The glue from the sticky base still present on the body of the hoverflies was removed using hexane and the hoverflies were identified under a binocular microscope.

Experiment 2 – Spring colour cue experiment

Colour cues were added to phenyl ethanol and methyl salicylate lures to see if this could increase the attraction to hoverflies. The experiment was set up on 26 May 2015 in orchard EMR VF. Each block was a single row of trees cv. Rajka with traps at least 15 m apart within and 15 m apart between the rows. Each plot was a single tree. Trees were marked at the central post with red electrical insulating tape for ease of assessment. A pre-treatment assessment was done by marking aphids colonies, counting the number of leaves affected and counting the number of aphids per colony, and counting any predators present. Treatments were allocated in a randomised block design, with four blocks (replicates) of four treatments. Treatments were dispensers containing methyl salicylate + phenyl ethanol (Sigma, UK), 0.5 ml loading of each chemical, loaded onto dental roll, either with no colour cue, or with a yellow or blue colour cue (Image 1). These were compared with an untreated control. Bottle traps containing sucrose solution (30%) were attached to the base of each tree on 9 June to attract ants and to deter them from visiting the aphids. Trees were assessed on 5, 17 and 25-26 June 2015 to assess whether colony numbers have increased/decreased in treated plots.

Image 1. Phenyl ethanol and methyl salicylate dispensers without and with a colour cue.

Experiment 3 –Summer volatile experiment

This experiment compared methyl salicylate, both alone and in combination with phenyl ethanol. Two sources of methyl salicylate were used, a sachet produced by NRI, with the chemical from Sigma UK, as has been used in the previous experiments, and a sachet containing methyl salicylate, marketed by AgBio. Inc., USA, as Predalure™. The phenyl ethanol was a single volatile dispenser produced by NRI, with the chemical from Sigma UK.

This was set up in EMR GE186. Each block was a single row of cv. Rubinicola with traps at least 18 m apart within and 19.5 m apart between the rows (10 trees apart, and at least 5 trees into the row). Treatments were dispensers containing:

1. Methyl salicylate (Sigma, UK. Dispenser produced at NRI, Greenwich)
2. Methyl salicylate (as Predalure, AgBio. Inc. USA)
3. Methyl salicylate (Sigma, UK. Dispenser produced at NRI, Greenwich) + Phenyl ethanol (Sigma, UK. Dispenser produced at NRI, Greenwich)
4. Methyl salicylate (as Predalure, AgBio. Inc. USA) + Phenyl ethanol(Sigma, UK. Dispenser produced at NRI, Greenwich)
5. Untreated control

Each dispenser had a 0.5 ml loading of each chemical loaded onto dental roll. As in experiment 1, the dispensers were hung inside a white delta trap with a sticky insert (size 15 cm x 15 cm). Treatments 3 and 4 had two dispensers per trap. The experiment was set up in a randomised block design with 5 replicates of 6 treatments. Treatments were put out on 06 August 2015. Traps were assessed on 11, 17 and 24 August. Beneficial insects were identified under a binocular microscope and were assessed to species level where possible.

Experiment 4 – Autumn trapping experiment with colour cues

In an autumn colour experiment, different coloured delta traps (with white sticky inserts), yellow, white, blue or green (as a control) plus and minus a phenyl ethanol & methyl salicylate lure were compared. The experiment was a randomised block design at GE186, with 4 blocks with the 8 treatments. Traps were placed on every 8th tree in the row (Var. Rubinicola), starting 3 trees into the row. Blocks were on every 6th row (from row 5). There was at least one row on either side of the block. Traps were put out on 25 September 2015 and assessed on 1, 14 and 28 October and 18 November. Hoverflies were collected and identified under a binocular microscope.

Overwintering experiments

Overwintering experiment 2014-2015

As reported in the last annual report, an autumn experiment was deployed to attempt to encourage hoverflies into the orchards. This was assessed in the spring of 2016. This experiment used single synthesised volatiles, either methyl salicylate or phenyl ethanol or β Farnesene which were attached on 17 September 2014 directly to the trees using red electrical insulating tape at 150 cm height in a 3 x 3 grid formation 7 m square (which will be compared to the untreated control). This was a randomised block design with 3 replicates of

each treatment. Large plot sizes were required for this experiment therefore as the Wiseman orchard at NIAB EMR is planted in twelve areas, separated by windbreaks, these were used as experimental units. Plots were assessed from March 2015 until May 2015 by placing a blue and yellow monitoring trap with a phenyl ethanol and methyl salicylate lure at the base in the centre of plot (Image 2).

Image 2. Spring monitoring trap with yellow and blue colour cues and a phenyl ethanol and methyl salicylate dispenser

Overwintering experiment 2015-2016

To enable the overwintering experiment to be trialled on a larger scale, a higher number of dispensers were put out into orchards, 20 per plot, each with a yellow colour lure. Individual orchards were used as blocks with a control and treated area in each orchard. Orchards were Wiseman orchard at NIAB EMR (2 blocks were included due to the partitioning of this orchard, and yellow plus white colour lures were used), and 6 orchards at Broadwater Farm, Kent, courtesy of Peter Checkley. The volatile dispensers were placed in every 2nd to 4th row depending on the orchard, and in every 3rd or 4th tree within the row. These were placed in the orchards on 2 and 7 Oct 2015 for the Wiseman and Broadwater farm orchards respectively. On 24 Feb 2016 the dispensers were collected from the orchards and these were replaced with new white delta traps, 2 per plot, containing a phenyl ethanol and methyl salicylate dispenser. Traps were assessed on 10 & 23 March and 5 & 18 April 2016.

Image 3. Volatile dispensers plus colour cue for autumn attraction of hoverflies.

Results

Experiment 1 – Spring volatiles 2016

The phenyl ethanol + methyl salicylate + e β farnesene dispenser caught significantly higher numbers of hoverflies across the season than the untreated control (Table 1). The phenylacetaldehyde and methyl salicylaldehyde dispenser was also significantly different from the control when looking at the June data alone. The phenyl ethanol and methyl salicylate dispenser was not significantly different to the control, but was also not significantly different to the phenylacetaldehyde and methyl salicylaldehyde dispenser. *Episyrphys balteatus* and *Platycheirus* spp, were the main species found, with other species including *Eupeodes spp.* and *Melanostoma* spp. also found early in the season.

Table 1. The effect of volatile dispensers on mean numbers of hoverflies caught in white delta traps placed in an apple orchard (EMR GE186) in the spring.

		June only	**Total (22 April – 12 June)**
Treatment	Phenyl ethanol + methyl salicylate	3.2	4.4
	Phenyl ethanol + methyl salicylate + e β farnesene	**7.0***	**9.0***
	Phenylacetaldehyde and methyl salicylaldehyde	**3.8***	5.6
	Control	1.4	4.4
Statistics	p	0.002	0.015
	s.e.d.	1.09	1.33
	l.s.d.	2.37	2.90

* Significantly different from the control at $p<0.05$

Table 2. Species of hoverflies caught in white delta traps (of 120 identified).

Species and date	Count of Male	Count of Female	Sum of No
Dasysyrphus albostriatus	**1**		**1**
05/05/2015	1		1
Episyrphus balteatus	**9**	**8**	**20**
22/05/2015	2		2
02/06/2015	3		3
12/06/2015	4	8	15
Eupeodes corollae		**6**	**6**
22/05/2015		4	4
02/06/2015		1	1
12/06/2015		1	1
Eupeodes luniger		**3**	**3**
28/04/2015		1	1
12/06/2015		2	2
Melangyna lasiophthalma		**1**	**1**
12/06/2015		1	1
Melanostoma		**1**	**1**
12/06/2015		1	1
Melanostoma mellinum	**1**	**2**	**3**
22/05/2015	1		1
02/06/2015		2	2
Meliscaeva auricollis	**5**	**4**	**12**
02/06/2015	1	1	2
12/06/2015	4	3	10
Meliscaeva cinctella	**1**		**1**
12/06/2015	1		1
Platycheirus albimanus	**1**	**15**	**18**
05/05/2015		2	2
22/05/2015		2	2
02/06/2015		3	3
12/06/2015	1	8	11
Platycheirus angustatus		**4**	**4**
22/05/2015		4	4
Platycheirus balteatus		**1**	**1**
22/04/2015		1	1
Platycheirus peltatus	**7**	**1**	**8**
05/05/2015	1		1
22/05/2015	6	1	7
Platycheirus sp.		**18**	**21**
22/05/2015		4	6
02/06/2015		7	7
12/06/2015		11	14
Rhingia campestris	**4**	**4**	**9**
22/05/2015	3	2	6
02/06/2015	1	1	2

12/06/2015		1	1
Syrphus ribesii	**1**	**1**	**2**
12/06/2015	1	1	2
Syrphus torvus		**1**	**1**
12/06/2015		1	1
Syrphus vitripenis		**1**	**1**
28/04/2015		1	1
Xanthogramma pedissequum		**1**	**1**
12/06/2015		1	1
Grand Total	**30**	**76**	**120**

Experiment 2 – Spring colour cue experiment

There was no significant effect of colour cues attached to volatile dispensers in apple trees on the numbers of hoverflies or of other predators after one month, on 26 June (Table 3). Hoverflies were found in both the original aphid colonies, which were mainly *Dysaphis plantaginea*, and the new tagged colonies. Of the other predators recorded, these were mainly coccinelids, with only 1 earwig (note that assessments were done during the day), 5 spiders and 5 predatory bugs. The effect of volatiles on hoverfly attraction was difficult to assess as the level of aphid infestation was high in the orchard, which may have affected the volatile profile of the trees, with upregulation of the volatiles in question.

Table 3. The total number of hoverflies and other beneficial insects found in aphid colonies within 1 m of a phenyl ethanol + methyl salicylate dispenser, +/- a 2 x 5 cm colour cue, in an apple orchard, 2015.

	No. Colonies Marked/Assessed		**No. Hoverfly larvae/pupae**		**No. other predators**	
	26-May	26-Jun	26-May	26-Jun	26-May	26-Jun
Dispenser + Blue	37	57	3	5	2	6
Dispenser + Red tape (blank)	33	53	1	3	1	21
Dispenser + Yellow	40	58	2	8	3	20
No dispenser	34	51	2	3	3	22

Experiment 3 – Summer trapping experiment

Low numbers of hoverflies were caught in the summer trapping experiment (7 across all three sample dates). These were *Episyrphus balteatus* and *Playcheirus* spp. However, the green lacewing, *Chrysoperla carnea,* was the most commonly caught beneficial species, with 60 caught in total. The data for this species was analysed. They were most attracted to the combined phenyl ethanol plus methyl salicylate treatment with a mean total of 4.2 and

5.6 lacewings per trap for the NRI and Predalure™ dispensers respectively, significantly different from the control which caught no insects (P = 0.01, d.f. = 20, s.e.d. = 1.615, l.s.d. = 3.368) (Fig. 1). There was no significant difference between the sources of methyl salicylate. Although other beneficial species were caught, such as parasitoid wasps, soldier beetles and *Orius* bugs, numbers were low and with no significant treatment effect.

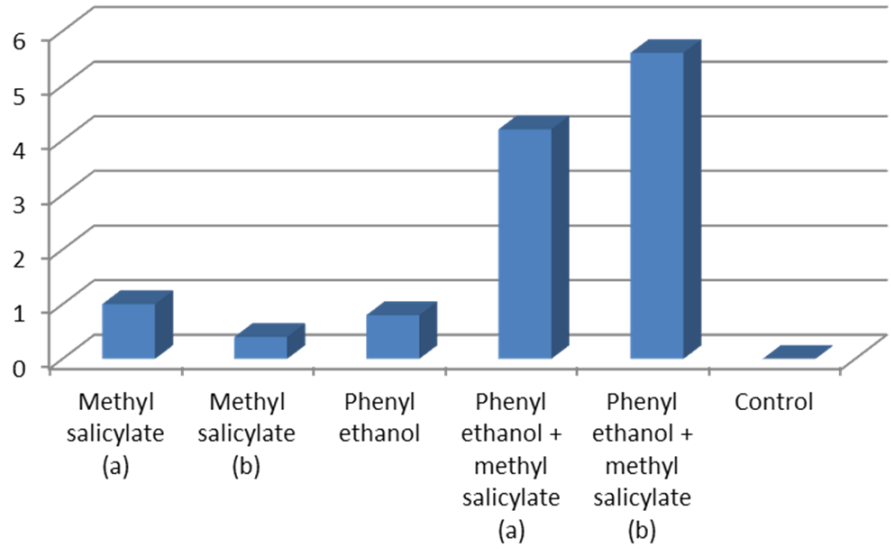

Figure 1. The mean total number of *Chrysoperla carnea* caught per volatile treatment per trap. The source of methyl salicylate dispenser is shown in parenthesis: (a) Sigma chemicals UK, dispenser produced by NRI, the University of Greenwich, (b) Predalure™ AgBio Inc. USA. The source of phenyl ethanol dispensers (Sigma chemicals UK, dispenser produced by NRI, the University of Greenwich) are the same regardless of the source of methyl salicylate.

Experiment 4 – Autumn trapping experiment with colour cues

In the autumn colour experiment 27 hoverflies were found: *Episyrphus balteatus, Eupeodes luniger, Helophilus pendulus, Melanostoma mellinun, Meliscaeva auricollis, Platycheirus sp., Platycheirus sp., Sphaerophoria scripta, Syrphus ribesii* and *Syrphus torvus.* The majority of hoverflies were found in white traps with a volatile dispenser, surprisingly no hoverflies were found in the yellow traps with a dispenser, as the literature suggests this as an attractive colour. Only low numbers were found in the blue traps with a dispenser (Fig. 2).

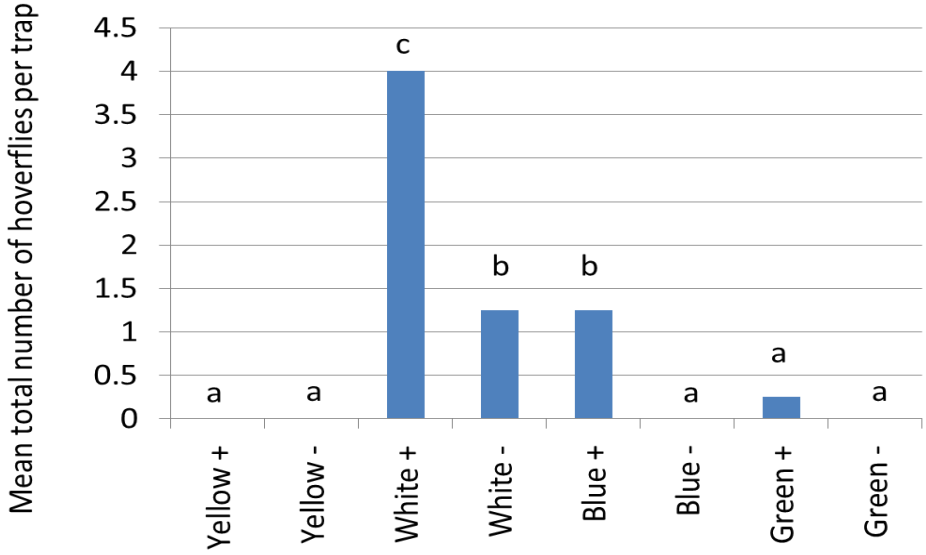

Figure 2. The mean total number of hoverflies caught per trap, in traps of different colour and with (+) or without (-) a methyl salicylate and phenyl ethanol lure, in an apple orchard between 25 Sep to 18 Nov 2015.

Overwintering experiments

Overwintering experiment 2014-2015

Following the autumn experiment 2014, few hoverflies were caught early in the spring season 2015. *Episyrphus balteatus* was the first hoverfly species caught in March and no more than two hoverflies were caught on any one date (Table 4), therefore no statistical analysis could be done.

Table 4. Hoverfly species found in an apple orchard early in the 2015 season.

Date	Species	Total
24 Mar 15	*Episyrphus balteatus*	1
01 Apr 15	*Episyrphus balteatus*	1
01 Apr 15	*Melangyna umbellatarum*	1
14 Apr 15	*Platycheirus sp.*	1
14 Apr 15	*Syrphus torvus*	1
01 May 15	*Platycheirus sp.*	1
22 May 2015	*Sphaerophoris interrupta*	1

Overwintering experiment 2015-2016

Following the autumn experiment in 2015, in 2016 more hoverflies were caught early in the spring season than in the previous year. The first hoverfly was caught in early March and whilst 21 hoverflies were caught (with more in the control plots), numbers were still low and therefore no statistical analysis was done (Table 4). By the third sample date the numbers were similar in both the treated and control plots. Sampling will be continued until the end of May to give an indication of the species in the orchards at this time, and to cover all species which may have overwintered, as emergence times vary greatly.

Table 5. Hoverfly species found in eight apple orchards early in the 2016 seaon, following treatments of methyl salicylate + phenyl ethanol dispensers plus a yellow colour cue in autumn 2015.

Date	Species	Sum of No. Autumn volatile	Sum of No. Control
10-Mar-16		**6**	**15**
	Episyrphus balteatus	2	6
	Eupeodes luniger	0	1
	Meliscaeva auricollis	3	8
	Platycheirus albimanus	1	0
23-Mar-16		**7**	**14**
	Episyrphus balteatus	4	3
	Eupeodes luniger	0	6
	Meliscaeva auricollis	2	3
	Platycheirus albimanus	1	2
05-Apr-16		**16**	**22**
	Episyrphus balteatus	1	0
	Eupeodes luniger	7	7
	Melanostoma scalare	0	1
	Meliscaeva auricollis	0	2
	Platycheirus albimanus	6	12
	Syrphus ribesii	1	0
	Syrphus torvus	1	0
18-Apr-16		**36**	**37**
	Eupeodes corollae	1	0
	Eupeodes luniger	9	5
	Melanostoma mellinum	6	1
	Melanostoma scalare	1	5
	Platycheirus albimanus	19	23
	Platycheirus scutatus	0	1
	Syrphus torvus	0	2

Discussion

The results clearly show that hoverflies can be attracted to specific volatiles, and in these experiments a combination of the volatiles phenyl ethanol, methyl salicylate plus (E)-β-farnesene had the greatest catches when blends were compared. Given that (E)-β-farnesene is expensive to purchase, it may not be a cost effective addition to a dispenser. However, a combined blend of farnesene isomers may still give an increased catch and is worth exploring given that the cost of production is far cheaper. The combined phenyl ethanol and methyl salicylate dispenser may have a use in attracting other orchard beneficials such as lacewings, the combined blend being more effective than the single compounds alone. Addition of colour cues may bring added benefits to attract hoverflies, however this was unclear from the 2015 work and the spectral profile of the colour traps used would need to be determined. Work for 2016 will concentrate on the volatile blend required for hoverfly attraction and the economics of scale. Given the results of the autumn overwintering experiments, it is likely that this is an unlikely avenue for control purposes. With the withdrawal of products such as chlorpyrifos this year, alternative control options are valuable in an IPM system.

Conclusions

Work to date has shown that the combination dispensers are more attractive to hoverfly species. The emphasis for work in 2016 will be to determine a cost effective blend for use in the field.

Knowledge and Technology Transfer

23 Feb 2016 EMRA AHDB Tree Fruit Day.

Acknowledgements

Thanks go to Zeus Mateos for help with the field experiments and identification of hoverfly species.

Glossary

Plant volatiles – these are chemicals that are produced by the plant. These can be referred to as herbivore induced plant volatiles (HIPVs) if the chemicals are upregulated following feeding by a pest.

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