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Project number:	TF 209
Project leader:	Professor Jerry Cross, East Malling Research
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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.

Professor Jerry Cross

PPESCM Programme Leader

East Malling Research

Signature ..... Date .....

Professor David Hall

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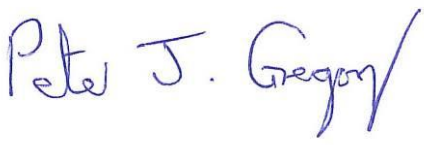

26 February 2015

Signature ..... Date .....

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GROWER SUMMARY

Headline

- Studying the behaviour and appearance of apple fruit rhynchites in orchards has begun to reveal possible attraction to host-plant volatiles and when best to time spray applications.

Background and expected deliverables

Damage by apple fruit rhynchites (AFR), *Rhynchites aequatus* (Figure 1) has been increasing in UK apple orchards and sometimes pear orchards in recent years, probably due to changing patterns of insecticide use. Losses of 1% of fruit are common and losses >5% are not unusual. Hawthorn and blackthorn are the pest's usual host. Damage to apple is caused by feeding punctures in young developing fruitlets during and after blossom. In the first year of this project we found that females sever the stems of apple fruitlets after laying eggs and the development then probably occurs on the fruit on the ground (Massee 1954; Alford 1984). Up to this point it had never been seen or reported by growers or advisors. The pest causes damage at low population densities and the weevils are difficult to spot whilst they are feeding or egg laying. The extent of damage only becomes apparent when the characteristic corky scars develop (Figure 1), when it is too late to take action.

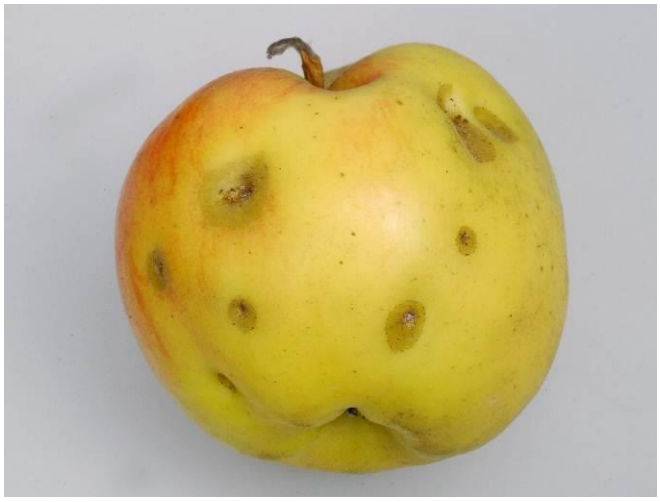

Figure 1. Damage by apple fruit weevil, *Rhynchites aequatus,* on apple

The weevil can be controlled by sprays of chlorpyrifos or thiacloprid (Calypso) but the former cannot be used during blossom because of the risk to bees and growers are reluctant to use thiacloprid during flowering for the same reason. Chlorpyrifos is broad spectrum and can damage other beneficial insects in the orchard and both chlorpyrifos and thiacloprid are damaging to earwigs.

It would be beneficial to develop a sensitive, species-specific semiochemical based monitoring trap for this pest. However, it is not known whether *R. aequatus* produces a sex or aggregation pheromone, when it is produced or which sex produces it. Many weevils are known to produce sex or aggregation pheromones, e.g. strawberry blossom weevil and pepper weevil, but in others pheromones do not seem to be so important, e.g. apple blossom weevil. Nothing is known about pheromones of Rhynchitidae and so it is important to demonstrate in preliminary studies whether semiochemical-mediated sexual attraction occurs before embarking on a major project to identify, synthesise and exploit it for pest monitoring or control.

Summary of the project and main conclusions

In Year 1 (2013) in the laboratory, it was found that males and females were able to identify each other and successfully mate, resulting in eggs being laid.

In a field experiment no statistical significances were identified to suggest attraction was occurring between males and females. There was some evidence that male AFR was repelled by other male AFR.

Sixteen volatile collections were made, but analyses of these collections by gas chromatography coupled to mass spectrometry (GC-MS) were unsuccessful and no sex specific compounds were identified.

In year 2 (2014) a replication of the year 1 field trial was deployed within the same unsprayed apple orchard. Live AFR were used as bait and tap sampling used as the collection method. Cages in single trees held single males, single females, both a male and a female or no weevils. Data was collected twice a week from the beginning of April (first collection), until mid-May when no more weevils were found within the orchard. Weevils were collected from apple orchards from the bud stage of flowering until fruit setting. In the field trial, no attraction between the sexes was observed. The only significant result was

seen in the numbers of female weevils caught on unbaited trees at the fruit setting stage. Mating and egg laying occurred in the laboratory culture, so males are females were able to identify each other. Larvae were found within fruitlets but they did not pupate and died.

Also as a repeat of year 1, volatiles were collected from weevils as individuals or in groups of 1-5 and with or without apple buds as food. Twenty-three collections were made. Analysis of these by gas chromatography coupled to mass spectrometry (GC-MS) showed no apparent differences in compounds present in collections from males or females that might be potential components of a sex or aggregation pheromone. When the collections were tested by electroantennographic (EAG) recording from antennae of *Rynchites*, good responses were obtained to collections made in the presence of food but not to those made without. Analyses of the collections by GC coupled to EAG recording showed a small EAG response to the large amount of benzyl alcohol in collections made with apple buds present. This compound may play a role in attraction of *Rynchites* to host plants.

Financial benefits

This project could eventually lead to the development of a sensitive, specific, semiochemical-based monitoring trap for apple fruit rhynchites. This will enable growers to minimise losses due to the pest, which probably average >1% in apple, and direct sprays against it only when they are needed. This project is therefore consistent with the industry's need to minimise and rationalise the use of pesticides.

Action points for growers

- Growers should monitor for AFR by inspection and tap sampling apple trees and surrounding hawthorn and blackthorn from early April.
- Data, thus far, suggests that spray applications targeted before the blossom is open should coincide with when AFR is in the trees.
- Orchards with high fruit damage the previous year should be treated in the spring avoiding bloom.

SCIENCE SECTION

Introduction

Apple fruit rhynchites weevil (AFR), *Rhynchites aequatus,* is a common pest of apple and pear. It damages fruit directly by inserting its rostrum into developing fruitlets and feeding. Females have been observed laying eggs in fruitlets and severing stems, causing them to drop. Although hawthorn is AFR's normal host, it has been increasing in numbers in commercial orchards, causing losses of between 1% and 5%. Chlorpyrifos and thiacloprid are capable of controlling the weevil. However, to be effective, these should be applied during blossom, and this is not approved as they can cause harm to pollinating bees.

In recent years, growers have reported problems in controlling AFR, as damage is only noticed when the fruit develop the characteristic corky scars (Fig. 1); by this time it is too late to take action.

R. aequatus moves from host to host depending on which species is in flower and it is able to successfully breed on hawthorn, blackthorn, apple and pear. Damage is caused by adult weevils feeding on the fruit or females laying eggs in the fruit. The rostrum is inserted into the fruit by both males and females for feeding. The females make a large hole in the fruitlet in which to lay a single egg. Once an egg is laid, the female partially severs the stem, causing the fruit to fall to the ground at a later stage (personal observations in this study) (Fig. 2).

Figure 2. Female *R. aequatus* partially severing the fruitlet stem after egg laying

The larvae develop within the fruitlet through the summer, migrating to the soil to pupate when the fruitlet drops. Adults emerge from the soil in the early spring. Only one generation a year is produced. Some adults are said to overwinter under bark but this has not been observed directly. Adults feed on buds, shoots and flowers, but primarily young fruitlets. It is not certain when mating occurs in the field.

There are currently no known biological controls for AFR. It is possible to control AFR with insecticide sprays although timing of sprays can be damaging to bees, compromising pollination.

Chlorpyrifos is a moderately persistent organophosphate (OP) insecticide which is fairly effective against AFR. In order for chlorpyrifos to be effective against AFR it must be applied to orchards throughout all stages from budding to fruit set development. For apple orchards, one spray can be applied pre blossom and three sprays can be applied post blossom with a 14-day harvest period. However, it cannot be applied during blossom because of its risk to bees.

Thiacloprid (Calypso) is a neonicotinoid which targets the central nervous system of the insect. Two applications can be applied each year. Although there is no evidence that thiacloprid has any adverse effects on bees and other pollinators, growers are reluctant to

spray during blossom. Thiacloprid and chlorpyrifos are harmful to earwigs, which are important predators of many tree fruit pests.

Materials and methods

Field trapping tests

Site:

All facilities and testing were at East Malling Research (EMR), New Road, East Malling, Kent, ME19 6BJ, by kind permission of the farm manager Graham Caspell. *R. aequatus* were collected from hawthorn (Aylesford Rugby Club, Kent) or apple (Wiseman Orchard, East Malling). The trial was done in Wiseman Orchard at EMR. Trees were rows of cvs. Queen Cox, Royal Gala, Fiesta, Saturn, Ahra, Ecolette and were part of an unsprayed apple orchard which was planted in 1994 (Fig. 3).

Figure 3. Map showing the location of Wiseman Orchard, EMR

Experimental design and layout:

The trial was a randomised block experiment with eight replicates of four treatments including an untreated control. The randomised design was divided between two orchard blocks (132 and 143) in the orchard. Each plot consisted of an individual apple tree. The plots in each block were arranged end to end in a row; with one tree spacing between each plot both running down the row and between the rows (Fig. 4).

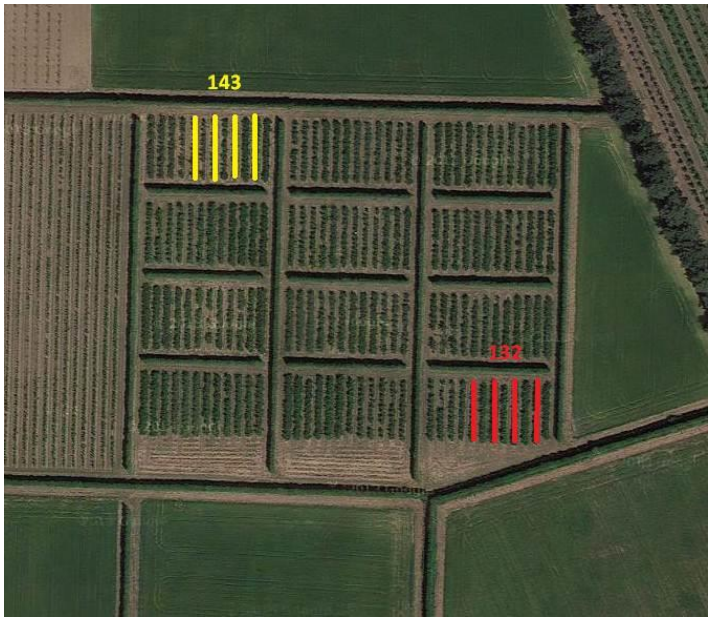

Figure 4. Location of weevil baited and unbaited trees in Wiseman orchard, EMR

Treatments:

Live AFR were used as the bait and were held in a mesh ball (tea strainer 5 cm circumference) suspended from the tree. Weevils were provided with a food source of either a fruitlet or flower bud depending on the growth stage of the tree. A sugar solution feeder consisting of a cigarette filter soaked in 15% sugar solution was also provided. The treatments were either one male, one female, both sexes or unbaited. Treatments that contained both a male and female weevil were housed in separate mesh balls to prevent mating. Each treatment was replicated eight times.

Assessments:

As a defence mechanism, AFR drop to the ground when disturbed. Assessments were done by tap sampling each tree over a white sheet spread under the tree. AFR were sexed and counted. Assessments were done twice a week. A subsample of weevils was collected to be used for entrainment (see collection of volatiles).

Plot maintenance:

All AFR used as bait were checked twice weekly at the same time as the assessment. Each was given a new flower bud and sugar feeder. Any dead weevils were replaced with a new weevil of the same sex.

Meteorological records:

Records from the EMR meteorological station are shown in Fig. 5 below.

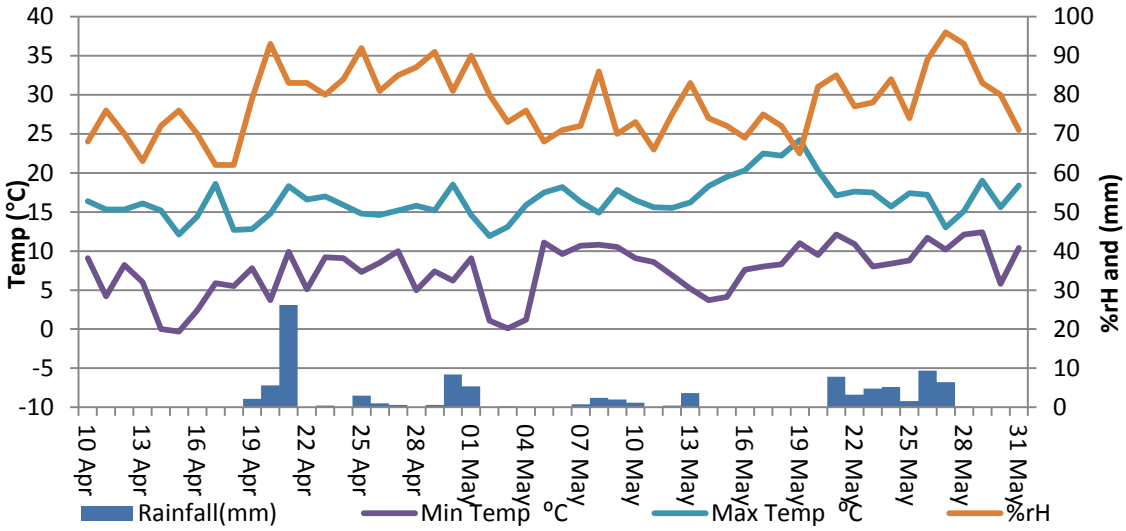

Figure 5. Meteorological records from 10 April to 30 May 2014

Statistical analysis:

Data were transformed to square roots and subjected to ANOVA. Differences between means were tested for significance ($P < 0.05$) by a Least Significant Difference (LSD) test.

Collection and analysis of volatiles

Collection of volatiles:

Collection of volatiles from *R. aequatus* was carried out in Controlled Temperature (CT) Room 2 at EMR. Lighting was on between 09:00 and 01:30 h and off between 01:30 and 09:00 h.

Insects were contained in silanised glass vessels (12 cm x 5 cm) and air was drawn in (200 ml/min) through an activated charcoal filter (20 cm x 2 cm; 8-10 mesh) and out through a collection filter consisting of Porapak Q (200 mg; 50/80 mesh) held between glass wool plugs in a Pasteur pipette (4 mm i.d.). Six sets of entrainment apparatus were used simultaneously.

The apparatus was cleaned by passing a continuous air flow through for 24 hours before the collections began. Collections were made for three-four days using the same filter for the whole period. The filters were connected and the pump was switched on for 30 minutes after placing the AFR in the chamber to give the insect time to settle. This was to reduce the likelihood of collection of any potential alarm compounds. At the end of volatile collection, all chambers were wiped clean with 100% ethanol and then by passing a continuous air flow through for 24 hours before being stopped.

It was not possible to determine if AFR were mated or unmated. The six treatments consisted of five males, five females or no insects, each with and without an apple bud as food source. Collections were made on 1 March (47 hours), 4 April (68 hours) and 10 April 2014 (88 hours).

Analysis of volatiles by gas chromatography coupled to mass spectrometry (GC-MS):

Collections of volatiles were analysed by gas chromatography coupled to mass spectrometry (GC-MS) at Natural Resources Institute, University of Greenwich (NRI).

The Porapak filters were eluted with dichloromethane (1 ml; Pesticide Residue Grade). Samples were analysed by GC/MS using a Varian 3800 GC coupled to a Saturn 2200 ion trap MS. A fused silica capillary column (30 m x 0.25 mm i.d. x 0.25 µ film thickness) was used coated with polar DBWax with helium as carrier gas (1 ml/min). Injection was splitless (220°C) and the oven temperature was programmed for 40°C for 2 minutes then the temperature increased by 10°C/min to 240°C. Data were captured and processed with Varian MS workstation v6.8.

Compounds were identified by comparison of their mass spectra and retention times with those of authentic standards. Samples were also analysed by GC with flame ionisation detection on a non-polar column (30m x 0.32mm i.d. x 250µ film thickness) coated with HP5.

Analysis of volatiles by electroantennography (EAG):

Collections of volatiles were also analysed by GC coupled to electroantennographic (EAG) recording from male and female *R. aequatus* in early June 2014, i.e. towards the end of the season.

EAG preparations were made by removing the head of the AFR. A ground electrode was then inserted into the back of the head and the distal end of one antenna was inserted into the recording electrode. Electrodes were glass capillaries filled with electrolyte (0.1 M KCL + 1% polyvinylpyrrolidone) and connected via silver wire electrodes to a Syntech INR-2 integrated micromanipulators and amplifier. The latter was connected as a second detector to the GC.

The outlet of the GC was split 1:1 between the flame ionisation detector and a glass T-piece in the GC oven which was flushed continuously with humidified air (300 ml/min) over the EAG preparation. Analyses were carried out with a fused silica capillary column (30 m x 0.32 mm i.d. x 0.25 µ film thickness) with polar DBWax with helium as carrier gas (2.4 ml/min). Injection was splitless (220°C) and the oven temperature was programmed from 50°C for 2 minutes then increased by 10°C/min to 240°C.

EAG responses to collections were also measured by direct "puff" tests. The sample was deposited on a strip of filter paper in a Pasteur pipette and air blown over it (300 ml/min for three seconds) to remove solvent. The end of the pipette was then inserted into the arm of a T-piece (4 mm i.d.) positioned over the EAG preparation and air blown over the sample and onto the preparation (300 ml/min for three seconds).

GC and EAG data were captured and processed with EZChrom Elite v6.

Results

Sexing and reproduction of AFR

In Year 1, it was observed that the male rostrum is as long as the head and pronotum together. The female is larger in size and the rostrum is 1.3-1.4 times longer than the head and pronotum together (Fig. 6). It was subsequently found that similar observations were documented by Morris (1990).

In the laboratory, males and females were able to identify each other and successfully mate, resulting in eggs being laid. This indicated that the weevils were suitable for use in trapping experiments and for collection of volatiles to identify potential pheromone components.

Figure 6. Female *R. aequatus* (left) with longer rostrum and male (right)

Field trapping tests 2014

Tapping for weevils started in late February in apple, hawthorn and blackthorn. Weevils were not found until the beginning of bud swelling in the three host species (Fig. 7). Weevils were collected in apple until fruit setting.

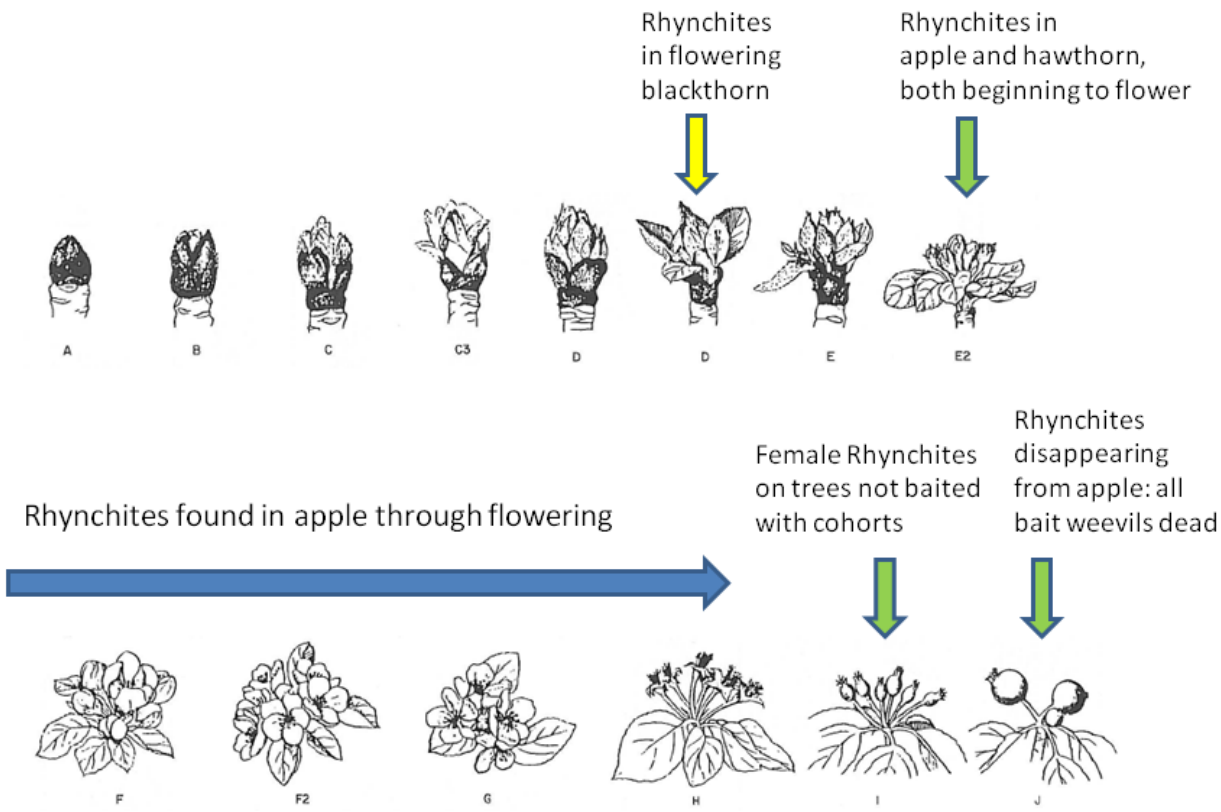

Figure 7. The presence of AFR in host species in relation to the growth stage of apple

For ANOVA, AFR counts were originally categorised by (Orchard / Variety) x Date x Sex x Treatment x Plot but due to the infrequency of data the developmental stage was used to categorise the counts instead of date. As the trial was run in several different apple varieties, they all had different times for flowering, petal drop and fruit setting. With this in mind, data was correlated with the growth stage of each tree using the European Plant Protect Organisation (EPPO) growth stage key for apples and pears using the scale from the Federal Republic of Germany (FRG). Stages were: Buds closed, Beginning of flowering, 10% Flowers open, 50% Flowers open, Flowering almost over, End of flowering, Flowering complete, Fruit development, Fruit 5-10mm.

Inspection of the number of observations in each Stage x Variety x Treatment showed that for some of the varieties that some of the stages were not used (Table 1). In view of this the stages were collapsed into three new stages making the data more evenly spread. The new groups are highlighted in different colours at the top of Table 1.

Table 1. Spread of data and new grouping of the stages highlighted by different coloured sections

Variety	Treatment	Buds closed	Beginning of flowering	10% Flowers open	50% Flowers open	Flowering almost over	End of flowering	Flowering complete	Fruit development	Fruit 5-10mm
Ahra	F	0	0	2	6	2	2	2	2	2
Ahra	M	4	0	0	2	4	2	2	2	2
Ahra	M/F	0	0	2	4	4	2	2	2	2
Ahra	U	0	0	2	4	4	2	2	2	2
Ecolette	F	2	0	0	4	4	0	4	2	2
Ecolette	M	0	2	0	4	4	0	4	2	2
Ecolette	M/F	0	2	0	4	4	2	2	2	2
Ecolette	U	2	0	0	4	4	0	4	2	2
Fiesta	F	2	4	0	0	4	0	4	2	2
Fiesta	M	2	4	0	0	4	0	4	0	4
Fiesta	M/F	2	4	0	0	4	0	4	2	2
Fiesta	U	2	4	0	0	4	0	4	2	2
Queen Cox	F	2	0	2	2	6	2	0	2	2
Queen Cox	M	0	2	2	2	6	0	2	2	2
Queen Cox	M/F	2	0	2	2	6	0	2	2	2
Queen Cox	U	2	0	2	2	6	0	2	2	2
Royal Gala	F	6	4	2	0	8	2	6	4	4
Royal Gala	M	6	4	2	0	8	2	6	4	4
Royal Gala	M/F	6	4	2	0	8	2	6	4	4
Royal Gala	U	6	4	2	0	8	2	6	4	4
Saturn	F	4	0	0	4	12	8	0	4	4
Saturn	M	4	0	0	4	12	8	0	4	4
Saturn	M/F	4	0	0	4	12	8	0	4	4
Saturn	U	4	0	0	4	12	8	0	4	4
Total		62	38	22	56	150	52	68	62	66

Square root of mean counts for each Variety x Treatment x Plot x Stage x Sex combination were analysed using ANOVA. There was evidence of overall Variety differences (not reported), and a Treatment x Stage (New) x Sex interaction (P = 0.011) (Table 2). There was a significant difference between the numbers of females caught on un-baited trees at Stage 3, which is when fruit setting occurs (Fig. 8).

Table 2. Table of mean counts of AFR

Table of sqrt(Mean Counts per Stage_new)

		Sex	
Treatment!	Stage_New!	M	F
F	Stage 1	0.555	0.631
F	Stage 2	0.417	0.530
F	Stage 3	0.354	0.354
M	Stage 1	0.781	0.646
M	Stage 2	0.373	0.473
M	Stage 3	0.088	0.390
M/F	Stage 1	0.535	0.894
M/F	Stage 2	0.330	0.295
M/F	Stage 3	0.250	0.088
U	Stage 1	0.718	0.532
U	Stage 2	0.228	0.443
U	Stage 3	0.213	0.720
Between Treatments	SED	0.189	
	LSD	0.386	
	d.f.	30	
M vs F	SED	0.154	
	LSD	0.311	
	d.f.	40	

Backtransformed Means

		Sex	
Treatment!	Stage_New!	M	F
F	Stage 1	0.308	0.398
F	Stage 2	0.174	0.281
F	Stage 3	0.125	0.125
M	Stage 1	0.611	0.418
M	Stage 2	0.139	0.224
M	Stage 3	0.008	0.152
M/F	Stage 1	0.286	0.799
M/F	Stage 2	0.109	0.087
M/F	Stage 3	0.063	0.008
U	Stage 1	0.516	0.283
U	Stage 2	0.052	0.196
U	Stage 3	0.046	0.518

Highlighted cell indicates significant difference

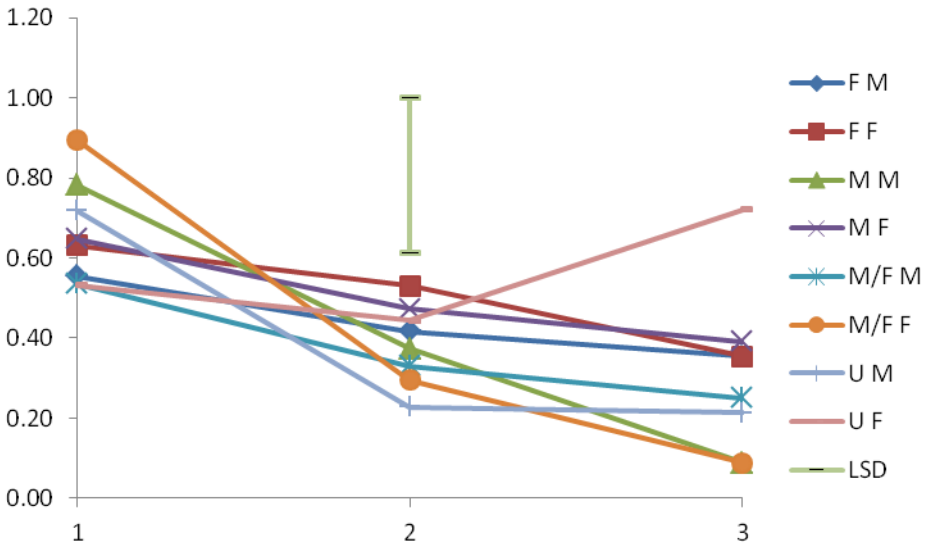

Figure 8. Mean number of AFR caught in relation to treatment, sex and stage of tree

Collection and analysis of volatiles

Analysis of volatile collections by GC-MS: In all, three batches of six samples were analysed by GC-MS on a polar column without concentration and again after concentration approximately x 10. Comparison of GC-MS analyses of volatiles collected from male and female AFR weevils with and without apple buds as food did not show any obvious differences between the sexes that could be potential components of a pheromone. Figs 9-12 show the analyses of samples after concentration.

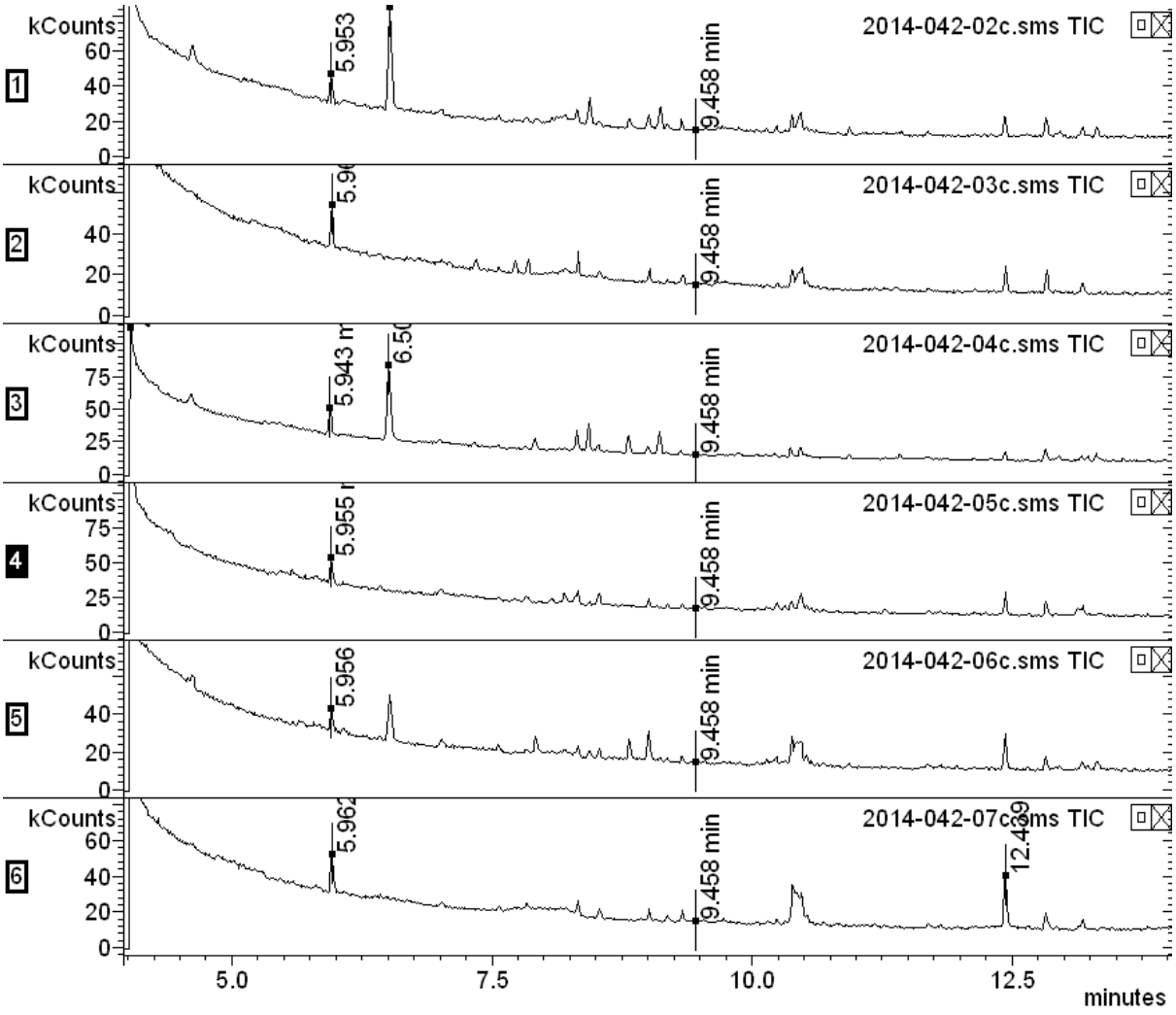

Figure 9a. GC-MS analyses (4-14 min) of volatile samples collected from AFR weevils 1 March 2014: (from top) five males with food, five males without, five females with food, five females without, food only, no insects or food (Compounds from apple bud: 6.51 min (*E*)-2-hexenal; 8.4 min 1-hexanol; 8.8 min (*Z*)-3-hexenol; 9.1 min (*E*)-2-hexenol)

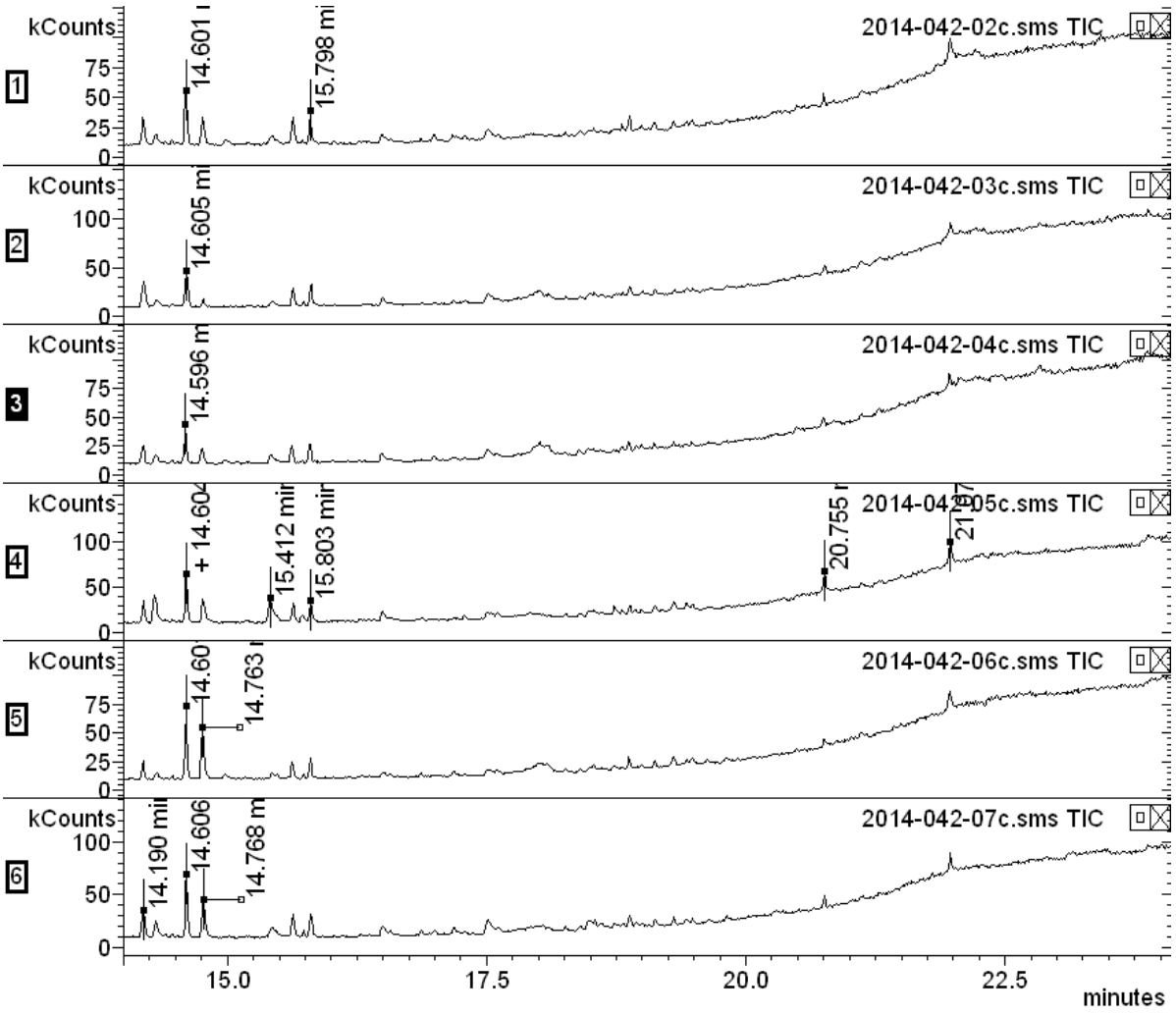

Figure 9b. GC-MS analyses (14-24 min) of volatile samples collected from AFR weevils 1 March 2014: (from top) five males with food, five males without, five females with food, five females without, food only, no insects or food

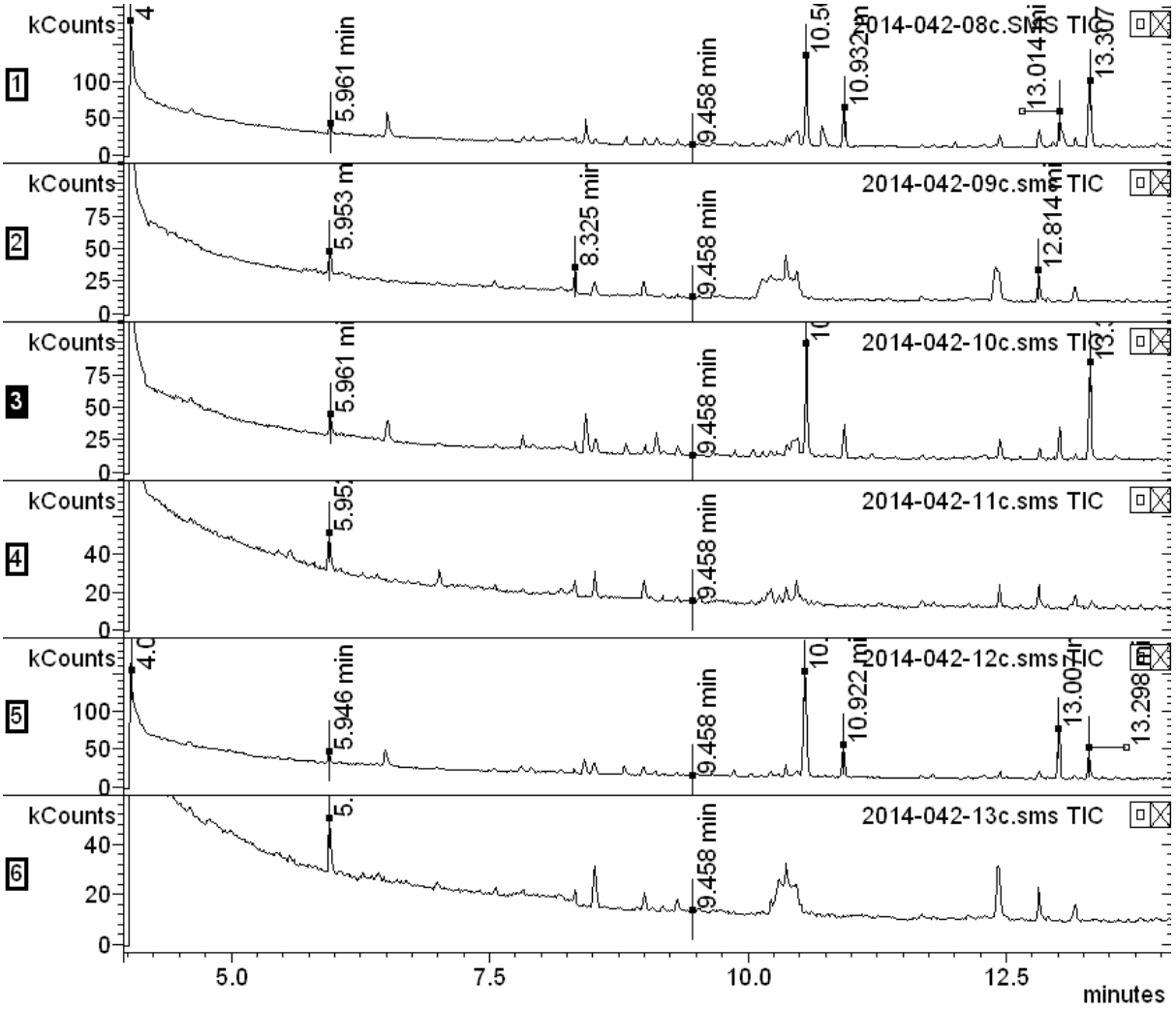

Figure 10a. GC-MS analyses (4-14 min) of volatile samples collected from AFR weevils 4 April 2014: (from top) five males with food, five males without, five females with food, five females without, food only, no insects or food (Compounds from apple bud: 6.51 min (*E*)-2-hexenal; 10.57 min benzaldehyde; 13.31 min α-farnesene)

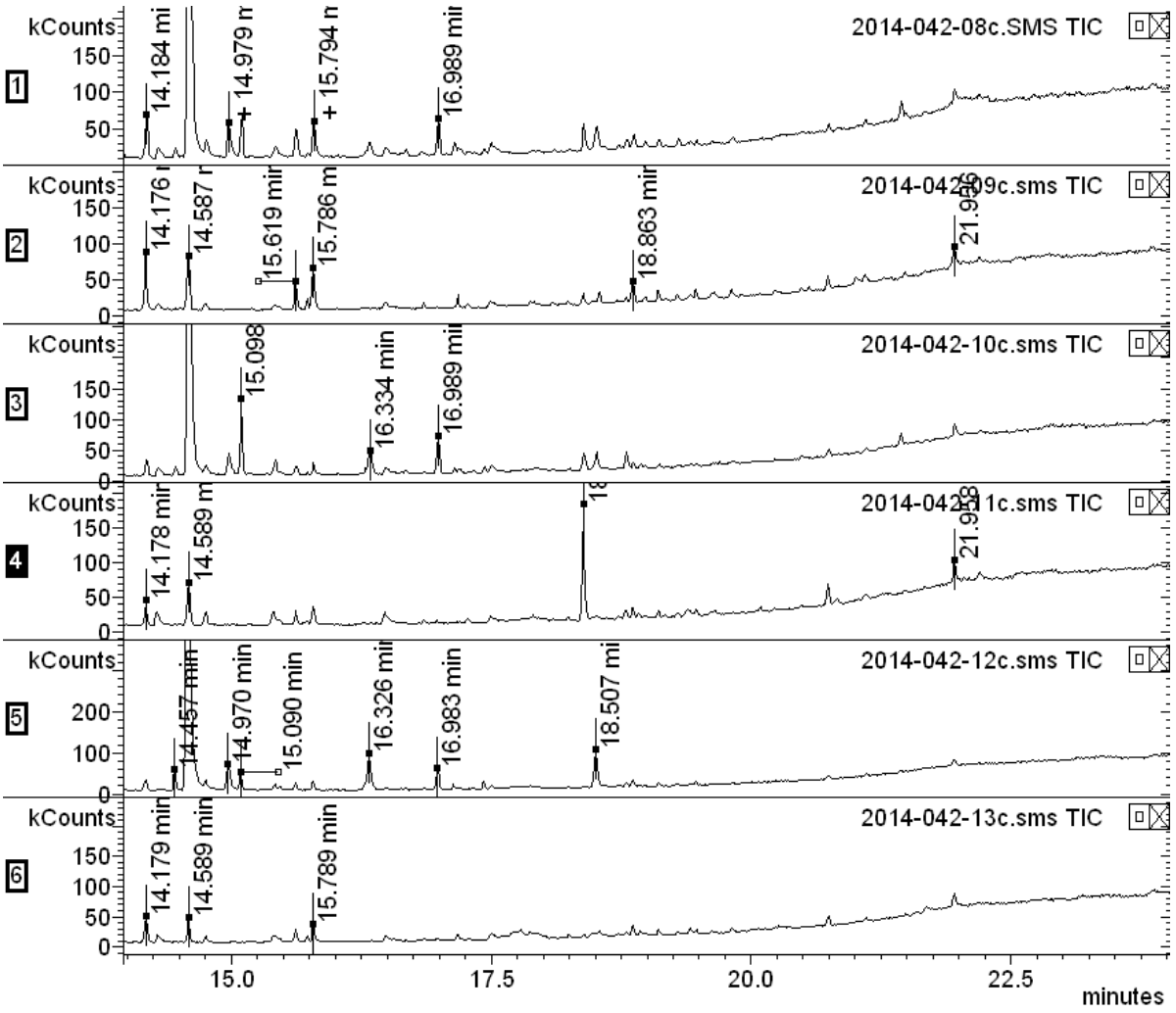

Figure 10b. GC-MS analyses (14-24 min) of volatile samples collected from AFR weevils 4 April 2014: (from top) five males with food, five males without, five females with food, five females without, food only, no insects or food (compounds from apple bud: 14.59 min benzyl alcohol)

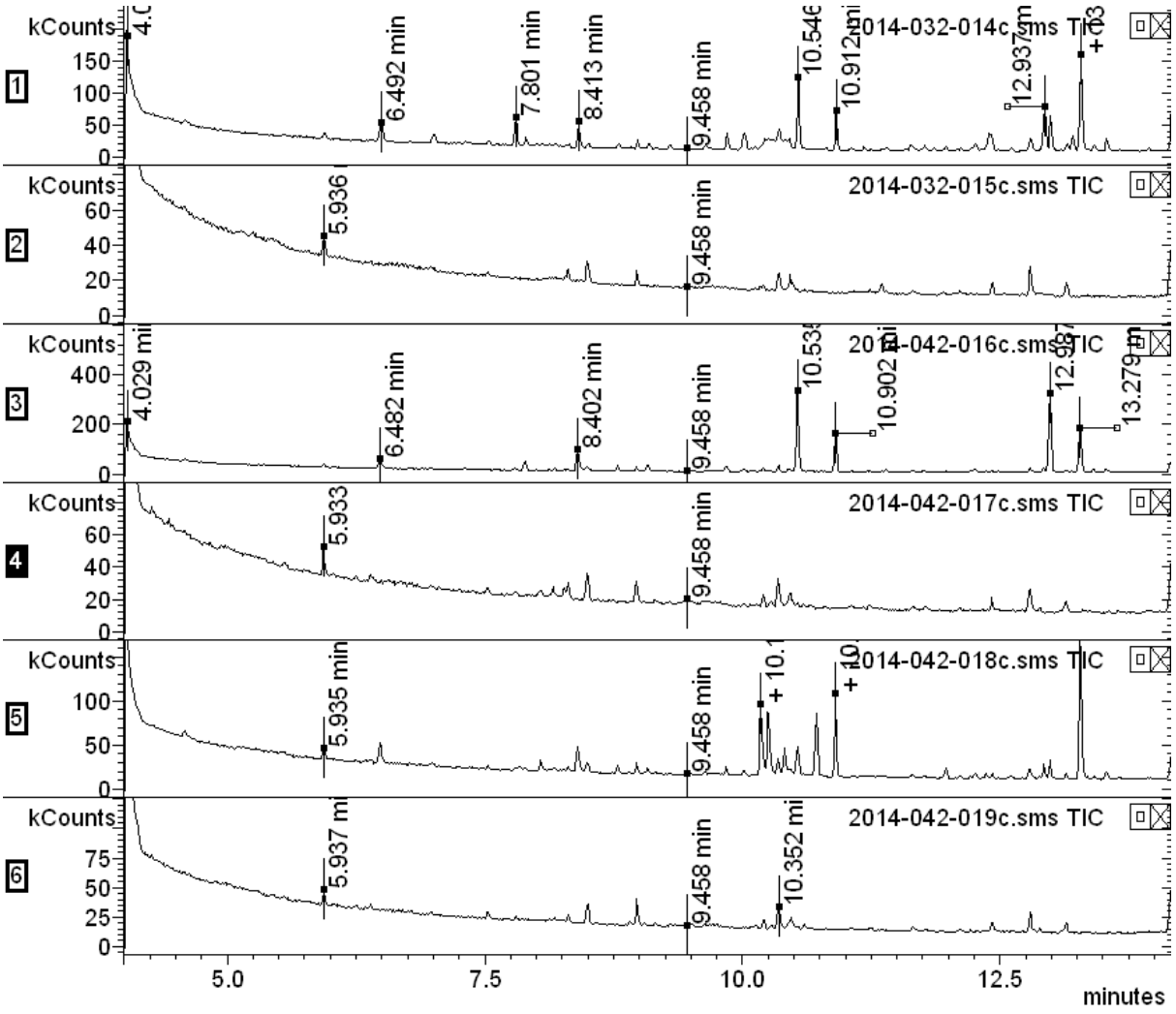

Figure 11a. GC-MS analyses (4-14 min) of samples of volatiles collected from AFR weevils 10 April 2014: (from top) five males with food, five males without, five females with food, five females without, food only, no insects or food (Compounds from apple bud: 6.51 min (*E*)-2-hexenal; 10.57 min benzaldehyde; 10.90 linalool; 12.98 benzyl acetate; 13.31 min α-farnesene)

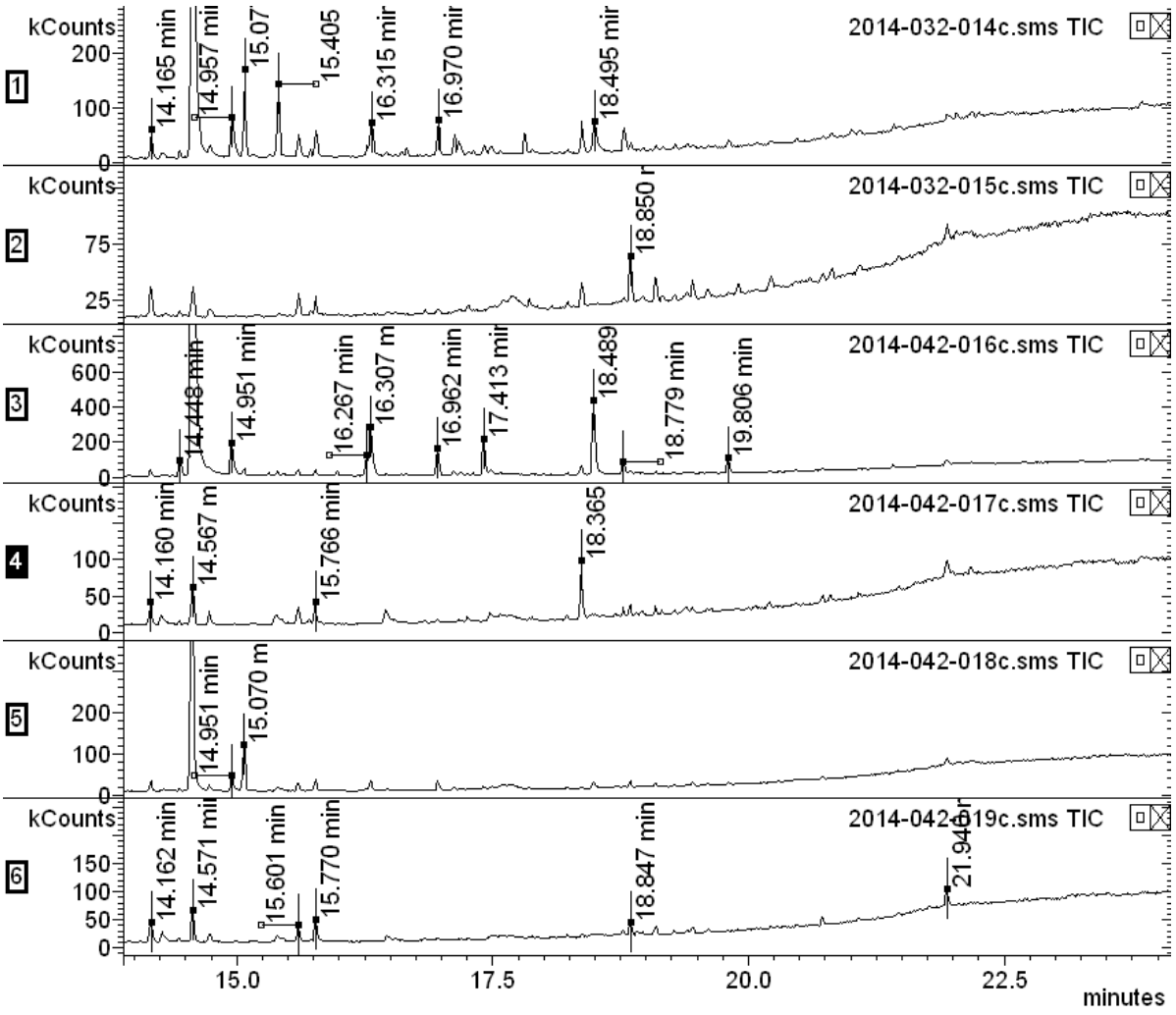

Figure 11b. GC-MS analyses (14-24 min) of samples of volatiles collected from AFR weevils 10 April 2014: (from top) five males with food, five males without, five females with food, five females without, food only, no insects or food (Compounds from apple bud: 14.44 min geranyl acetone; 14.58 min benzyl alcohol; 14.95 phenyl ethanol; 14.97 min benzyl nitrile; 16.31 phenyl propanol; 16.98 benzyl tiglate; 17.41 eugenol; 18.49 cinnamyl alcohol; 19.81 indole)

Several volatile compounds from the apple buds were detected and identified, particularly in the later samples (Fig. 11). The major compound was benzyl alcohol.

Analysis of volatile collections by EAG:

When collections of volatiles from male AFR weevils were “puffed” over the EAG preparation from a female AFR weevil, strong responses were recorded to the collection from weevils with an apple bud and very weak responses to the collection from weevils without (Fig. 12).

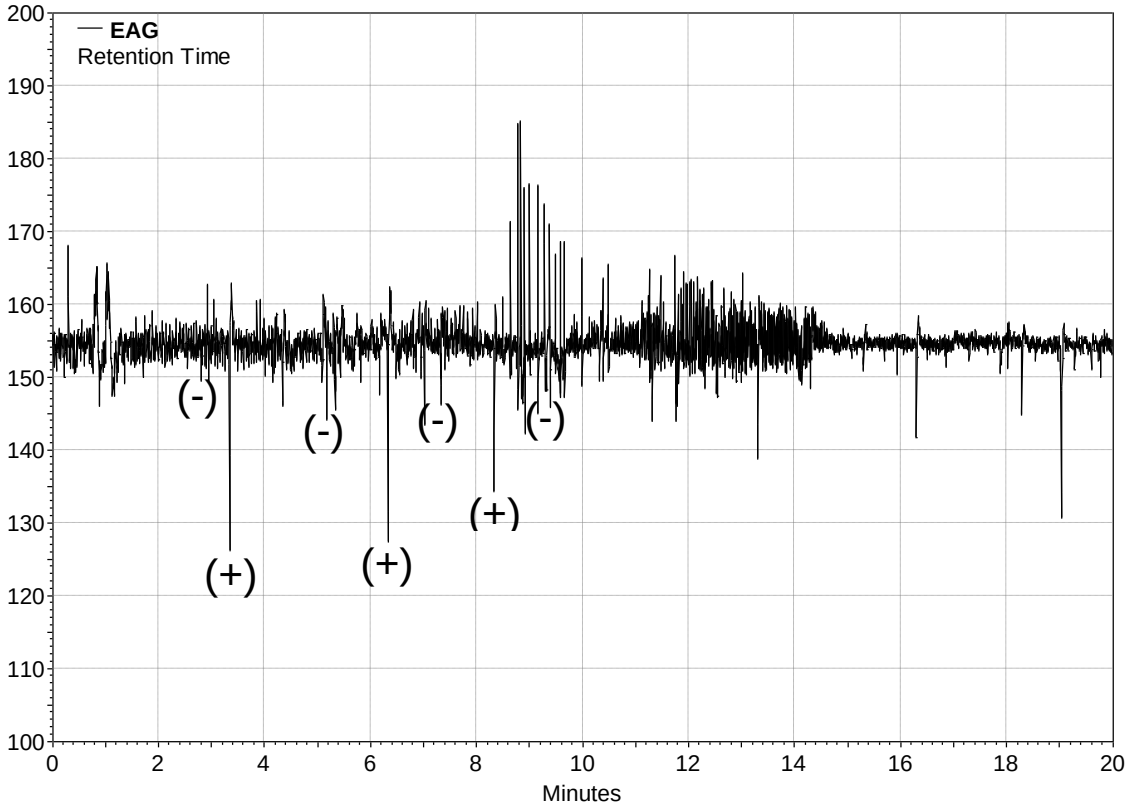

Figure 12. EAG responses of EAG preparation from female AFR weevil to volatile collections from males with (+) and without (-) an apple bud as food

When the sample from males was analysed by GC-EAG with antennal preparations from female or male AFR weevils, a small EAG response to the major component, benzyl alcohol was observed, but no other consistent responses (Fig. 13).

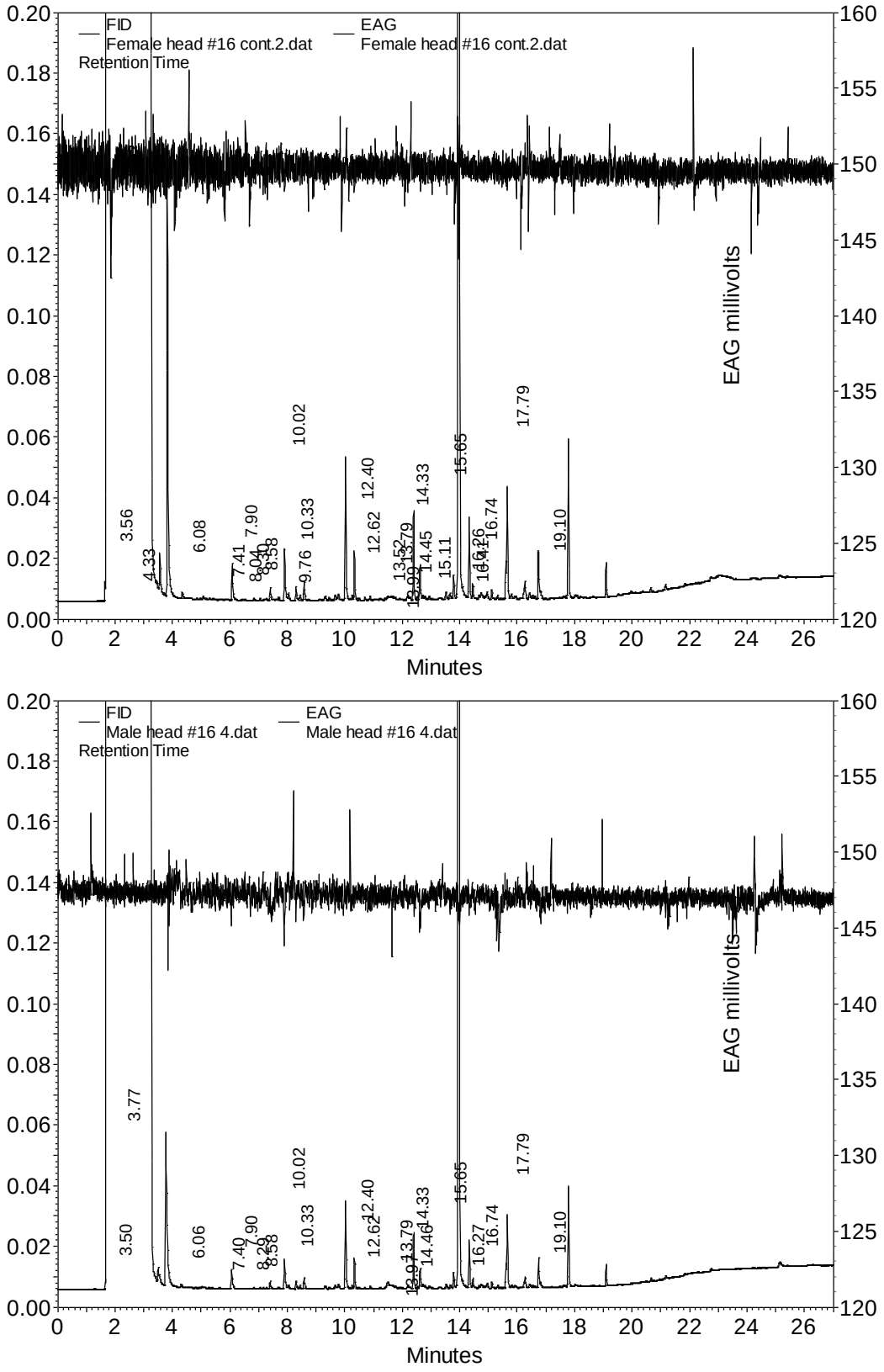

Figure 13. GC-EAG analyses of volatiles from male AFR weevils with food against antennal preparations from female (upper) or male (lower) AFR weevils (benzyl alcohol at 13.79 min)

Discussion

AFR did not appear on apple trees before blossom. On hawthorn, blackthorn and apple the first collections were made from pink bud stage through flowering. Weevils were also found on apple through to fruit setting, which is when AFR egg laying occurs. The majority of weevils that were used as bait in the trees had died by the time fruit had reached 20 mm in size, which is when weevils were no longer found in the apple trees. Hawthorn and blackthorn were not sampled through till the end of flowering so it is not known when weevils were no longer to be found on those hosts.

Sufficient numbers were collected for experiments and the field population was higher in 2014 than in 2013 (Fig. 14).

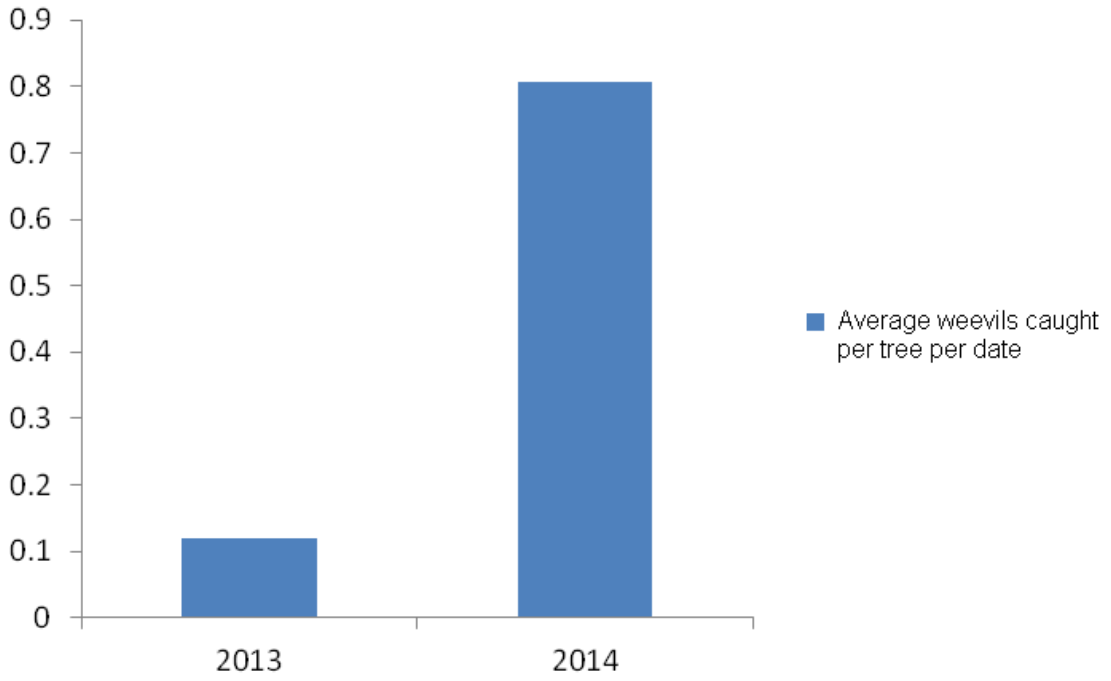

Figure 14. The average numbers of AFR caught per tap per date for 2013 and 2014

In the laboratory, male and female AFR were able to identify each other and successfully mate, resulting in eggs being laid and larvae developing (Fig. 15). Although eggs and larvae were observed in the laboratory, none survived through the winter to adult stage.

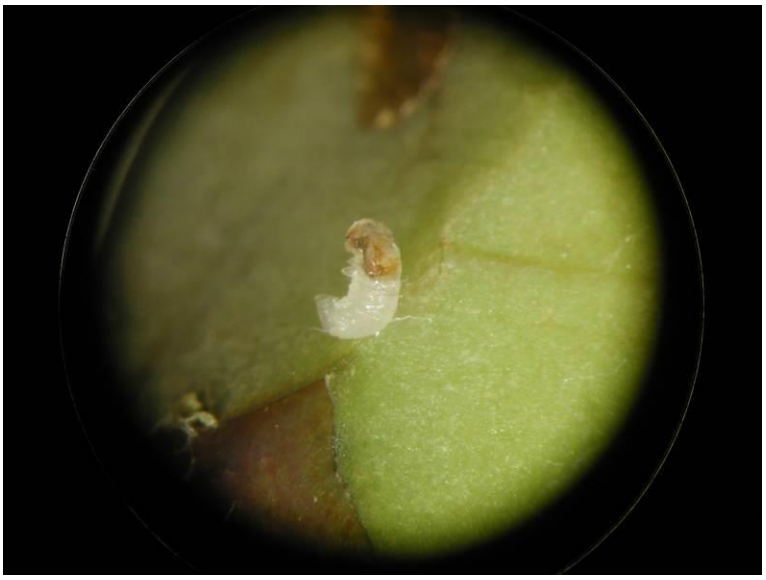

Figure 15. AFR larva in fruitlet

The field results for Year 2 were analysed in terms of the stage of the tree rather than date of assessments as in Year 1. As there were several different cultivars of apple used in the trial, growth stage was used as opposed to date. Different apple cultivars develop at different rates and therefore dates for specific growth stages. There were a significantly higher number of females caught in unbaited trees during fruit setting, which is when egg laying would be expected to occur. This could mean that females were looking for trees that did not have any other weevils in, reducing the competition for egg-laying sites. There was no evidence of attraction in the field trial.

Volatiles were collected from male and female AFR weevils with and without food three times during the season. Analyses by GC-MS failed to show any sex-specific compounds that might be potential pheromone components. In analyses by EAG, responses were obtained from female weevils to collections from male weevils with food but only very weak responses were shown to collections from males without food. This suggested that either the females were responding to volatiles from the apple buds used as food or that the males were only producing active compound(s) in the presence of food. In analyses by GC linked to EAG recording, a response was obtained from both males and females to the large amount of benzyl alcohol observed in the collections from weevils with food, suggesting that the former explanation was probably the case.

Conclusions

Weevils were not detected in apple orchards until flower buds were present. As they appeared before flowers were open, growers could target control measures (e.g. chlorpyrifos or thiacloprid at the recommended field rate) before blossom to reduce AFR numbers at the beginning of the season without risking harm to pollinators. Female weevils are still found in the trees until fruit has reached ~20mm, therefore sprays could be applied targeting the egg laying females. At this stage, the damage for that season may have already taken place but this could reduce the number of females which are egg laying and thus reduce the next season's generation. Exploitation of this understanding can be a useful tool in designing spray programmes, i.e. spray before blossom, at the pink bud stage, to target males and females preparing to mate and again at beginning of fruit setting when females are looking for egg laying sites.

No behavioural, chemical or electrophysiological evidence could be found for the existence of a pheromone in AFR weevils, although EAG responses to host-plant volatiles, particularly benzyl alcohol, were observed and this compound may have some behavioural role.

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Michelle Fountain, Jamie Stotzka, Eduardo Jimenez and Adrian Harris assisted with the field work at EMR. EAG studies at NRI were carried out by Dr Mandela Fernandez-Grandon.

Knowledge and Technology Transfer

AHDB Horticulture EMRA tree fruit day presentation 'feasibility of developing a semiochemical based monitoring trap' for apple fruit Rhynchites, 26 March 2014, EMR.

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