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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.

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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.

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GROWER SUMMARY

Headline

- Progress is being made to establish control thresholds for blackcurrant sawfly using the recently developed pheromone monitoring trap.

Background and expected deliverables

Blackcurrant sawfly is a common and frequently damaging pest of blackcurrant, present to varying degrees in most UK blackcurrant plantations. Larvae feed on foliage in May-June (1st generation) and July-August (2nd generation) making irregular holes in leaves and causing defoliation which weakens the bushes and causes substantial losses in yield. Larvae may also contaminate harvested fruit so good control prior to harvest is important.

Infestation is sporadic and localised and damage can occur rapidly. Frequent crop inspection is needed for first signs of eggs, larvae and damage. Current grower practice relies upon application of a control product as soon as eggs, larvae or damage is detected by crop scouting. No practical systematic sampling methods or attendant crop damage thresholds have been developed and it is believed that there is widespread use of prophylactic treatment. Adequate crop scouting is time-consuming and expensive, and a more sensitive and rapid monitoring method is needed. Pheromone traps could provide such a tool.

Non-UV reflective white sticky traps are used for monitoring various other Tenthredinid sawfly pests of fruit trees including apple sawfly (*Hoplocampa testudinea*). Female gooseberry sawfly (*Nematus ribesii*), has been shown to produce a sex pheromone that attracts conspecific males, but, until recently, nothing was known about the chemical ecology of blackcurrant sawfly.

Development of a pheromone trap for blackcurrant sawfly was one of the objectives of the Defra Horticulture LINK project 'Developing Biocontrol Methods and their Integration in Sustainable Pest and Disease Management in Blackcurrant Production' (HL01105) which ran from 2010-2015. In this project, it was shown that male blackcurrant sawfly were attracted to virgin females, confirming the existence of a sex pheromone. Four potential pheromone components were detected, identified and synthesised. Three of these were produced only by females. They had structures unrelated to those of compounds reported as pheromone components in other sawfly species, but they caused very strong electroantennogram (EAG) responses from blackcurrant sawfly males. The fourth

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compound was produced in large quantities by both females and males and did not elicit an EAG response.

Trapping tests were carried out with blends of these compounds on several growers' farms during 2013 and 2014. A blend of two of the three EAG-active compounds was shown to be highly attractive to male blackcurrant sawfly, and addition of the fourth component seemed to increase attractiveness even further. The trapping experiments also confirmed the sporadic nature of this pest in that few or no sawfly were caught on several of the farms.

Blackcurrant growers differ in their approach to sawfly control. Some spray prophylactically, and others apply no sprays for the pest. In trials in the Defra Horticulture LINK project it was noted that one of the latter growers had sawfly adults in the crop, detected using pheromone traps. Eggs and young larvae were found in the bushes, but no older larvae were observed and no significant damage occurred. This may be because growers using fewer broad spectrum control products have a higher diversity of natural enemies, particularly earwigs which are known to feed on a range of pest species in tree fruits (see AHDB Project TF 220 (*Further development of earwig-safe spray programmes for apple and pear orchards*). However, this was not explored in the Defra Horticulture LINK project. In addition, *Drosophila suzukii* (SWD) could become an increasing pest of blackcurrant meaning that insecticide sprays used against this pest may disrupt natural enemy numbers in the crop near to harvest. These factors have obvious implications for spray programmes and targeting of sprays for sawfly control.

Summary of the project and main conclusions

In 2015, pheromone trapping of blackcurrant sawfly was carried out in blackcurrant grower field trials. A replicated trial confirmed previous results that a three-component blend of two isopropyl esters, Z7-14iPr and Z7-16iPr, and the unsaturated hydrocarbon, Z9-23H, is attractive to male blackcurrant sawfly. New results found that reducing the pheromone loading from 1 mg Z7-14iPr to 0.1 mg reduced catches. In addition, more sawfly were caught in red delta traps than green, at least for the most attractive blend. In a further trial to optimise the relative amount of Z7-16iPr in the blend, few blackcurrant sawfly were caught and no conclusions could be drawn. The different blends and traps were also tested in three other growers' fields, but catches were low, and overall the results illustrated the sporadic and localised nature of this pest.

In 2016 we aimed to relate catches of blackcurrant sawfly with this optimised pheromone blend and trap, to infestations by blackcurrant sawfly. The influence of natural enemies on this relationship will be determined.

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Thirty eight red delta traps with the optimised three component blend released from a polythene vial were hung from the bushes throughout a plantation in Kent. Natural enemies, sawfly adults, eggs, larvae and damage levels were assessed for 20 weeks from 13 May – 22 September. Low adult sawfly catches (18 in total) were found. There were only 15 sawfly eggs, 12 larvae and very low levels of foliar damage detected. Low damage was found after observations of eggs and early stage larvae were made, and this potentially suggested that predation could be occurring before significant damage could take place. The adult blackcurrant sawfly catch was not significantly affected by the row in which the trap was deployed. A survey of earwig abundance in blackcurrant plantations in five regions across the UK in 2016 (SF 168) showed earwig numbers varied significantly between plantations and farms.

Work in 2017 aims to replicate the trial at a site with higher sawfly numbers in the East Midlands, allowing for a comparison to be drawn between the site used in 2016, to establish thresholds and optimal trap placement within a plantation.

Financial benefits

Blackcurrant sawfly is a common and frequently damaging pest of blackcurrant, present to varying degrees in all UK blackcurrant plantations. Larvae feed on foliage causing defoliation which weakens the bushes and causes substantial losses in yield. Larvae may also contaminate harvested fruit so good control prior to harvest is important.

Chlorpyrifos is no longer approved and the future of thiacloprid is uncertain.

Adequate crop scouting is time-consuming and expensive, and a more sensitive and rapid monitoring method is needed. More effective monitoring would help to make more cost-effective use of control products currently available with a likely reduction in their use. Monitoring will be vital for effective use of any more benign, biological approaches developed in the future.

Pheromone traps could provide such a tool. Growers are generally familiar with this technology providing it is made readily available through commercial suppliers with adequate supporting information and protocols.

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Action points for growers

- Look for adults flying in April and May and target with approved control products to prevent egg laying.
- Check for eggs on the underside of leaves in the centre of the bush.
- Check for larval damage low down in the centre of the bush.
- Monitor predator populations (earwigs) in plantations by tap sampling, preferably after dark, using a white tray and beating stick,
- Monitoring traps are commercially available through Agralan.

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SCIENCE SECTION

Introduction

Blackcurrant sawfly is a common and frequently damaging pest of blackcurrant, present to varying degrees in all UK blackcurrant plantations. After overwintering, adults will emerge in late April or May. They are most active on warm sunny days laying their eggs on the underside of the leaves. Feeding occurs at the base of the bushes, during May and June. Hatched larvae (1st generation) develop through four or five larval instars (Mitchell et al., 2011). After spinning a cocoon, the pre-pupal stage falls to the ground and pupates in the soil. In July - August, second generation adults emerge. Developing larvae make irregular holes in leaves (Figure 1), causing defoliation which weakens the bushes and causes substantial losses in yield (Mitchell et al., 2011). Larvae may also contaminate harvested fruit so good control prior to harvest is important.

Figure 1. Blackcurrant sawfly damage on blackcurrant leaves

Monitoring the pest relies on the detection of the eggs on the underside of leaves in the centre of the bushes and this egg laying may be aggregated within a plantation. Hence, crop scouting is not always reliable because doing an adequate search is time consuming. It is not uncommon for early infestations to be missed if the plantation is not well covered during an inspection.

In a previous Hort LINK project (Developing biocontrol methods and their integration in sustainable pest and disease management in blackcurrant production: HL01105), four potential components of the female sex pheromone of blackcurrant sawfly were identified and synthesised. Field tests suggested that three of these compounds were necessary for attraction of males. High catches of males were obtained in some fields and very low in others, confirming the sporadic nature of the pest.

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This project aims to optimise the pheromone blend, dispenser and trap and then calibrate catches in the traps with field populations of blackcurrant sawfly. Factors affecting this relationship, such as the presence of natural enemies and the use of pesticides, will be investigated and thresholds for the two generations estimated.

Materials and Methods

Field Monitoring

From the optimisation experiments in 2015 we selected the most attractive trap colour and lure to use in trialling in 2016 (Figure 2). Sticky bases were used in the base of the delta trap and were replaced weekly or before they became saturated with by-catch.

Thirty eight red delta (10 x 20 x 28 cm) traps (Sentomol) were deployed in a blackcurrant plantation in Horsmonden, Kent. Traps were placed 43 m apart. In rows containing 6 traps the first trap in the row was 21.5 m from the edge and in rows containing 7 traps the first trap was placed at the end of the row (Figure 3). The bait was a three-component pheromone blend of two isopropyl esters, Z7-14iPr and Z7-16iPr, with the unsaturated hydrocarbon, Z9-23H, dispensed from a polyethylene vial at 1 mg Z7-14iPr.

Figure 2. Trap deployed in plantation

Assessments

Assessments were done weekly or fortnightly from 13 May – 22 September 2016. Adult blackcurrant sawflies were identified in the field on the sticky bases (Figure 4). Sticky bases with sawfly were wrapped in cling film and brought back to the laboratory where the sex was determined.

At each trap location four blackcurrant bushes were examined for eggs, larvae and damage. Ten leaves in the centre at the base of each bush were assessed to give a count of the

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number of eggs, larvae and damage (Figure 5). An assessment of the whole bush was carried out for sawfly damage and given a score of **0** none, **1** 1-10%, **2** 11-50%, **3** 50-75% and **4** 75-100%. Leaves with eggs and early instar larvae were tagged and inspected the following week for presence of eggs, larvae and damage.

At each of the 38 trap locations four bushes were sampled for natural enemies. A white tray was held at the base of the bush and the bush was given three sharp shakes over the tray. The number of natural enemies (earwig nymphs/males/females, ladybird larvae/adults, anthocorids, soldier beetles, lacewing larvae, Heterotoma, spiders) was then recorded.

An assessment of the crop growth stage was made each week using the EPPO (1984) crop growth stage key for blackcurrants.

The spray programme was requested from the grower to determine when insecticides that may impact insect phenology were applied.

Correlations between adult sawfly trap catch, sawfly eggs, sawfly larvae, sawfly related damage and natural enemy numbers were calculated using the summated data and removing date and trap classifications and producing a correlation matrix using GENSTAT V 14.1.

To determine whether the adult blackcurrant sawfly trap catch was related to the row in which the trap was deployed, an ANOVA was carried out on SQRT transformed blackcurrant sawfly trap catch data testing for row differences.

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Figure 3. Sawfly (red triangles) and *Drosophila suzukii* (white circles) trap locations in the blackcurrant plantation

Figure 4. Adult sawfly on white sticky bases collected from red delta traps containing a polythene vial with the optimised three component pheromone blend. Red arrow and circle indicate examples of sawflies on sticky base

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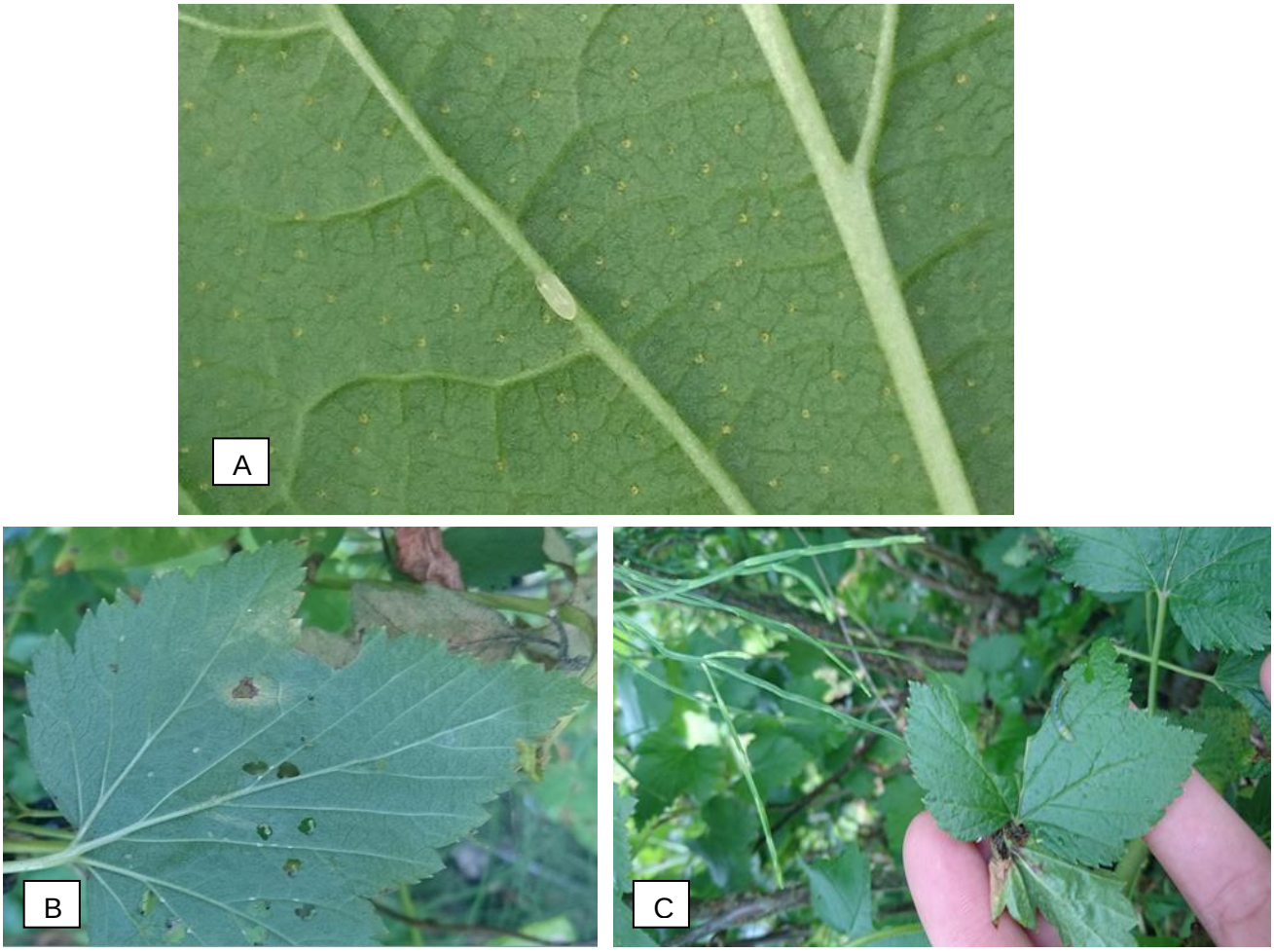

Figure 5. A. Sawfly egg, B. Sawfly young instar larvae, C. Sawfly damage and late instar larvae

National adult trap catches

Red pheromone traps containing the blackcurrant sawfly sex pheromone three component blend were deployed at 4 sites across the UK, two in the West Midlands, one in East Anglia and one in Scotland (2 traps per site).

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Results

Blackcurrant sawfly adults, eggs, larvae and damage

Blackcurrant sawfly adult trap catches were observed at the first assessment on 13 May but were consistently low throughout the season. This is consistent with industry reports of low numbers of blackcurrant sawfly in the South East in 2016 (H. Roberts, pers. comm.). There was a slight increase in adult sawfly trap catch (3 adults) on 19 August. Small numbers of adults continued to be caught until 16 September (Figure 6). A total of 18 male blackcurrant sawfly adults were caught throughout the entire 20 weeks of sampling. There was no more than 1 adult sawfly caught in the same trap at each weekly assessment, lower than previous years.

No sawfly eggs or larvae were found throughout blackcurrant flowering and fruit set. A late stage larva was observed on 1 July as the fruit began to ripen. No other observations of sawfly were found until after the crop was harvested (5 August). After harvest a total of 15 eggs were found from 11 August – 01 September and 11 larvae from 23 August – 01 September (Figure 6). No eggs or larvae were observed after 01 September. The trial ended on 22 September.

No significant sawfly related damage was observed throughout the planation with only three leaves with sawfly damage recorded throughout the 20 weeks. It was observed that eggs and larvae would be present at an assessment and the following week, when the same leaf was checked, no eggs or larvae were present and very little damage was observed.

Due to the particularly low numbers of blackcurrant sawfly adults, eggs, larvae and damage at the site there was no significant correlation observed between the adult sawfly trap catch and sawfly eggs ($P = 0.151$), larvae ($P = 0.659$) or damage ($P = 0.796$).

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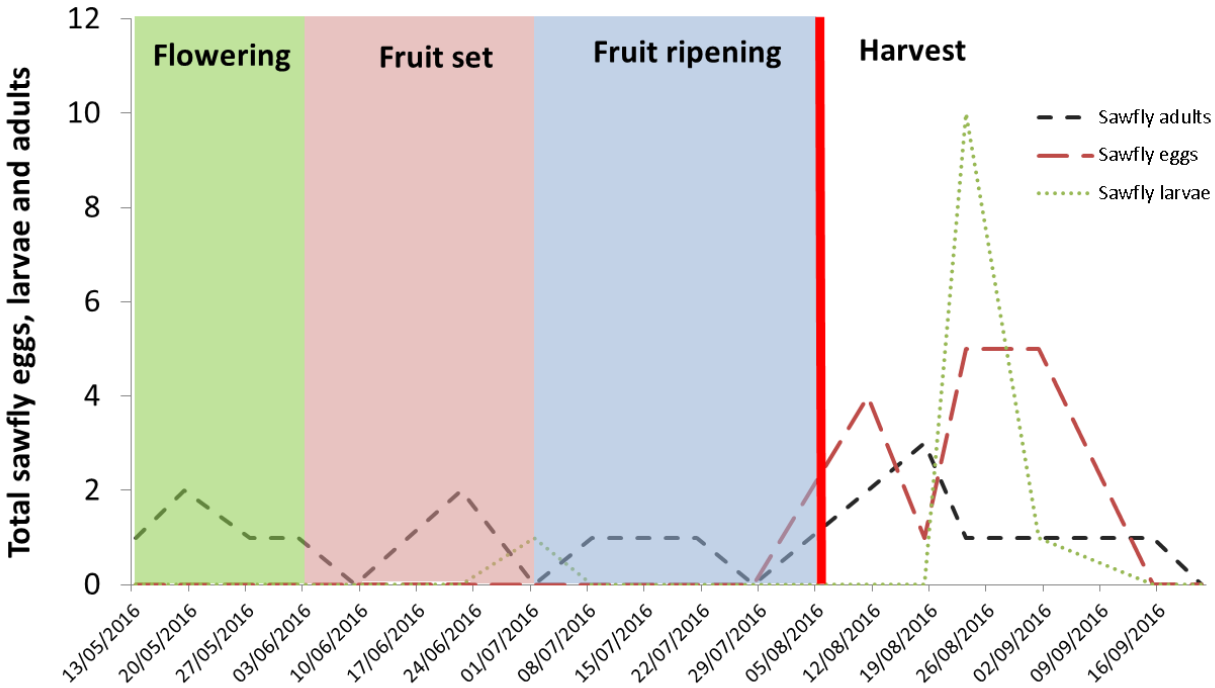

Figure 6. Total weekly blackcurrant sawfly eggs, larvae and adult trap catches from the 13 May – 22 September 2016

The distribution of adult sawfly in the traps across the plantation was sporadic with no significant correlation (*P = 0.088*) between the row in which the trap was deployed and the number of adult blackcurrant sawfly caught in the trap (Figure 7).

Repeated observations of eggs and larvae were made in the bushes around trap number 2 (1 larva, 23 August and 5 eggs and 1 larva, 01 September) and trap number 38 (1 larva, 01 July and 9 larvae, 23 August). However, the total cumulative distribution of eggs and larvae also showed no clear pattern through the plantation (Figure 8).

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Figure 7. Distribution map of the total cumulative number of adult blackcurrant sawfly caught in pheromone traps. Size of red circle relates to total numbers of adult male sawfly trapped

Figure 8. Distribution map of the total cumulative blackcurrant sawfly eggs and larvae. Size of yellow circle relates to total numbers of sawfly eggs and larvae sawfly recorded

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Natural enemy numbers

Low natural enemy counts were observed throughout flowering. The number of soldier beetles (Cantharidae) increased throughout fruit set then decreased as the fruit began to ripen. Heterotoma numbers increased at this time point and remained high throughout fruit ripening. Low levels of ladybirds (Coccinellidae) and anthocorids were observed throughout the season. There was a consistently high number of spiders in blackcurrant bushes throughout the season, with numbers never falling below a total of 97 at each assessment (Figure 9A).

Earwig numbers remained low throughout flowering, consistent with populations of other natural enemies. Nymphs and adult females were the first observed in late May. From fruit set until harvest (05 August) the numbers of adult earwigs remained low and numbers of earwig nymphs increased. After harvest the numbers of earwig nymphs decreased and the number of male and female earwigs increased until no nymphs were found in the canopy (16 September) (Figure 9B).

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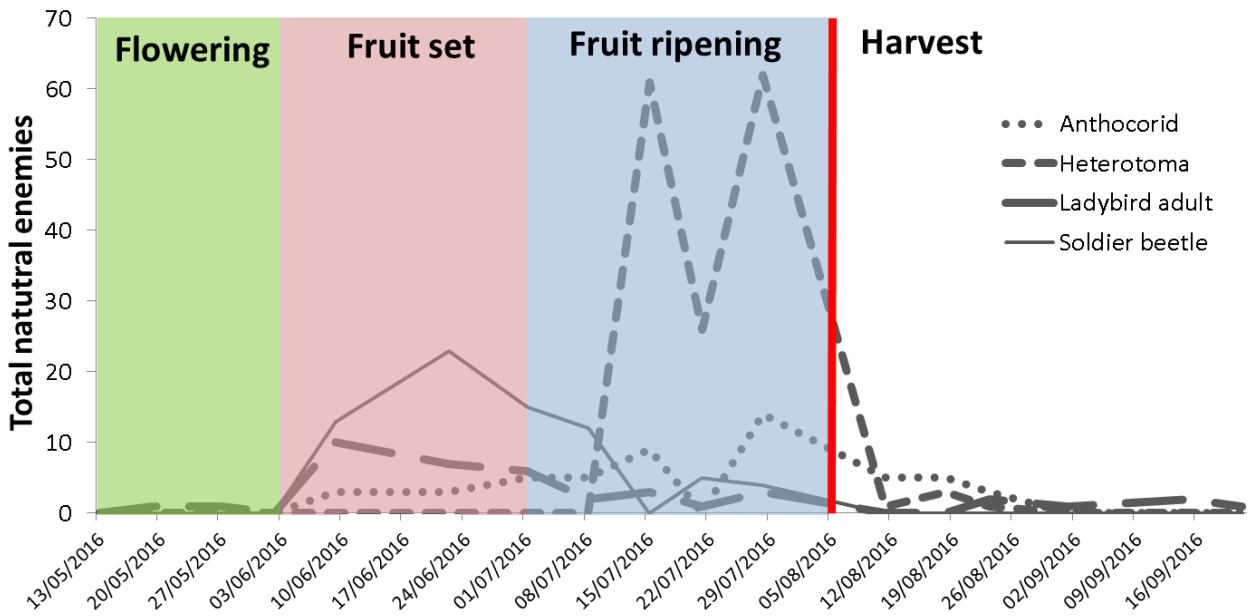
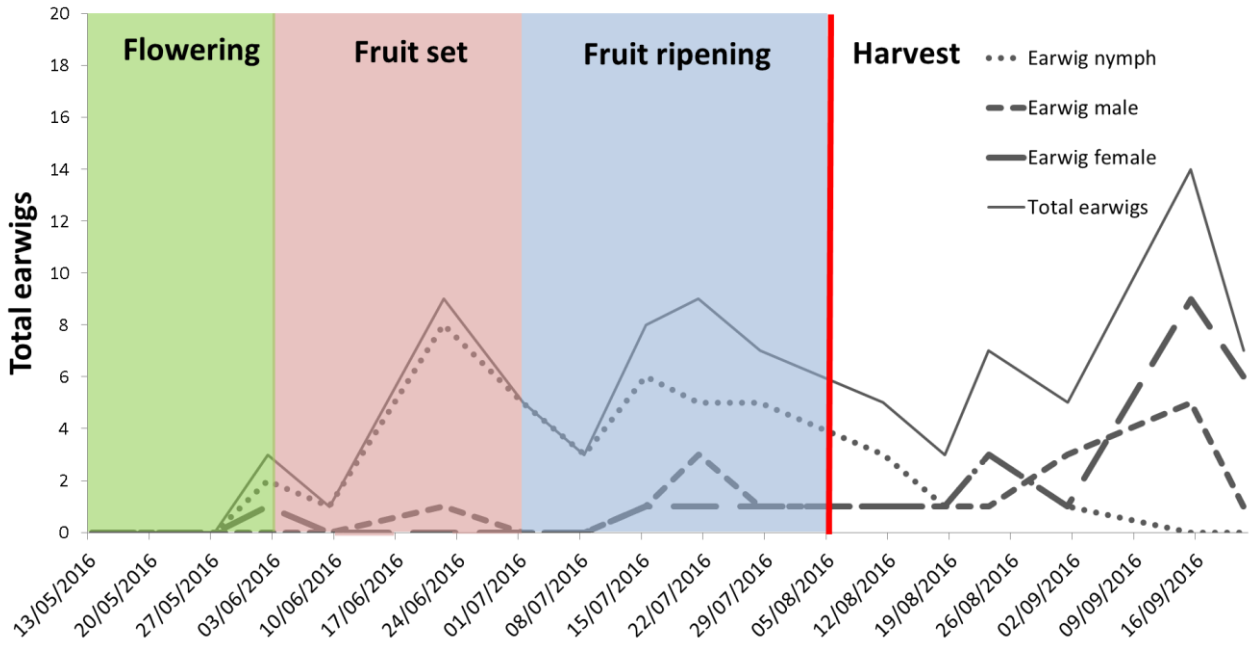


A.



B.

Figure 9. A. Total counts of natural enemies per week from the 13 May - 22 September 2016, B. Total earwig counts per week from the 13 May – 22 September 2016

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A cumulative total of 86 earwigs was recorded over the twenty weeks. The distribution map (Figure 10) clearly shows they were present throughout the plantation. However, it also shows that higher earwig numbers were in the first row nearest the edge of the plantation (Figure 10).

There was no significant correlation between any natural enemies and sawfly eggs, larvae, adults and damage (*P > 0.05*).

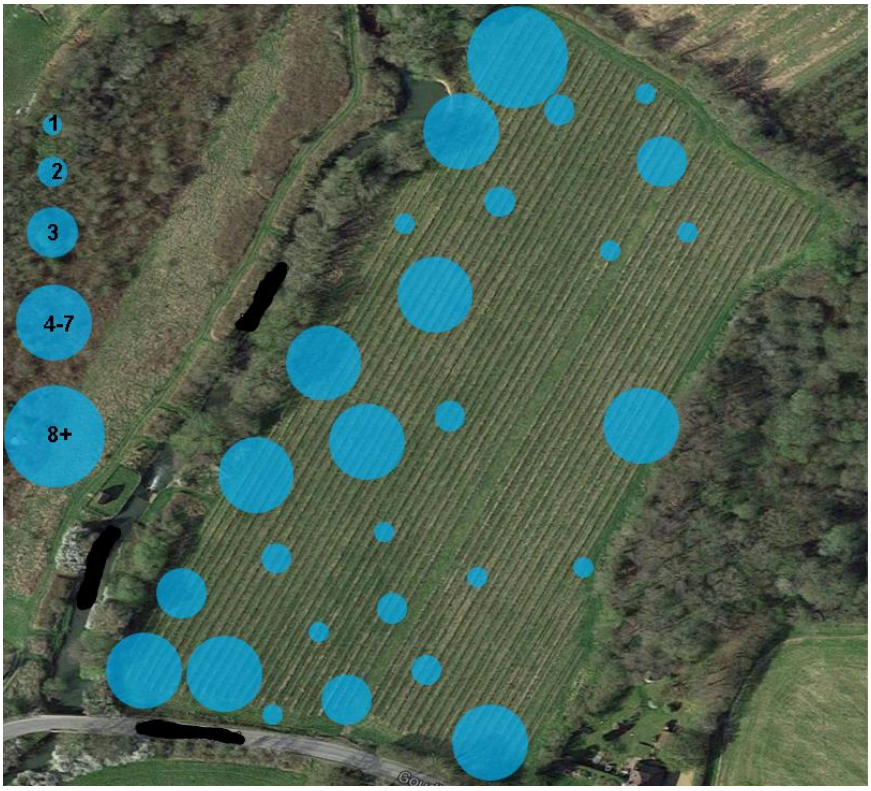

Figure 10. Distribution map of the total cumulative number of earwig males, females and nymphs. Size of blue circle relates to total numbers of earwigs recorded

No insecticides were applied to the plantation in 2016. However, Calypso (Thiacloprid) was applied at early - late flowering (20 May) in 2015.

Regional adult sawfly trap catches

Blackcurrant growers and the industry representative (Harriet Roberts, LRSuntory) observed that there were very low numbers of sawfly adults, eggs and larvae in the South East in 2016 resulting in no significant incidence of sawfly related damage. However, at one site, in East Anglia, 488 adult sawfly were captured on two pheromone traps.

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Discussion

Low adult sawfly trap catches (total 18 in 20 weeks) were observed throughout the season at this site and corresponded to low numbers of eggs (total 15 in 20 weeks), larvae (total 12 in 20 weeks) and sawfly related damage (3 leaves with damage). The adult blackcurrant sawfly trap catch was not significantly affected by the row in which the trap was deployed. A wide range of natural enemies was found in the plantation (spiders, earwigs, anthocorids, ladybirds, soldier beetles, Heterotoma) with overlapping population peaks at different periods throughout the season, possibly responding to prey populations (aphids, midges, sawfly).

Virtually no sawfly damage was observed in the blackcurrant bushes and only one late instar larva was found in the crop canopy. Leaves with eggs and early instar larvae were tagged and, on return, the eggs and larvae were gone and little leaf damage observed. Timing of earwig movement into the canopy corresponded to that observed in apple and pear orchards (Gobin et al., 2008) with females and nymphs present in the canopy (bush) in May, followed by increasing numbers of nymphs of different stages from May until Mid-September. From Mid-September onwards only adult males and females were present.

In 2017 the study will be repeated in a plantation in East Anglia found to have high numbers of adult sawfly in 2016.

Conclusions

1) Sawfly numbers were low in the plantation studied in Kent in 2016
2) Numbers of sawfly did not correlate with numbers of natural enemies
3) There were numerous and diverse natural enemies in the studied plantation throughout the blackcurrant growing season
4) Earwig movement into canopy of the blackcurrant plantation corresponds to earwig movement into the canopy of pear and apple orchards
5) A site in East Anglia was found with high trap catches of adult blackcurrant sawfly.
6) Future work will look to determine thresholds between adult sawfly and sawfly eggs, larvae and damage, the significance of trap placement and thresholds between natural enemies and sawfly adults, eggs, larvae and damage levels at the East Anglian blackcurrant plantation.

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Knowledge and Technology Transfer

The role of earwigs and other predators for pest control in blackcurrants. Madeleine Cannon, ADHB Soft Fruit Day, NIAB EMR, 23 November 2016.

Sex Pheromones of the Blackcurrant Sawfly, Nematus olfaciens*, and the Gooseberry Sawfly,* N. ribesii *(Hymenoptera: Tenthredinae)*. David Hall, ADHB Soft Fruit Information Day, Winter Meeting, February 2016.

Development of Sex Pheromone Monitoring Traps for Blackcurrant and Gooseberry Sawfly. Michelle Fountain, ADHB Soft Fruit Information Day, Winter Meeting, 16 Feb 2017.

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