Determining the threat of rose thrips (*Thrips fuscipennis*) in UK strawberry crops

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Background and purpose of this study

The problem

For many years, the western flower thrips (WFT, *Frankliniella occidentalis*) has been a serious pest of strawberry, feeding on flowers and developing fruits and giving rise to brown or bronzed coloured fruits which are unmarketable. Similar damage to that caused by WFT has occasionally also been caused by onion thrips, *Thrips tabaci* but ADAS has recently identified the presence of rose thrips (*Thrips fuscipennis*) in strawberry flowers where fruit bronzing is occurring.

Rose thrips adult females are darker than those of WFT but microscopic examination is needed for species confirmation. At a few sites where fruit bronzing has occurred, rose thrips has been the only thrips species present in the flowers but usually it has been present in species mixes with other thrips species such as the rubus thrips (*Thrips major*). However, where fruit damage has occurred and thrips species mixes have been present, numbers of rose thrips have been much higher than those of other species suggesting that rose thrips have been responsible for the damage.

At sites where fruit damage attributed to rose thrips has occurred, some growers have been using Integrated Pest Management (IPM) programmes based on the predatory mite *Neoseiulus cucumeris* and good control of WFT has been achieved. However at these sites, rose thrips have not been controlled and growers have needed to apply plant protection products to prevent further fruit damage. Growers have often used spinosad (Tracer) for control of rose thrips which is currently effective. However, there is concern that like WFT, rose thrips could develop resistance to Tracer and other insecticide products. In addition the number of Tracer applications permitted on each crop is limited and growers may prefer to reserve these for control of spotted wing drosophila (SWD). Some growers have also used synthetic pyrethroid products such as deltamethrin (Decis) for control of rose thrips, but pyrethroids are incompatible with biological control agents used in IPM programmes and there is also the risk that resistance may develop.

So why does rose thrips not seem to be controlled on crops where *N. cucumeris* is providing good control of WFT? Fruit damage often seems to occur soon after ‘dark’ thrips adults are noticed in the flowers, so it is possible that rose thrips and possibly other *Thrips* species adults are migrating into the crop and damaging the fruit before they start reproducing. It has been suggested that as these species seem to migrate into the crop as adult thrips in large numbers, they are not controlled by *N. cucumeris* which only feeds on first instar WFT larvae. It is unknown whether *N. cucumeris* can successfully predate *T. fuscipennis* larvae. ADAS work in AHDB Project CP 89 indicated that the predatory bug *Orius laevigatus* provided similar reduction in numbers of rose thrips to Tracer on an outdoor commercial strawberry crop in 2014 (Bennison & Hough, 2015). This predator was observed feeding on rose thrips in the field. However, *O. laevigatus* needs high temperatures to breed and not all years are warm enough for good establishment. In addition, fruit damage can occur before the predator establishes in sufficient numbers to provide control.

Current knowledge of *Thrips fuscipennis*

Distribution

Rose thrips is native to the UK (Morison, 1957) but very little is known or published about its biology. A literature review was conducted by ADAS in 2014 in the IPM Fellowship project (CP 89) funded by AHDB Horticulture, HTA and the East Malling Trust (Bennison & Hough, 2015). The pest is known to be present in Europe and elsewhere including North America and China (Nakahara, 1994). It has been reported from most counties of the UK (Mound *et al*, 1976) and to be more abundant in the east and south of England than in the west and north (Morison, 1957).

Biology and host range

Rose thrips has a wide host range including ornamentals such as rose, (Alford, 1991), fruit crops including blackberry, strawberry, tree fruits including apple (Alford, 1984) and legumes and cucumber (Lewis, 1997). Until recently, control of rose thrips on strawberry has been considered unnecessary (Alford, 1984). Rose thrips also occurs in weeds such as bindweed and meadowsweet (Kirk, 1985a). Rose thrips adults are recorded as overwintering on tree trunks and amongst 'herbage' (Morison, 1957) and in bark crevices on chestnut for example (Speyer, 1938) together with rubus thrips. It is possible that like WFT it may overwinter in strawberry fields but this has not been recorded. Adult females have been recorded from January to December and both males and larvae have been recorded from May to September (Mound *et* al, 1976).

After adult females have become active, they lay eggs from May onwards. Young apple shoots have been recorded as egg laying sites and the larvae feed on leaves, shoots and flowers until September (Alford, 1984). Rose thrips is reported to have up to four generations a year (Alford, 1984). Adults have been found on more than 298 species of flowering plants (Morison, 1957). Host plants suitable for larval development include Althaea (e.g. marshmallow), Chenopodium (e.g. fat hen), strawberry, ash, mint, *Prunus* spp., rose and *Rubus* spp. (e.g. blackberry and raspberry) (Morison, 1957). Larvae pupate either in sheltered vegetation or in soil (Morison, 1957). Populations can be naturally regulated to some extent by egg laying decreasing with increasing population density (Kirk, 1994).

Feeding behaviour and strawberry fruit damage

Thrips cause plant damage by piercing and sucking out the contents of plant cells which results in silvery flecks or patches on leaves and petals which later senesce and turn brown. It is widely known that WFT can also cause damage to strawberry fruit (e.g. Sampson, 2014; Raffle *et al*, 2016.) Rose thrips has also been recorded as damaging strawberry fruit but until recently has not been considered as an important pest of fruit crops and control was thought to be unnecessary (Alford, 1984). Like WFT, *Thrips fuscipennis* also feed on the contents of pollen grains but can reproduce on leaves in the absence of pollen (Kirk, 1984; Kirk, 1985b). An experiment was done in the IPM Fellowship project (CP 89) to compare strawberry fruit damage caused by WFT, onion thrips (*Thrips tabaci*) and rose thrips in thrips-proof cages (Bennison & Hough, 2015). Adults of each of the three thrips species were added to replicate cages containing strawberry plants and any fruit damage was recorded. Fruit damage occurred in the rose thrips cages but contamination with onion thrips meant that it was not

possible to attribute the fruit damage to rose thrips. Onion thrips also contaminated the untreated control cages where fruit bronzing occurred and this confirmed that this species can damage strawberry fruit.

Identification

Identification of this pest in the field is impossible due to its similarity to other *Thrips* species that can occur in strawberry flowers including rubus thrips. Rose thrips and rubus thrips adult females can be distinguished from WFT in the field as they are darker in colour (Figure 1 and see Raffle *et al*, 2016). However, species confirmation can only be carried out using a high powered microscope and a diagnostic key to adult females. Males of both rose thrips and WFT are smaller than females and yellow in colour so can easily be confused in the field. In the UK, onion thrips populations are mainly female and males are rarely found.

Figure 1. Rose thrips adult female (*Thrips fuscipennis*) left and western flower thrips female (WFT), right, mounted on microscope slides © ADAS

Aim of the study

The aim of this study was to identify how widespread rose thrips is on UK strawberry farms and to investigate its threat to the industry.

Detailed Objectives

- Complete six case studies on sites where dark thrips adults are occurring in UK strawberry crops.
- Determine how widespread rose thrips is on UK strawberry farms.
- Gather information on the occurrence of rose thrips adults and larvae in strawberry flowers together with grower use of biological control agents and insecticides for thrips at the case study sites.

- Gather information on incidence of rose thrips in flowering weeds on the case study sites and on the species of surrounding trees and hedgerow plants where the pest might overwinter.

Summary of the project

Methods

During 2017, ADAS fruit consultants were asked to send samples of 20 strawberry flowers from crops where thrips damage (bronzing) to fruit was occurring and where dark coloured thrips adults were present in flowers. Flower samples (25) from 18 sites were sent to ADAS Boxworth for confirmation of thrips species. In the laboratory, all thrips adults were collected and counted from each of the 25 samples and a sub-sample of 10 randomly selected thrips adults (if available) from each sample were identified to species. If less than 10 adults were found in a sample of flowers all of them were identified. Identification was done by mounting adult thrips females in a clearing medium on glass slides, viewing them under a high power microscope once the specimens had cleared sufficiently to see the diagnostic feature and using a morphological key (Mound *et al*, 1976).

It was agreed that case studies would be done on six selected infested sites in different parts of the country but seven sites were studied. At each case study site, 20 strawberry flowers and a sample of any flowering weed species from within or around the edge of the crop were randomly sampled, collected into screw-cap tubes and brought back to the laboratory at ADAS Boxworth. The following information was recorded:

- Numbers and species of thrips adults up to 10 specimens from 20 randomly selected strawberry flowers and in any flowering weed species.
- Percentage fruit with bronzing and percentage fruit area bronzed on 20 randomly selected green and ripe fruit (if available) (Figures 2 and 3). In addition to the case study sites, fruit samples were also occasionally sent by the ADAS fruit consultants from some of the other sites together with flower samples. If fruit were sent from these extra sites, the same assessment of bronzing was made on these too.
- Species of tree and hedgerow plants around the crop.

- The grower or ADAS fruit consultant at each site was asked to provide details of the cropping history, any biological control agents applied for thrips control and any plant protection products applied before the visit for control of thrips or other pests.

Figure 2. Green fruit bronzing by rose thrips ©ADAS.

Figure 3. Ripe fruit bronzing caused by rose thrips ©ADAS.

Case Study Results

Site 1

Crop and site
Second year everbearer crop cv. Everest in Surrey. Outdoor crop on table tops.

Date of visit and reason for selection
18 May 2017. This site was visited without any previous sample of flowers sent by an ADAS fruit consultant. The site was selected as the ADAS fruit consultant reported that dark coloured thrips were present in the flowers. There was no previous history of rose thrips damage.

Biological control agents applied before and after visit
No biological controls were applied before the visit. *Neoseiulus cucumeris* (for control of thrips) and *Phytoseiulus persimilis* (for control of spider mites) were applied after the visit. Naturally-occurring predatory mites were found in flowers on the visit and confirmed to be *Amblyseius andersoni*. This predator primarily feeds on mites including two-spotted spider mite but will also feed on pollen and young thrips larvae. However it will not control thrips in the absence of other thrips natural enemies.

Plant protection products applied for pest control before or after visit
Lambda-cyhalothrin (Hallmark) and pymetrozine (Plenum) for aphid control applied before the visit.

Mean numbers of thrips adults per flower in 20 strawberry flowers
1.8 (total of 36 adults)

Thrips species confirmed in strawberry flowers
Ten specimens of the 36 adults were identified to species. Of these, five were rose thrips, *Thrips fuscipennis* and five were rubus thrips, *Thrips major*.

Percentage fruit with bronzing and % fruit area bronzed on 20 fruit
No ripe fruit was present on the date of the visit. Mean of 30% fruit with bronzing and mean of 1.4% green fruit area bronzed (range 0-9.4% on individual fruit).

Flowering weeds on site
Dandelion, white clover, buttercup.

Thrips species confirmed in flowering weeds
In the dandelion, 57 thrips adults were found. Ten specimens were identified to species. Of these, eight were *Thrips vulgatissimus* and two were rubus thrips. One *T. vulgatissimus* was found in the white clover and two rubus thrips in the buttercup.

Trees and shrubs in hedgerows
The surrounding hedgerows contained a variety of trees and shrubs including elder, alder, elm, silver birch, sycamore and hazel. On the date of the visit the elder was in flower and over 150 thrips adults were found in a small sample of flowers. Identification of 20 of these confirmed them all to be *T. vulgatissimus*.

Site 2

Crop and site

First year June bearer crop cv. Sonata in Essex. Outdoor crop on table tops in new grow bags.

Date of visit and reason for selection

30 May 2017. This site was visited without any previous sample of flowers sent by an ADAS fruit consultant earlier in the year. The site had a history of previous damage by 'dark' thrips and the ADAS fruit consultant had reported the presence of dark coloured thrips in flowers.

Biological control agents applied before and after visit

No biological controls were applied to this crop.

Plant protection products applied for pest control before and after visit

None applied before visit. Thiacloprid (Calypso) was applied after the visit for thrips control as fruit damage was increasing.

Mean numbers of thrips adults per flower in 20 strawberry flowers

1.8 (total of 36 adults).

Thrips species confirmed in strawberry flowers

Ten specimens of the 36 adults were identified to species. Of these, eight were rose thrips and two were rubus thrips.

Percentage fruit with bronzing and % fruit area bronzed on 20 fruit

Mean of 45% green fruit with bronzing and mean of 7.5% green fruit area bronzed (range 0-50% on individual fruit).

Mean of 20% ripe fruit with bronzing and mean of 1% ripe fruit area bronzed (range 0-5% on individual fruit).

Flowering weeds on site

Bindweed, dandelion, white clover, vetch.

Thrips species confirmed in flowering weeds

In the bindweed, one western flower thrips (WFT), Frankliniella occidentalis was found. Two, eight and three onion thrips (Thrips tabaci) were found in the white clover, dandelion and vetch respectively.

Trees and shrubs in hedgerows

The surrounding hedgerows contained a variety of trees and shrubs including silver birch, sycamore, willow, bird cherry, oak, beech, lime, laurel, hawthorn and blackberry. Six thrips adults were found in a sample of blackberry flowers, two were rose thrips and four were onion thrips. The crop was also surrounded by various other soft fruit crops including gooseberry and raspberry. The gooseberry crop was not in flower but the raspberry crop was. A sample of six flowers from the raspberry crop contained eight thrips adults; one was rose thrips and seven were rubus thrips.

Site 3

Crop and site
First year everbearer crop cv. Finesse in Berkshire. Outdoor crop on table tops, to be kept for a further year's cropping in 2018.

Date of visit and reason for selection
5 July 2017. No previous sample of flowers had been sent by an ADAS fruit consultant. This site was selected as fruit damage by rose thrips had been confirmed by ADAS in previous years.

Biological control agents applied before and after visit
No biological controls were applied to this crop. The grower intended to use Orius laevigatus if thrips damage became a problem as good control of rose thrips had been achieved in a previous year with this predator. However, as insecticides were applied after the visit for SWD and thrips control Orius was not released.

Plant protection products applied before and after visit
Before the visit, Plenum and Calypso were applied for aphid control on 8 and 20 June respectively. After the visit, spinosad (Tracer) and pyrethrum (Spruzit) were applied for SWD and thrips control respectively on 10 July and 17 July respectively.

Mean numbers of thrips adults per flower in 20 strawberry flowers
0.23 (seven thrips in 31 flowers)

Thrips species confirmed in strawberry flowers
Of the seven thrips adults found in the flowers, five were rose thrips and two were rubus thrips.

Percentage fruit with bronzing and % fruit area bronzed on 20 fruit
No ripe fruit was available on the date of the visit.

Mean of 55% green fruit with bronzing and a mean of 2.8% green fruit area bronzed (range 0-5%).

Flowering weeds on site
Crop hygiene was at a high standard at this site with no flowering weeds in or around the crop.

Trees and shrubs in hedgerows
The closest hedge to this crop was hawthorn.

Site 4

Crop and site
A mix of both first and second year everbearer crops cv. Evie 3 in Essex. Outdoor crop on table tops in new grow bags.

Date of visit and reason for selection
16 June 2017, after receiving a sample of flowers from an ADAS fruit consultant which contained 90% rose thrips and 10% onion thrips adults. This site had a history of a high proportion of rose thrips occurring in strawberry flowers (Bennison, unpublished data).

Biological control agents applied before and after visit

Neoseiulus cucumeris (for control of thrips) had been released twice during May at the rate of 50 per m^2. *Orius laevigatus* was released after the visit and established well and no insecticides for thrips control applied.

Plant protection products applied for pest control before or after visit

Pirimicarb (Aphox) was applied twice for aphid control during May.

Mean numbers of thrips adults per flower in 20 strawberry flowers

A mean of 1.1 (total of 21 adults in 19 flowers).

Thrips species confirmed in strawberry flowers

Ten specimens of the 21 adults were identified to species. Of these, nine were rose thrips and one was rubus thrips.

Percentage fruit with bronzing and % fruit area bronzed on 20 fruit

Mean of 50% green fruit with bronzing and mean of 9.5% green fruit area bronzed (range 0-75% on individual fruit).

Mean of 65% ripe fruit with bronzing and mean of 7.3% ripe fruit area bronzed (range 0-50% on individual fruit).

Flowering weeds on site

Dandelion, cow parsley, rosebay willowherb and thistle.

Thrips species confirmed in flowering weeds

In the dandelion, five thrips adults were found, four were *Thrips pillichi* and one was rubus thrips. The cow parsley and rosebay willowherb contained 10 *Thrips vulgatissiumus* and three rose thrips respectively. No thrips were found in the thistle flowers.

Trees and shrubs in hedgerows

The surrounding hedgerows contained a variety of trees and shrubs including elm, hazel, silver birch, oak, lime, maple poplar, cypress, pine, hawthorn and wild blackberry. The blackberry plants were flowering and a sample of flowers contained one rose thrips and two rubus thrips.

Site 5

Crop and site

First year tunnel-grown everbearer crop cv. Sweet Eve grown in raised beds in a mix of new and old grow bags in Nottinghamshire.

Date of visit and reason for selection

22 September 2017, following original sample of flowers received on 2 August. This site was visited because the initial sample of flowers received contained a high proportion of T. major. Therefore it was of interest to confirm the severity of fruit damage compared with sites where rose thrips was the dominant species.

Biological control agents applied before and after visit

Neoseiulus cucumeris (for control of thrips) had been released every 2-4 weeks during the season.

Plant protection products applied for pest control before or after visit

Spirdiclofen (Envidor) was applied on 14 April for spider mite control and pymetrozine (Chess WG) was applied on 2 May for aphid control. Two applications of Tracer were applied between 2 August and 22 September.

Mean numbers of thrips adults per flower in 20 strawberry flowers

A mean of 0.9 (total of 41 adults in 44 flowers) in the initial sample received on 2 August. A mean of 3.1 (total of 66 in 21 flowers) in the sample collected on the visit on 22 September.

Thrips species confirmed in strawberry flowers

Ten specimens of the 41 thrips received on 2 August and of the 66 thrips collected on 22 September were identified to species. In the sample received on 2 August, eight of these 10 thrips were rubus thrips and two were rose thrips. In the sample collected on 22 September, all 10 of the thrips identified were WFT. This is likely to have been due to the Tracer killing the *Thrips* species but allowing any WFT with spinosad resistance to survive and breed in between the two samples (WFT were not confirmed in the first sample received on 2 August but as a sub-sample of only ten thrips were identified to species low numbers of WFT could have been missed by not being included in the sub-sample).

Percentage fruit with bronzing and % fruit area bronzed on 20 fruit

On the visit on 22 September, the grower had finished picking and was shortly going to remove the crop.

Mean of 35% fruit with bronzing and mean of 2.1% green fruit area bronzed (range 0-15% on individual fruit).

Mean of 15% of ripe fruit with bronzing and mean of 1.1% ripe fruit area bronzed (range 0-12% on individual fruit).

Flowering weeds on site

Dandelion, common speedwell and spear-leaved willowherb.

Thrips species confirmed in flowering weeds

WFT were present in the dandelion and common speedwell flowers and no thrips were found in the spear-leaved willowherb flowers.

Trees and shrubs in hedgerows

The tunnels with strawberry at this site were surrounded by forest containing alder, elder, oak, elm, cedar and privet.

Site 6

Crop and site

First year tunnel-grown 60-day crop cv. Vibrant grown in raised beds in new grow bags in Yorkshire and adjacent tunnel-grown 60-day crop cv. Elsanta grown in raised beds in new grow bags.

Date of visit and reason for selection

29 August 2017, following original sample of flowers received from cv. Vibrant on 22 August. This site was visited because the initial sample of flowers received contained a high proportion of rubus thrips and no rose thrips, so it was of interest to determine the severity of fruit damage.

Biological control agents applied before and after visit

Phytoseiulus persimilis (for control of spider mite) had been released to both the Vibrant and Elsanta crops on 8 August but no biological controls had been released for thrips control.

Plant protection products applied for pest control before or after visit

Deltamethrin (Decis) was applied on 14 June for control of thrips.

Mean numbers of thrips adults per flower in 20 strawberry flowers

On the Vibrant crop, a mean of 2.8 (total of 91 adults in 32 flowers) were found in the sample received on 22 August. A mean of 3.2 (total of 79 in 25 flowers) in the sample collected from the Vibrant crop on the visit on 29 August. A mean of 0.9 (total of 18 adults in 21 flowers) in the sample collected from the Elsanta crop on 29 August.

Thrips species confirmed in strawberry flowers

On the Vibrant crop, ten specimens of the 41 thrips received on 22 August and ten of the 79 thrips collected on 29 August were identified to species. In the sample received on 22 August, eight of these 10 thrips were rubus thrips and two were onion thrips. In the sample collected on 29 August, five of the thrips in the sub-sample identified were rubus thrips and five were onion thrips. On the Elsanta crop, in the sub-sample of 10 thrips from those collected on 29 August, five were onion thrips, three were rubus thrips and two were rose thrips.

Percentage fruit with bronzing and % fruit area bronzed on 20 fruit

On the Vibrant crop 95% of the green fruit had bronzing and a mean of 1.8% green fruit area was bronzed (range 0-20% on individual fruit). Of the ripe fruit, 45% had bronzing and a mean of 8.2% ripe fruit area was bronzed (range 0-30% on individual fruit).

On the Elsanta crop, 95% of the green fruit had bronzing and a mean of 25.7% green fruit area was bronzed (range 0-80% on individual fruit).

No bronzing was seen on the ripe fruit.

Flowering weeds on site

None present.

Trees and shrubs in hedgerows

The tunnels were surrounded by hedges and trees including oak, silver birch, alder and hawthorn.

Site 7

Crop and site
First year tunnel-grown everbearer crop cv. Amesti grown in raised beds in soil in Staffordshire.

Date of visit and reason for selection
24 July 2017 after dark thrips were reported in flowers by ADAS fruit consultant. No previous history of dark coloured thrips on this field.

Biological control agents applied before and after visit
Neoseiulus cucumeris applied every two weeks for thrips control at 25 per plant. *Phytoseiulus persimilis* had also been applied for spider mite control.

Plant protection products applied for pest control before or after visit
Spinosad (Tracer) had been applied in mid-May for thrips control as the grower was concerned about the apparent influx of dark coloured thrips adults.

Mean numbers of thrips adults per flower in 20 strawberry flowers
Three thrips adults per flower (62 thrips in 21 flowers)

Thrips species confirmed in strawberry flowers
Ten specimens of the 62 thrips were identified to species. Nine of these were rubus thrips and one was rose thrips.

Percentage fruit with bronzing and % fruit area bronzed on 20 fruit
Mean of 50% green fruit with bronzing and a mean of 2.5% green fruit area was bronzed (range 0-5% on individual fruit).

No bronzing damage was seen on the ripe fruit.

Flowering weeds on site
Groundsel, mayweed, dandelion, rosebay willowherb and shepherd's purse.

Thrips species confirmed in flowering weeds
No thrips were found in the groundsel and mayweed. Three thrips adults were found in the dandelion flowers, two of these were onion thrips and one was rubus thrips. Two thrips were found in the rosebay willowherb, one was rose thrips and one was T. vulgatissimus. One thrips was found in the shepherd's purse and this was rose thrips.

Trees and shrubs in hedgerows
The surrounding hedges and trees were elder, willow, oak, cypress, walnut, hawthorn, dogwood and blackberry. The blackberry plants had just finished flowering soit was not possible to collect flowers to check for thrips.

Summary of case study results

Distribution of rose thrips and other species in strawberry flowers

In addition to the seven case study sites, additional information was gained from 18 other strawberry flower samples received, making a total of 25 flower samples. Rose thrips was present in 18 of these 25 samples (nine samples from outdoor crops and nine samples from tunnelled crops). Rose thrips occurred in the highest proportions in thrips species mixes in the south of England. (Table 2 – page 17 and Figure 4 – page 18). Of the eight samples where over 50% of the thrips species were rose thrips, six were from outdoor crops and two were from tunnelled crops. *Thrips major* was present in 20 of the 25 samples, occurring in the highest proportions of thrips species mixes in the north of England (Table 2 –page 17). These geographical distribution patterns of rose thrips and *T. major* are consistent with published information (Morison, 1957). Onion thrips (*Thrips tabaci*) was present in nine of the 25 samples with no obvious bias to the north or south of England. Three other thrips species, *T. atratus*, *T. pillichi* and *T. vulgatissimus,* were only recorded in strawberry flowers at single sites.

Rose thrips occurred as a single species at only one site (site 9, in Hertfordshire) - i.e. in 4% of flower samples (Table 1). In the remaining 17 flower samples, rose thrips was found in a mixture with other thrips species, most frequently (in 60% of samples) with *Thrips major* (Table 1) but also with onion thrips (*Thrips tabaci*), WFT, *Thrips pillichi* and *Thrips atratus*.

Table 1. The percentage of flower samples with rose thrips occurring as a single species or in a mixture with other species.

Thrips species present together with rose thrips (*Thrips fuscipennis*)	**% flower samples***
Thrips major	60%
Thrips tabaci	16%
Frankliniella occidentalis (WFT)	8%
Thrips pillichi	4%
Thrips atratus	4%
Thrips fuscipennis (as a single species on its own)	4%

*Rose thrips (*Thrips fuscipennis*) did not occur in all samples and sometimes occurred with more than one of the above species in the same sample, so the values do not total 100%

Rose thrips (*Thrips fuscipennis*) was confirmed in strawberry flowers between May and August 2017. At one of the case study sites (site 5 in Nottinghamshire), the thrips species found in strawberry flowers on 2 August contained a mean of 0.9 thrips adults per flower, 80% of which were *T. major* and 20% of which were rose thrips. However, on the case study visit on 22 September, there was a mean of 3.1 thrips adults per flower and all of these were WFT. This change in thrips species present is likely to be due to the grower having applied two applications of Tracer for thrips control in between the two visits. Tracer would have killed all the thrips species except for WFT, which has developed resistance to Tracer.

Table 2. Summary of mean percentage area of fruit damaged and numbers and species of thrips in flower samples at each site. Sites 1-7 (shown in blue) are case study sites and the other sites are additional sites. Only those additional sites where fruit damage records were taken are shown

Site	**Sample**	**Date**	**County**	**Cultivar**	**Green Fruit Mean % area damaged**	**Ripe fruit mean % area damaged**	**Mean thrips adults per flower**	***Thrips fuscipennis***	***Thrips major***	***Thrips tabaci***	**WFT**	***Thrips vulgatissimus***
1	1	18 May	Surrey	Everest	1.44	N/A	1.8	50%	50%			
2	2	30 May	Essex	Sonata	7.5	1	1.8	80%	20%			
3	3	2 June	Berks	Elsanta	0	0	1		20%	80%		
3 (Field 2)	4	5 July	Berks	Elsanta	2.5	N/A	0.55	70%			30%	
3 (Field 3)	5	5 July	Berks	Finesse	2.81	N/A	0.23	71%	29%			
4	12	16 June	Essex	Evie 3	9.45	7.3	1.11	90%	10%			
5 (Visit 2 seven weeks later)	17	22 Sep	Notts	Sweet Eve	2.1	1.1	3.14				100%	
6 (Visit 2 one week later)	22	29 Aug	North York	Vibrant	1.8	8.2	3.16		50%	50%		
6 (Field 2)	23	29 Aug	North Yorks	Elsanta	25.7	0	0.86	20%	30%	50%		
7	13	24 July	Shrops	Amesti	2.5	0	2.95	10%	90%			
12	8	6 June	Staffs	Sonata	0	0	0.18	30%	60%	10%		
13	18	10 Aug	Oxfordshire	Murano	0	0	0.29		60%	40%		
14	19	15 Aug	Cambs	Murano	1	0.15	1.4			100%		
15	20	22 August	West Yorkshire	Malling Centenary	0	0	1.92		60%			40%
18	25	24 August	Herefordshire	Murano	5.4	N/A	0.57	20%		80%		

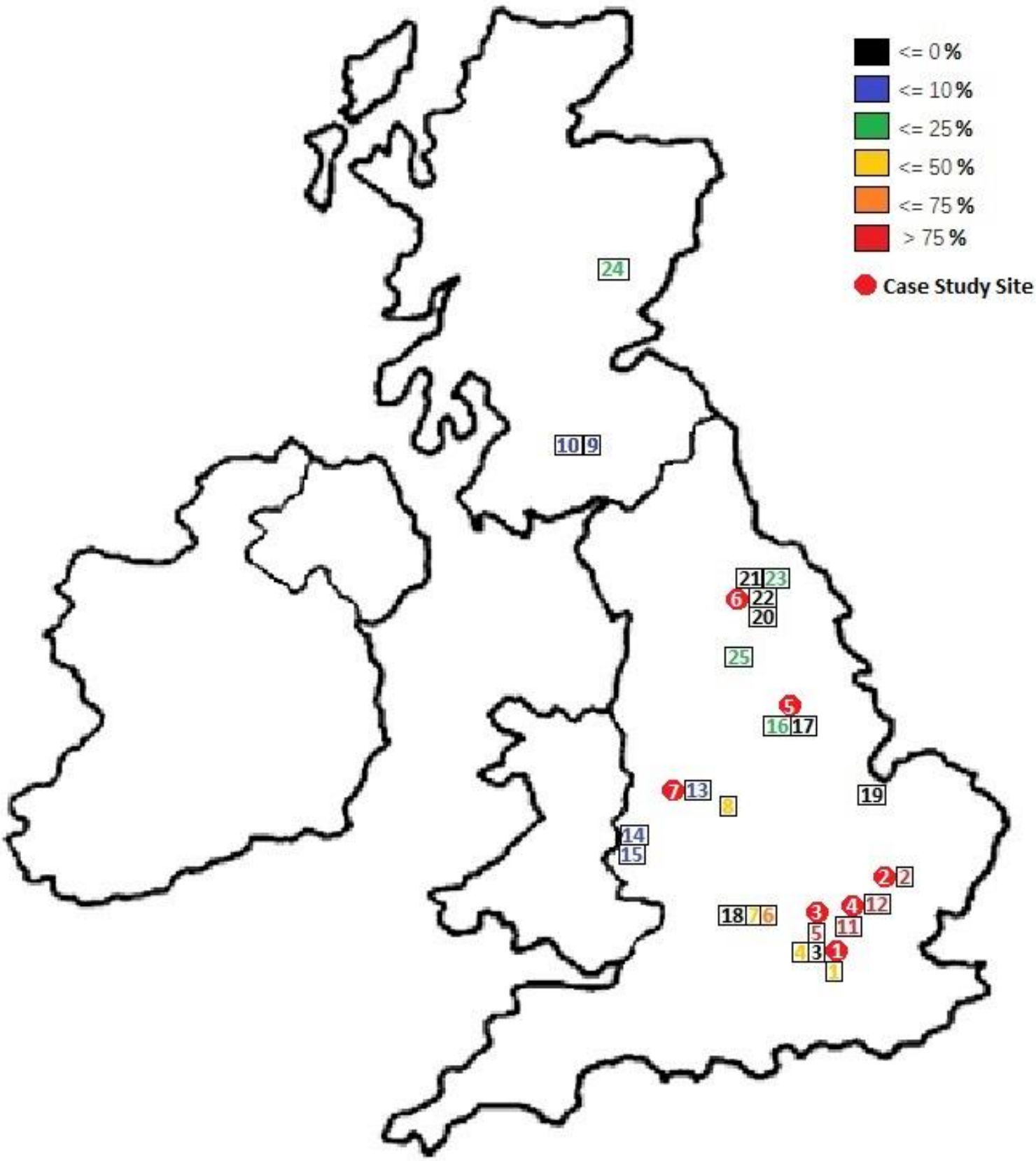

Figure 4. Location of strawberry flower samples. The number in each square is the site number and the colour of the number represents percentage of rose thrips in each sample of thrips adults in the flowers (see key to colours).

Strawberry varieties infested with rose thrips

Including both the case study sites and the additional sites from which flower samples were received, rose thrips (*Thrips fuscipennis*) were confirmed in the following everbearer and 60-day varieties:

Everbearers:

- Everest
- Finesse
- Evie 3
- Sweet Eve
- Amesti

60-day varieties:

- Sonata
- Elsanta
- Malling Centenary

Potential sources of rose thrips

Rose thrips (*Thrips* fuscipennis) adults were present in strawberry flowers at all seven case study sites. The crops at six of these sites were first year crops. Four out of these six first year crops were planted into new grow bags. One was planted into a mix of new and old grow bags and one was planted into soil in raised beds. As rose thrips adults occurred in flowers at four sites where first year crops were planted into new grow bags, this indicates that unlike WFT, the source of rose thrips adults in these crops was not from within an overwintering strawberry crop or substrate but may have flown in from overwintering sites around the crop. Rose thrips are reported to overwinter as adult females in bark crevices and in 'herbage'. Flowering weeds were found at five of the seven case study sites. Rose thrips were found in flowering weeds at only two sites, in rosebay willowherb and shepherd's purse, so it is possible that they overwintered in the vegetative plant material of these two weed species, similar to weed sources of WFT such as dandelion and groundsel. Rose thrips is also known to occur in bindweed and meadowsweet flowers (Kirk, 1985a). Bindweed was present at only one of the case study sites (site 2) where rose thrips was found in the strawberry flowers but although the bindweed flowers contained WFT they did not contain rose thrips. Meadowsweet was not recorded at any of the case study sites.

However, ADAS confirmed high numbers of rose thrips in bindweed (*Calystegia sepium*) around a strawberry crop infested with rose thrips in 2014 (Bennison and Hough, 2015). Kirk (1985a) confirmed that rose thrips aggregates and mates in bindweed flowers once they open at dawn, from where they continue to actively disperse during the day.

Various trees and hedgerow plants surrounded the crops at all case study sites and could have been potential overwintering sites. Flowering blackberry plants were in the hedgerows at two sites visited in June and rose thrips adults were found in the flowers at both sites. An interesting observation

made by one of the ADAS fruit consultants was that heavy rain between visits to one of the 'additional' sites reduced numbers of dark coloured thrips adults in the flowers of an outdoor strawberry crop but numbers were still high in the wild blackberry flowers in the surrounding, more sheltered hedgerow. It is reported that periods of cold wet weather usually causes a high mortality in thrips populations (Mound *et al*, 1976) so it is possible that numbers of rose thrips adults in outdoor strawberry crops are reduced after periods of heavy rain.

Mean numbers of rose thrips and other species per flower and fruit damage

Overall, mean numbers of adult thrips per flower were low at the time of the case study visits, with all being less than four per flower (Table 2). However, at five of the seven case study sites, plant protection products had been applied for control of either SWD or thrips before the visit. These would have reduced numbers of rose thrips present on an earlier date as unlike WFT, rose thrips have not yet developed resistance to any plant protection products. In addition, only one case study visit was made to each site. On the date of the visit, the adult thrips recorded in strawberry flowers may not have caused any green or ripe fruit damage recorded on the same date. Experience with WFT is that fruit damage by thrips is caused at an early stage of fruit development during late flowering and early fruit stages. However the damaged fruit is not seen in the field until 20-40 days later (the time taken for flowers to develop into fruit depending on temperature and pollination). However, as damaged fruit has been reported soon after growers or consultants have seen high numbers of dark coloured thrips adults in flowers, it is possible that rose thrips adults can damage fruit at later stages of fruit development than WFT does. At present it is not possible to correlate numbers of rose thrips in flowers with severity of fruit damage.

However, more fruit damage was recorded at two case study sites where the highest numbers of rose thrips per flower were recorded. These were at site 2, sample 2, with a mean of 1.4 rose thrips and 0.4 rubus thrips per flower and mean green fruit area damaged was 7.5% (Table 2), with a range of 0-50% area damaged on individual fruit. Similarly at site 4 with a mean of 0.9 rose thrips per flower and 0.2 rubus thrips per flower, mean green fruit area damaged was 9.5% (range 0-75%) and mean ripe fruit area damaged was 7.3% (range 0-75%). In previous work carried out by ADAS, higher numbers of rose thrips adults (a mean of six per flower) were associated with mean fruit area damage of around 80% (Bennison & Hough, 2015)

The site with the highest ratio of rose thrips in the flowers was site 9, sample 11, where 100% of the thrips in the flowers were rose thrips. It was not possible to visit this site to record numbers of thrips per flower or fruit damage due to difficulties contacting the grower. However the ADAS consultant reported that fruit damage did occur and the grower applied Tracer for thrips control.

The highest mean areas of fruit area damaged were recorded at site 6, where a mean of 8.2% of ripe fruit area was damaged on cv. Vibrant and a mean of 25.7% of green fruit area was damaged on cv. Elsanta crop (Table 2). At this site, means of 1.6 onion thrips (*Thrips tabaci*) and 1.6 rubus thrips adults per flower were recorded on the Vibrant crop and means of 0.2, 0.3 and 0.4 rose thrips, rubus

thrips and onion thrips respectively were recorded on the Elsanta crop. It is known that onion thrips can damage strawberry fruit (Bennison & Hough, 2015).

At site 7, where means of 2.7 rubus thrips and 0.3 rose thrips per flower were recorded, a mean of only 2.5% green fruit area was damaged and no ripe fruit damage was recorded. However, rubus thrips was present in 20 of the 25 flower samples received in this study and occurred in low numbers at most of the sites where fruit damage was recorded (Table 2). There is not enough evidence from this study to demonstrate that rubus thrips is less damaging than rose thrips or onion thrips.

Some fruit damage attributed to rubus thrips (*Thrips major*) occurred at a site where biological control of WFT was successful in 2014 (Sampson, 2014).

Control of rose thrips and other thrips species by biological control agents and plant protection products

Biological control agents were used for thrips control at four of the seven case study sites. *Neoseiulus cucumeris* were used at sites 4, 5 and 7 before the visit and at site 1 after the visit. At site 4 rose thrips was the predominant species confirmed in strawberry flowers and at sites 5 and 7, rubus thrips was the main species.

At site 4 with a mean of 0.9 rose thrips per flower and 0.2 rubus thrips per flower, mean green fruit area damaged was 9.5% (range 0-75% on individual fruit) and mean ripe fruit area damaged was 7.3% (range 0-50% on individual fruit). It is generally considered that fruit is downgraded to class 2 when there is a mean of over 10% ripe fruit area damaged. Therefore at this site, as up to 50% damage occurred on individual ripe fruit which would have caused potential downgrading, indicating that *N. cucumeris* did not give adequate thrips control. At this site (an outdoor crop), *N. cucumeris* had been released twice during May at 50 per m^2 (equivalent to approximately five per plant) before the visit on 16 June. This rate of *N. cucumeris* is lower than the 'standard' rate on strawberry (25 per plant every week or fortnight) for control of WFT, so this might be one reason why inadequate control of rose thrips achieved. Following the visit, *Orius laevigatus* was released and established well leading to good thrips control (see later in this section).

At both sites 5 and 7, where the predominant thrips species in flowers was rubus thrips , Tracer had been applied at least once before the visit indicating that the grower considered that the biological control progamme was not giving adequate control of the thrips. In previous years to this study, rose thrips have been associated with fruit damage on crops where *N. cucumeris* was giving good control of WFT but not rose thrips. Western flower thrips occurred at only one of the case study sites in this study (site 5) and this was at the end of the season when two applications of Tracer would have killed any *T. major* and rose thrips present earlier in the year.

In this study, rose thrips larvae were not found in any of the flower samples where rose thrips adults were confirmed in this study. This is in contrast to flowers infested with WFT where larvae are commonly found. Strawberry is recorded as a host plant suitable for larval development (Morison 1957). One possible reason for rose thrips damage occurring in crops where WFT has been

controlled by *N. cucumeris* is that influxes of adult rose thrips cause damage before they breed and produce larvae. *Neoseiulus cucumeris* feed only on first stage thrips larvae and would not predate any adults. Adult female rose thrips have been recorded from January to December in flowering plants and males and larvae only from May to August (Mound *et al*, 1976). Another possible reason for larvae not being found in flowers may be that rose thrips may lay their eggs in leaf tissue rather than in flower bud or flower tissue. This could possibly explain why *N. cucumeris* might give poorer control of rose thrips larvae than those of WFT. WFT larvae are usually found in flowers if they are available and *N. cucumeris* prefer to be in flowers rather than on leaves so that they can feed on pollen as well as thrips larvae.

Orius laevigatus was released at only one of the case study sites (site 4), after the site visit when 90% of the thrips in flowers had been confirmed as rose thrips. The ADAS fruit consultant reported that *Orius* established well at this site and no plant protection products were needed for thrips control. In an ADAS experiment in 2014, *Orius* established well following release in a rose thrips infested strawberry crop, reduced numbers of rose thrips as effectively as an application of Tracer and were observed predating on rose thrips in flowers (Bennison & Hough, 2015). The advantage of *Orius* over *N. cucumeris* is that the adults can fly to find thrips prey and they feed on both thrips adults and larvae. However, *Orius* needs higher temperatures than *N. cucumeris* to establish so rose thrips damage may occur before they can start to give control. In addition, *Orius* is also very sensitive to plant protection products.

Plant protection products were used for thrips control at five of the case study sites before the visit and at one site after the visit. Products used included Hallmark, Decis, Tracer and Spruzit. Of these, Spruzit and Tracer are least harmful and persistent to biological control agents used in IPM programmes. Growers and ADAS fruit consultants have reported that Tracer is more effective against thrips than Spruzit but growers would prefer to reserve the limited number of Tracer applications permitted for use on strawberry crops for control of SWD if needed. In addition, there is the risk of rose thrips and rubus thrips developing resistance to Tracer and other products in the same way that WFT has. Onion thrips (*Thrips tabaci*) has already developed resistance to pyrethroid products such as deltamethrin (e.g. Decis) on leek and onion and the first case of resistance to Tracer has recently been confirmed on salad onion in Kent (Foster, personal communication).

Conclusions

- Results of this study indicated that rose thrips (*Thrips fuscipennis*) can cause similar fruit bronzing to that caused by WFT. It is possible that rubus thrips (*Thrips major*) can also cause similar fruit damage but this has not yet been confirmed.
- Rose thrips (*Thrips fuscipennis*) commonly occurred in strawberry flowers in both outdoor and tunnelled crops in England during 2017. Its presence was also confirmed in Scotland.

- Rose thrips was usually found in combination with other thrips species, often the rubus thrips (*Thrips major*) which is very similar in appearance. Rose thrips was also sometimes found together with with onion thrips (*Thrips tabaci*) and other thrips species (*T. atratus*, *T. pillichi* and *T. vulgatissimus*) but rarely with WFT Rose thrips was the predominant species found in the south of England and rubus thrips was predominant in the north.
- Rose thrips adult females are darker than those of WFT so can be distinguished from WFT in the field. However, males of both rose thrips and WFT are smaller than the females and are yellow, so they can easily be confused in the field. The different thrips species can only be identified using a diagnostic key and a high powered microscope.
- No rose thrips larvae were found together with adults in the strawberry flowers sampled.
- As many of the plantations where rose thrips was confirmed were first year crops planted into new grow bags, it is likely that the pest does not overwinter in strawberry crops (as WFT does) but may fly in from surrounding overwintering sites. Rose thrips is reported to overwinter as adult females under tree bark or amongst 'herbage'. The pest was found in flowering rosebay willowherb and shepherd's purse in or around some strawberry crops so if these overwintered in the field they may also have been a source of the pest. Rose thrips was also found in blackberry flowers in hedgerows around two of the affected strawberry crops.
- Rose thrips in flowers were associated with fruit damage in both 60-day and everbearer crops between May and August. Usually, other thrips species were also present in the flowers where fruit damage occurred including rubus thrips (*Thrips major*) but at the case study sites rose thrips were usually predominant. Flower samples were received from one site where the thrips species were 100% rose thrips and although it was not possible to visit this site, the grower applied Tracer for control as fruit damage was occurring and this was reported to be effective.
- Fruit damage also occurred at one site where there were no rose thrips in the flowers but where onion thrips and rubus thrips were present. Onion thrips is known to damage strawberry fruit and it is possible that rubus thrips can also damage fruit but this needs to be confirmed. Western flower thrips was confirmed in strawberry flowers at only one site.
- Of the seven sites visited, *Neoseiulus cucumeris* was used for biological control of thrips prior to the visit on one outdoor and one tunnelled crop but inadequate control of both rose thrips and rubus thrips was achieved. *Orius laevigatus* was released after the visit on the outdoor crop to supplement *N. cucumeris* and established well, leading to good rose thrips control without the need for a plant protection product. Tracer was used for control of rubus thrips on the tunnelled crop.
- At sites where *N. cucumeris* was not used, the growers applied plant protection products for thrips when numbers of dark coloured thrips were increasing in flowers, irrespective of species. This was often due to a history of fruit damage on the farm. Products used were Decis, Hallmark, Tracer and Spruzit. Unlike WFT, both rose thrips and rubus thrips seem to be susceptible to all these products at present. However, Decis and Hallmark are

incompatible with biological control agents and growers may prefer to reserve the limited number of Tracer applications permitted for use on strawberry crops for control of SWD if needed. In addition, there is the risk of insecticide resistance developing in both rose thrips and rubus thrips and increasing in onion thrips populations.

Action points for growers

Monitoring for thrips

- Check a minimum of 20 flowers per crop every week to get a good idea of the average numbers of thrips per flower during the season.
- Choose medium-aged flowers (all petals present, pollen shed and anthers brown rather than yellow) promising at the tops of the plants as more thrips are likely to be found in these flowers rather than in younger or older flowers and those at the sides of the plant or nestled within the leaves.
- Tap each flower sharply onto a sheet of white paper on a clipboard or in a notebook so that any thrips fall out and can be counted. Use a x10 or x20 hand lens if needed. Shake or brush the thrips off the paper in between flowers.
- Check fruit for thrips damage (i.e. bronzing around the seeds).

Identification of thrips

Identification of thrips species cannot be done in the field. However, rose thrips and rubus thrips adult females are darker than those of WFT (see Figure 1 and AHDB Factsheet 14/15 for photographs of rose thrips and WFT adult females). If you see dark thrips adults, they should be sent to an entomologist for identification. Flowers containing thrips should be placed into a screw-cap tube or other sealed, crush-proof container. These can be sent to Sam Brown at the following address or via an ADAS fruit consultant.

Sam Brown

ADAS Boxworth
Boxworth
Cambridge
CB23 4NN

Contact details:

Phone: 01954 268226
Mobile: 07774795065

Email: Sam.Brown@ADAS.co.uk

Alternatively, samples can be submitted to FERA for identification.

Control of thrips

- Thrips control should be planned as part of an Integrated Pest Management (IPM) programme. As mixtures of thrips species can occur on strawberry including WFT, rose thrips and other species, the biological control component of the IPM programme should be the same as that commonly used against WFT. Further details of current biological control strategies for WFT on strawberry are set out in AHDB Factsheet 14/15, but are summarised below.
- Release the predatory mites *Neoseiulus cucumeris* from first flowers. The minimum release rate is 25 per plant every week or fortnight (or increase to 50 per plant if numbers of thrips start to increase). These predators feed on young WFT larvae and although it is not yet known how effective this programme is against rose thrips, using them is a sensible strategy until more is known.
- Apply the ground-dwelling predatory mites *Statiolaelaps scimitus* (formerly known as *Hypoaspis miles*) once at about 10 per plant. It is not yet known how effective these are against rose thrips larvae that might drop to the ground to pupate, but as they are effective against WFT it is a sensible option until more is known.
- Release *Orius laevigatus* in addition to *N. cucumeris* once temperatures are suitable. This predator will feed on WFT adults and larvae and on pollen and they were shown to be as effective as Tracer against rose thrips in a strawberry crop (Bennison & Hough, 2015). *Orius laevigatus* needs a minimum of 15°C for egg laying and over 20°C for good establishment. Commonly used release rates are a minimum of 0.25 to one *Orius* per plant, repeated after two weeks. *Orius laevigatus* are very sensitive to plant protection products so avoid using any that are harmful (consult your supplier or adviser).
- Some growers use blue roller traps in the leg rows to help control WFT adults in strawberry but there is no evidence yet that these also help to control rose thrips adults.
- If fruit bronzing is seen and rose thrips has been confirmed in the crop, consider using an IPM-compatible plant protection product for control. Options include spinosad (Tracer) and pyrethrum (Pyrethrum 5 EC or Spruzit). Experience has shown that Tracer is more persistent than pyrethrum products but growers may wish to reserve the maximum of four applications of Tracer per crop for control of spotted wing drosophila. Do not use Tracer if only WFT are present as they are likely to be resistant to this product.
- The entomopathogenic fungus *Beauveria bassiana* is approved for use on all protected crops (Naturalis L) and has an EAUMU for use on outdoor or fully protected glasshouse crops (Botanigard WP). This fungus is recommended for whitefly control but may give some control of thrips, although its activity against rose thrips has not yet been tested.

Further work on rose thrips

Key gaps in knowledge on rose thrips biology and control on strawberry need filling so that effective IPM strategies can be developed. These include:

- When do adults first become active in strawberry crops?
- How many generations or influxes of adults occur?
- Do they breed in strawberry crops and if so where do the larvae occur?
- Where do the larvae pupate in strawberry crops?
- Do both adults and larvae cause damage to fruit?
- Is there a 'threshold' for numbers of rose thrips that cause fruit to be downgraded?
- Do *N. cucumeris* predate rose thrips larvae?
- Do ground-dwelling predatory mites feed on any larvae and pupae once any larvae have dropped to the ground to pupate?
- Do entomopathogenic fungi give any control of rose thrips?
- Are rose thrips attracted to blue or other colours and could roller traps help control adults?
- What is an effective IPM programme for rose thrips, taking into account the potential need to use plant protection products for control of SWD or other pests?

Work on rose thrips is being done during 2018 in SF 156 'Improving Integrated Pest Management in strawberry'. ADAS, NIAB EMR and Berry Gardens will monitor strawberry crops for thrips species, numbers and fruit damage at four commercial sites. The aim of the work is to fill key gaps in knowledge on rose thrips biology in strawberry crops so that IPM strategies can be developed. The objectives in 2018 are:

1. Determine when adult rose thrips activity starts in strawberry crops and identify peaks in numbers (and potentially numbers of generations) between April and August inclusive.
2. Determine if rose thrips larvae develop in strawberry flowers.
3. Record fruit damage associated with rose thrips and other thrips species in flowers.

The results of the work in 2018 will be used to guide further research on developing an IPM programme for rose thrips.

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References

Alford, D. (1994). A colour atlas of pests of fruit. Their recognition, biology and control. Wolfe Publishing Ltd. Glasgow, Scotland.

Alford, D. (1991). A colour atlas of pests of ornamental trees, shrubs and flowers. Wolfe Publishing Ltd., Barcelona, Spain.

Bennison & Hough, 2015. Maintaining the expertise for developing and communicating practical integrated pest management (IPM) solutions for horticulture. Annual report to HDC on project CP 089.

Kirk, W. (1994). The effects of density on the oviposition rate of flower thrips. Courier Forschunginstitut Senckenberg 178: 69-73.

Kirk, W. (1985a). Aggregation and mating of thrips in flowers of *Calystegia sepium*. Ecological Entomology 10: 433-440.

Kirk, W. (1985b). Pollen feeding and the host specificity and fecundity of flower thrips (Thysanoptera). Ecological Entomology 10: 281-289.

Kirk, W. (1984). Pollen feeding in thrips (Insecta: Thysanoptera). Journal of Zoology 204: 107-117.

Lewis, T. (1997). Major crops infested by thrips with main symptoms and predominant injurious species. In: Lewsi, T. Thrips as Crop Pests. CAB International. Wallingford, UK. Appendix II.

Mound, L.A., Morison, G.D., Pitkin, B.R. and Palmer, J.M. (1976). Royal Entomological Society handbook for the identification of British Insects, Vol 1, Part 11 (Thysanoptera).

Morison, G.D. (1957). A Review of British Glasshouse Thysanoptera. Royal Entomological Society, London pp501-502.

Nakahara, S. (1994). The genus *Thrips* Linnaeus (Thysanoptera: Thripidae) of the New World. United States Department of Agriculture. Technical Bulleting 1822: 1-183.

Raffle, S., Bennison, J., Fitzgerald, J. and Sampson, C. (2016). Western flower thrips control in strawberry. AHDB Horticulture Factsheet 14/15.

Sampson. (2014). Management of pesticide-resistant western flower thrips on tunnel-grown strawberry; a study of the reasons for successes and failures on commercial production sites. Report to AHDB Horticulture

Speyer, E.R. (1938) 3. Animal pests. 1. Rose thrips (Thrips fuscipennis, Hal.). Rep exp Res Stn, Cheshunt 24, 64-65.