‘New’ thrips problems in protected ornamentals and herbs

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Background

Thrips setosus

A ‘new’ thrips species has been causing problems recently on some UK protected ornamental and herb crops including *Cyclamen*, New Guinea *Impatiens*, primrose, basil and rosemary. The thrips has been confirmed as Japanese flower thrips, *Thrips setosus*, which is alien to the UK but is not currently classed as a notifiable quarantine species. Where *T. setosus* has been confirmed, the growers have been routinely using the predatory mite *Neoseiulus cucumeris* for biological control of thrips within integrated pest management (IPM programmes). This usually gives good control of western flower thrips (WFT) but *T. setosus* does not seem to have been controlled. A range of plant protection products have been used on the infested ornamental crops to control *T. setosus* with variable success and this has sometimes disrupted IPM.

Dichromothrips corbetti

One or two growers have also experienced problems with control of ‘Vanda thrips’ (*Dichromothrips corbetti*) on *Phalaenopsis*. This thrips species is also alien to the UK but is not currently a notifiable quarantine species.

Worldwide distribution and host plants

Thrips setosus

Thrips setosus is native to South East Asia and is widespread in Japan and has also been confirmed in Korea, Indonesia and more recently in some Northern European countries including Belgium, Croatia, France, Germany and the Netherlands. *Thrips setosus* was first found in the Netherlands in 2014, on both protected and outdoor *Hydrangea* (Vierbergen & Loomans, 2016) and was first detected in the UK in 2016 on poinsettia. The pest will feed on many different plant species – recorded ornamental host plants include: *Abelia*, *Aster*, *Begonia*, *Chrysanthemum*, *Cyclamen*, *Dahlia*, *Gerbera*, *Hippeastrum*, *Hosta*, *Hydrangea*, lily, poinsettia, primrose, rose, *Saintpaulia, Sparmannia*, *Streptocarpus,* and *Tagetes*. Recorded edible host plants include: aubergine, bean, chilli, cucumber, grapevine, lettuce, pea, pepper, potato, pumpkin, rice, sesame, strawberry, tobacco, tomato and various herbs. Weed hosts include hogweed, knotweed, nettle, red deadnettle and sowthistle. In the UK, particular problems have occurred on *Cyclamen*, New Guinea *Impatiens*, basil and rosemary. Other protected herb crops that have been infested in the UK include marjoram, mint, parsley, sage, tarragon and thyme. On some crops e.g. poinsettia and *Saintpaulia*, *T. setosus* adults have been found but no larvae, indicating that they do not lay eggs and breed on these plants (Gijsbertus Vierbergen, personal communication, 2021).

Dichromothrips corbetti

Dichromothrips corbetti is also native to South East Asia and has been recorded in Fiji, Florida, French Polynesia, Hawaii, India, Indonesia, Kuala Lumpur, Malaysia, Northern Australia, the Philippines, Puerto Rico, Samoa, Singapore, Taiwan and Thailand. The pest has spread to Europe via plant trade and has been recorded in the UK, Belgium, Germany, the Netherlands, Hungary and Slovakia. *Dichromothrips corbetti* feeds and breeds on various orchids including *Arundina, Cattleya, Dendrobium, Phalaenopsis* and *Vanda* species.

Recognition

Thrips setosus

The adult females are approximately 1.3mm long, dark brown with pale patches at the base of the wings (Fig. 1). They have seven antennal segments (only visible with a microscope). The females are easily distinguished from those of WFT which are paler and about 1.2mm long (Fig. 2). *Thrips setosus* males, like those of WFT, are yellow but the paler patches at the base of the wings are still visible (Fig. 3). *Thrips setosus*, like other thrips species have two wingless larval stages. The first stage larvae are white and smaller than the second stage larvae which are usually white (Fig. 4) but sometimes yellowish, depending on what they have fed on (Manfred Ulitzka and Gijsbertus Vierbergen, personal communications, 2021). With WFT, the first stage larvae are white and the larger, second stage larvae are always yellow.

Fig. 1 (top left) *Thrips setosus* adult female ©Dr Manfred Ulitzka; Fig. 2 (top right) WFT adult female, ©Nigel Cattlin/FLPA; Fig. 3 (bottom left) *Thrips setosus* adult male ©Dr Manfred Ulitzka; Fig. 4 (bottom right) *Thrips setosus* second stage larva ©Dr Manfred Ulitzka

Dichromothrips corbetti

The adult females are 1-1.2mm long, dark brown or black with white patches at the base of the wings (Fig. 5). They have eight antennal segments (only visible with a microscope). The second stage larvae are yellow (Sakimura, 1955).

For further information on identification of thrips see Thrips identification poster | AHDB.

Fig. 5 *Dichromothrips corbetti* adult female ©Dr Manfred Ulitzka

Damage symptoms

Thrips setosus

Due to their dark brown bodies, the adult females are easily visible on petals and leaves (Figs 6 and 7).

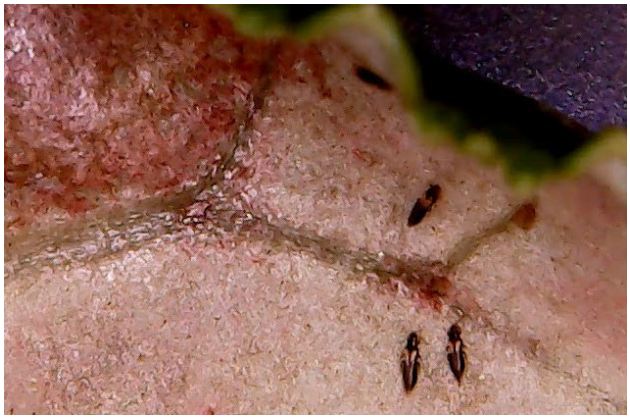

Fig. 6 (left) *Thrips setosus* adult females on cyclamen flower, grower source; Fig. 7 (right) *Thrips setosus* adult females on underside of cyclamen leaf, grower source

Like other thrips species, *Thrips setosus* feed by piercing plant cells and sucking out their contents, leaving bleached or silvery flecks or patches on leaves and petals which can then become brown due to necrosis. *Thrips setosus* leaf damage tends to be more severe than that of WFT, leading to severe browning and scarring on the underside of the leaves (Fig. 8). Similar browning and scarring can also occur on petals e.g. on *Cyclamen* (Fig. 9). *Thrips setosus* is reported to be primarily a leaf-feeding thrips which does not feed on pollen (Murai, 1991; 2001) and can be reared in the laboratory on leaf discs of various host plants including bean, *Hydrangea* and sweet pepper without any pollen as supplementary food. However, a preliminary experiment by Koppert in the Netherlands showed that *T. setosus* larvae survived on *Typha* (cattail) pollen for three days (Markus Knapp, Koppert BV, personal communication, 2021). In addition, as *T. setosus* have occurred on the flowers of some plants e.g. *Cyclamen* and *Saintpaulia*, it is possible that they feed on the pollen of some plant species but not others. On *Saintpaulia*, damage has been restricted to the flowers (Gijsbertus Vierbergen, personal communication), whereas on New Guinea *Impatiens* damage seems to be restricted to the leaves. On New Guinea *Impatiens*, damage has led to plants failing to recover from growth regulation using deficit

irrigation. On both New Guinea *Impatiens* and *Cyclamen*, severe leaf damage has also led to increased susceptibility to infection with *Botrytis*.

In addition to causing direct damage, like WFT, *T. setosus* can transmit Tomato spotted wilt virus (TSWV), but unlike WFT, it is not a vector of Impatiens necrotic spot virus (INSV), (Sakurai *et al*., 2004). As with WFT, TSWV is transmitted by *T. setosus* adults after the virus is acquired by larvae feeding on infected plants. Adult *T. setosus* can also acquire TSWV but cannot transmit it unless it is acquired at the larval stage (Ohnishi *et al*., 2001). This is important to consider for control of TSWV i.e. good control of larvae plays an important part in preventing or reducing virus spread.

Fig. 8 (left) *Thrips setosus* damage to cyclamen leaf underside, grower source; Fig. 9 (right) *Thrips setosus* damage to cyclamen petals, grower source

On protected herbs, *T. setosus* causes typical pale flecks or patches similar to those caused by WFT and as on other host plants, the small black faecal specks are often visible on the feeding patches (Fig. 10). However, basil seems to be particularly susceptible to damage by *T. setosus* where in addition to the flecking and bleaching, leaf distortion and discolouration often occurs and the leaves can appear shiny and wet (Fig. 11).

Fig. 10 (left) WFT damage to basil showing bleached patches with small faecal specks © ADAS; Fig. 11 (right) *Thrips setosus* leaf damage to basil showing distortion and shiny wet appearance, grower source

Dichromothrips corbetti

This species can cause feeding damage and distortion to young foliar growing points and to flowers and buds of susceptible orchid species (Fig. 12). Flower damage symptoms include chlorosis and deformation (Cavalleri *et al.*, 2020) and excessive feeding can cause the flowers to dry up (Navasero, 2002). *Dichromothrips corbetti* has not been recorded as a virus vector (Messelink, 2019).

Figure 12. *Dichromothrips corbetti* damage to *Phalaenopsis* flower, grower source

Sources of infestation

The original source of infestation with both *Thrips setosus* and *Dichromothrips corbetti* is likely to be imported plant material. In addition to plant material being infested with adults, eggs and larvae, pupal stages might be brought onto the nursery in the growing media of host plants, as *T. setosus* larvae are reported to drop to the ground to pupate (see below in Biology and life cycle). However, once these thrips species have occurred on a nursery, it is also possible that they spread and carry over from previously infested crops on site.

Biology and life cycle

Thrips setosus

Most of the published information on the life cycle of *T. setosus* is on *Phaseolus vulgaris* (French bean) leaf discs, based on laboratory experiments in Japan at constant temperatures (Murai, 2001). However, as thrips development rate varies according to host plant, laboratory work has also been done in the Netherlands on *Hydrangea* in order to help time applications of plant protection products on this crop (Leman, 2020).

Adults

On French bean, adult *T. setosus* females live for a mean of 31 days at 20°C and each female lays a mean of five eggs per day throughout her life, thus laying a mean total of 155 eggs. Adult females are reported to go into reproductive diapause (i.e. they stop laying eggs) at daylengths of less than 12 hours at 20°C (Murai, 2001) and at daylengths of less than 10 hours at 18°C (Nakao, 1998). This means that although *T. setosus* females have been seen on UK crops of ornamentals and herbs all year round, at daylengths shorter than 12 hours and at lower temperatures they may not lay eggs.

Eggs

As with other thrips species, *T. setosus* eggs are laid into plant tissue and therefore are not visible. The eggs hatch faster at warmer temperatures – for example, at 20°C, eggs hatch after 7.5 days on French bean and after eight days on *Hydrangea* and at 25°C, eggs hatch after 4.8 days on French bean and after four days on *Hydrangea*.

Larvae

As with other thrips species, *T. setosus* eggs hatch into first stage larvae which feed for a few days then develop into larger second stage larvae. As with the eggs, development of larvae is faster at warmer temperatures. At 20°C, the first larval stage lasts for three days on French bean and four days on *Hydrangea* and at 25°C, the second larval stage lasts for three days on both host plants.

Pupae

Like other thrips species, *T. setosus* has two pupal stages, the prepupa and the pupa, neither of which feed. The prepupa has short immature wings and short, forward-pointing antennae and the pupa has longer immature wings and antennae folded round the body. At 20°C, the combined pupal stages last for six days on bean and seven days on *Hydrangea* and at 25°C they last for four days on bean and five days on *Hydrangea*. This information was from laboratory experiments where the *T. setosus* larvae were kept on leaf discs. *Thrips setosus* second stage larvae are reported to drop from host plants to pupate in the ground (https://www.koppert.com/challenges/thrips/japanese-flower-thrips/). This information was gained from a laboratory experiment (Markus Knapp, Koppert BV, personal communication, 2021). This indicates that in addition to using biological control agents against adults and larvae, ground-based biological control agents should also have potential for contributing to control of *T. setosus*, as used in IPM programmes for control of WFT.

Time from egg to adult

At 25°C, *Thrips setosus* completes its life cycle from egg to adult on bean in 13 days, which is similar to that of WFT on *Chrysanthemum* (Table 1) and slightly faster than *T. setosus* on *Hydrangea* (15 days). At 20°C, *T. setosus* completes its life cycle on bean in 20 days, similar to that of WFT on bean (19 days) and faster than *T. setosus* on *Hydrangea* (22 days). At 15°C, *T. setosus* completes its life cycle on *Hydrangea* in 36 days, slower than on bean (34 days) but faster than WFT on *Chrysanthemum* (39 days). Thus, like WFT, *T. setosus* has the potential to complete several generations on a crop, depending on temperature, host crop and production cycle.

Table 1. Time taken (days) from egg to adult by *Thrips setosus* and western flower thrips on different host crops and at different temperatures

Temperature	*Thrips setosus* on bean[1]	*Thrips setosus* on *Hydrangea*[2]	WFT on bean[3]	WFT on *Chrysanthemum*[4]
15°C	-	36	33.7	39.3
17.5°C	24.6	-	-	-
20°C	20.2	22	19	26.3
25°C	13.2	15	-	13.5

- Data unavailable

[1] Murai, 2001

[2] Leman, 2020

[3] Lublinkhof & Foster, 1977

[4] Robb, 1989

Dichromothrips corbetti

The life cycle of *D. corbetti* has been studied on *Vanda* orchid flowers used for mass rearing of the thrips in the laboratory (Navesero, 2002). The laboratory temperature was not specified. Adult females laid eggs in the flower tissue and these hatched into first stage larvae after three to four days. The first and second stage larvae fed for around three days and the mature second stage larvae then left the flowers to pupate in between sheets of tissue paper. As with *T. setosus* and WFT, this indicates that *D. corbetti* larvae drop to the ground to pupate. All the next generation adults had emerged from pupae after a further seven days. The total time from egg to adult was 9-13 days with a mean of 10 days.

On a UK nursery, *D. corbetti* has been found on young plants where it has survived in foliar growing points, indicating that it does not need flowers or pollen for survival.

Management strategies for *Thrips setosus* and *Dichromothrips corbetti*

Cultural control and monitoring

- Careful and prompt disposal of any badly infested plants will reduce the risk of thrips migrating onto other crops on site.
- Good nursery hygiene and weed control will reduce potential sources of thrips. Known weed hosts for *T. setosus* include hogweed, knotweed, nettle, red deadnettle and sowthistle, but as this species has a wide host range, other weeds might also be potential hosts. So far only orchid species have been recorded as hosts for *D. corbetti*.
- Bought-in plant material should be monitored for thrips and damage symptoms on arrival, checking both upper and lower leaf surfaces and the flowers and buds. If no thrips are visible, eggs may be present in plant tissue and pupae may be present in growing media, so regular monitoring should be maintained during production.
- Thrips species should be identified by an entomologist.
- *Thrips setosus* adults have been caught on both yellow and blue sticky traps on UK nurseries (Neil Helyer, Fargro Ltd., personal communication, 2021) and *D. corbetti* has been caught on yellow traps (blue have not been tried to date). It is not yet known which colour trap is most effective for monitoring either species. In the Netherlands, sticky traps are not used for monitoring *T. setosus* in *Hydrangea* as more are found on the plants than on the traps (Rianne Lek, Koppert Biological Systems, 2021).

Biological control

Predatory mites

- The predatory mite, *Neoseiulus cucumeris* is commonly used in many UK protected crops including ornamentals and herbs, for control of WFT. This predator feeds only on first stage larvae, it does not feed on the larger second stage larvae or adults. However, where *T. setosus* has been confirmed on UK protected ornamentals and herbs, although *N. cucumeris* has given good control of WFT, *T. setosus* has not been controlled.
- In the Netherlands, Koppert confirmed in laboratory tests that three other species of predatory mite will feed on both first and second stage *T. setosus* larvae (Markus Knapp, Koppert Biological Systems, personal communication, 2021). The three species tested were *Transeius montdorensis*, *Amblydromalus* (*Typhlodromalus*) *limonicus* and *Amblyseius swirskii*, all of which can be released to permanently protected (glasshouse) crops in the UK. *Neoseiulus cucumeris* was not included in these laboratory tests. On *Hydrangea* in the Netherlands,

Koppert are advising growers to use *Transeius montdorensis* for control of *T. setosus* and this predator is giving promising results (Rianne Lek, Koppert Biological Systems, personal communication, 2021). Koppert are also advising the use of 'Nutari' (*Carpoglyphus lactis* mites) as 'feeder mites' to maintain high numbers of *T. montdorensis* for control of this pest. Some UK growers of both protected ornamentals and herbs where *T. setosus* has been confirmed have now switched to using *T. montdorensis* instead of *N. cucumeris* and have reported successful results to date. So far 'feeder mites' have not been tried on UK crops. It is possible that *T. setosus* first stage larvae are larger than those of WFT, which could explain why *N. cucumeris* might not feed on them. The three other species of predatory mite that have been shown to feed on both first and second stage *T. setosus* larvae are also known to feed on both first and second stage WFT larvae, whereas *N. cucumeris* only feeds on the first stage WFT larvae.

- On a UK nursery where *D. corbetti* has been confirmed on *Phalaenopsis*, use of predatory mites is avoided as previous experience of releasing *A. swirskii* to a flowering crop led to flower drop. It was considered that this was due to the flower 'thinking' it had been pollinated. Research in the Philippines has shown that the predatory mite *Proctolaelaps yinchuanensis* will predate *D. corbetti* adults and larvae (Navasero *et al.*, 2003a) but this predator is not available in the UK.
- Releases of green lacewing larvae, *Chrysoperla carnea*, with or without the predatory thrips, *Franklinothrips vespiformis*, both at a rate of 20 per m^2 reduced numbers of *T. setosus* on *Hydrangea* in the Netherlands when compared with untreated control plants (Pijnakker *et al*., 2019). The lacewings were released every two weeks from mid-March when thrips numbers were low. Although neither predator established in the crop, the repeated releases kept thrips numbers low and leaf and flower damage was negligible. *Franklinothrips vespiformis* is not native or commercially available in the UK. Optimum and cost-effective release rates for *C. carnea* on *Hydrangea* and other crops would need to be tested. *Chrysoperla carnea* are available in the UK as eggs or larvae and will feed on a range of prey including thrips, aphids, moth eggs, mealybugs and spider mites.
- Research in the Netherlands is currently being undertaken on the potential of *Orius* species (predatory bugs) against *T. setosus*. Laboratory tests have indicated that both *Orius laevigatus* and *Orius majusculus* had more predatory encounters with both *T. setosus* and *Echinothrips americanus* than with WFT (Gerben Messelink, Wageningen University and Research, personal communication, 2021). It is possible that WFT is a more difficult prey to catch as it is more agile than the other two thrips species. *Orius laevigatus* is commonly used on some UK crops including strawberry and sweet pepper for WFT control to supplement predatory mites. The predator feeds on both WFT adults and larvae needs warm temperatures and plenty of prey or pollen to establish.

Plant protection products

- *Thrips setosus* is reported to be susceptible to many insecticides (Vierbergen & Loomans, 2016). However, UK growers of both protected ornamentals and herbs have reported poor control with most plant protection products. For contact-acting products, this could be due to them not reaching all the target thrips on leaf undersides, buds and growing points.
- UK growers have experimented with using tank mixes of products with different modes of action and also with adding adjuvants such as Adpro Attrack (formerly known as Attracker) (fructose, glucose, saccharose). Adpro Attrack claims to lure thrips out of sheltered plant parts and increase their exposure to plant protection products. Another product based on sugars

and plant extracts, Combi-protec claims to increase efficacy of ingested insecticides against some pests, although this has not yet been tested for thrips control. Biosweet is another sugars product that claims to attract thrips out of flowers onto leaves where they may be easier targets for both predators and plant protection products. No research has been done on comparative efficacy of plant protection products against *T. setosus* or on whether adjuvants or tank mixes improve control of this species.

- Frequency of application will also affect product efficacy. Research in the Netherlands on the development rate of *T. setosus* on *Hydrangea* indicated that if an effective plant protection product kills all adults and larvae, sprays should be applied every 14-days at 15°C, every seven to eight days at 20°C and every five to six days at 25°C in order to kill the next generation of larvae hatching from any eggs (Leman, 2020). However, applications will need to be planned according to product label recommendations, permitted frequency and number of applications, and resistance management guidelines. In addition, the development rate of *T. setosus* varies with host plant and with fluctuating glasshouse temperatures so the data on *Hydrangea* at constant temperatures will not apply to all crops.
- If using biological control agents in an integrated pest management (IPM) programme, any plant protection products should be selected and timed carefully, using the least harmful and least persistent products when possible.
- Table 2 lists plant protection products currently approved on protected ornamentals and herbs that may give some control of *T. setosus* and *D. corbetti*.

Table 2. Currently approved plant protection products that may give some control of *Thrips setosus* on protected ornamentals and herbs and of *Dichromothrips corbetti* on protected orchids (April 2021)

Active ingredient	Example product names	Insecticide group/ bioprotectant type	Approval status for protected ornamentals	Approval status for protected herbs	Compatibility with biological controls*	Comments
Bioprotectants						
Azadirachtin	Azatin	Azadirachtin (botanical bioprotectant)	Approval (permanent protection). Label recommendation for thrips control	-	Safe/slightly harmful	Partially systemic on some host plants
Beauveria bassiana	Botanigard WP	Entomopathogenic fungus (microbial bioprotectant)	Approval (permanent protection). Label recommendation for whitefly control	EAMU 1792/2018 for control of thrips and other pests	Safe to most biocontrols	Contact action. Needs 20-30°C and over 70% relative humidity for optimum control
Beauveria bassiana	Naturalis-L	Entomopathogenic fungus (microbial bioprotectant)	Approval (permanent protection). Label recommendation for whitefly and reduction of thrips	Label approval on any edible crop	Safe to most biocontrols	Contact action. Needs 20-30°C and over 60% relative humidity for optimum control
Lecanicillium muscarium	Mycotal	Entomopathogenic fungus (microbial bioprotectant)	Approval (permanent protection). Label recommendation for whitefly control	EAMU 2679/2014 (permanent protection)	Safe to most biocontrols	Contact action. Use with Addit. Needs at least 18°C and 70% relative humidity for optimum control
Maltodextrin	Eradicoat Eradicoat Max Majestik	Botanical bioprotectant	Approval for all non-edible crops (permanent protection for Eradicoat Max). Label recommendation for spider mite and whitefly control	Approval for all edible crops (permanent protection for Eradicoat Max). Label recommendation for spider mite and whitefly control	Safe to biocontrols once spray deposit is dry	Contact action

Active ingredient	Example product names	Insecticide group/ bioprotectant type	Approval status for protected ornamentals	Approval status for protected herbs	Compatibility with biological controls*	Comments
Fatty acids	Flipper	Botanical bioprotectant	EAMU 1415/2020 for control of aphids, spider mites and whitefly	EAMU 3416/2019 for control of thrips, aphids and spider mites	Safe – moderately harmful to biocontrols depending on species. Safe once spray deposits are dry	Contact action. Use soft or rain water or add X-Fusion conditioner
Physically acting products (exempt from plant protection product regulations)						
Silicone polymers, siloxanes and organic antioxidants	ProTAC SF	Physically acting	Exempt	Exempt	Likely to be harmful to biocontrols hit by the spray but safe once spray residues are dry	Contact action. Spray during day in low humidities to avoid plant scorch. Do not spray to flowering crops due to high risk of damage
Chemical plant protection products						
Abamectin	Clayton Abba, Dynamec	Avermectin	Approval (permanent protection). Label recommendation for WFT control	Dynamec has EAMU 2832/2017 for use on certain herbs	Harmful to nematodes for up to seven days and to most other biocontrols for one to three weeks depending on species (6 weeks for *Orius*)	Contact and translaminar action
Acetamiprid	Clayton Vault, Gazelle SG	Neonicotinoid	Approval. Label recommendation for aphid and whitefly control	Gazelle SG has EAMU 2251/2019 for aphid control	Harmful to most biocontrols for one to three weeks depending on species (six weeks for *Orius*)	Systemic action
Deltamethrin	Decis Forte	Pyrethroid	Approval. Label recommendation for control of various pests	-	Safe to nematodes. Harmful to most other biocontrols for up to 12 weeks	Contact action. WFT and onion thrips likely to be resistant

Active ingredient	Example product names	Insecticide group/ bioprotectant type	Approval status for protected ornamentals	Approval status for protected herbs	Compatibility with biological controls*	Comments
Esfenvalerate	Clayton Cajole Sumi-Alpha	Pyrethroid	Approval. Label recommendation for control of thrips and other pests on flowers	-	Safe to nematodes. Harmful to most other biocontrols for up to 12 weeks	Contact action. WFT and onion thrips likely to be resistant
Lambda-cyhalothrin	Hallmark with Zeon Technology	Pyrethroid	EAMU 2944/2008	-	Safe to nematodes. Harmful to most other biocontrols for up to 12 weeks	Contact action. WFT and onion thrips likely to be resistant
Pyrethrins	Spruzit	Pyrethrins	Approval (permanent protection). Label recommendation for thrips (not WFT) and other pests	Approval (permanent protection). Label recommendation for thrips (not WFT) and other pests on certain herbs	Harmful to some biocontrols for up to one week	Contact action. WFT and onion thrips likely to be resistant
Spinosad	Conserve	Spinosyn	Approval. Label recommendation for WFT control	-	Harmful to some biocontrols for up to two weeks	Contact and ingestion action. WFT and onion thrips likely to be resistant
Spinosad	Tracer	Spinosyn	-	EAMU 1205/2018 for control of thrips and caterpillars	As for Conserve	As for Conserve
Spirotetramat	Batavia	Ketoenol	EAMU 2597/2019 (permanent protection) for control of WFT, aphids and whitefly	-	Moderately harmful to *T. montdorensis.* Harmful to *Phytoseiulus* for three to four weeks. Safe/slightly harmful to most other biocontrols	Two-way systemic action. Do not spray specified ornamentals including *Begonia*, *Cyclamen* and *Hydrangea* due to high risk of damage
Spirotetramat	Movento	Ketoenol	-	EAMU 0918/2018 for control of aphids and whitefly	As for Batavia	Two-way systemic action

- The information in this table has been collated using information from the Health and Safety Executive (HSE) website (www.pesticides.gov.uk) and from suppliers' labels and product technical information. Important - regular changes occur in the approval status of plant protection products, arising from changes in the legislation or for other reasons. For the most up-to-date information, please check the HSE website or with a professional supplier or BASIS-qualified consultant, as information could have changed since this table was created.
- EAMU - Extension of Authorisation for minor use.
- Growers must hold a paper or electronic copy of an EAMU before using any product under the EAMU arrangements. Any use of a plant protection product with an EAMU is at grower's own risk.
- Always follow approved label or EAMU recommendations, including rate of use, maximum number of applications per crop or year and where crop safety information is not available, test the product on a small number of plants to determine crop safety prior to widespread commercial use.

* Further details of compatibility of plant protection products with biological control agents are available from suppliers of biological control agents or plant protection products or consultants. See the following websites: https://www.biobestgroup.com/en/side-effect-manual and https://sideeffects.koppert.com/side-effects/. 'Safe': kills<25% of the biological control agents; 'slightly harmful': kills 25-50%; 'moderately harmful': kills 50-75%; 'harmful': kills >75%.

Recommendations for future work

- *Neoseiulus cucumeris* do not seem to have controlled *T. setosus* on either protected ornamentals or herbs in the UK. Koppert have shown that other species of predatory mite (*Transeius montdorensis*, *Amblydromalus* (*Typhlodromalus*) *limonicus* and *Amblyseius swirskii*) will feed on both first and second stage *T. setosus* in the laboratory but they have not tested *N. cucumeris*. Although some UK growers have now switched from using *N. cucumeris* to *T. montdorensis* for control of *T. setosus* with promising results, it would be useful to test whether or not *N. cucumeris* feed on first instar *T. setosus* larvae. This would help to inform growers on the thrips species controlled by this widely used and comparatively inexpensive predator.
- In the Netherlands, Koppert are advising *Carpoglyphus lacti* (Nutari) as 'feeder mites' to help *T. montdorensis* to establish for better control of *T. setosus* e.g. on *Hydrangea*. So far these have not been tried in the UK for control of this pest. It would be useful to test the benefit of feeder mites together with *T. montdorensis* for *T. setosus* control on other crops e.g. *Cyclamen*. Another species of feeder mites available in the UK is *Thyreophagus entomophagus* ('Mitefood') from Bioline AgroSciences.
- The biology of *T. setosus* has mainly been studied in the laboratory on leaf discs or detached leaves and one study indicated that the second stage larvae drop to the ground to pupate. It would be useful to confirm whether the larvae always drop from different ornamental and herb host plants (e.g. *Cyclamen* and basil) to pupate, in order to know whether ground-dwelling biological control agents have a potential role in an IPM programme.
- If *T. setosus* larvae always drop to the ground to pupate, it would be useful to test ground-dwelling biological control agents for their potential role in an IPM programme, as used to supplement predatory mites for the control of WFT. Candidate species include the predatory mites *Stratiolaelaps scimitus* (formerly known as *Hypoaspis miles*) and *Macrolophus robustulus*, the predatory beetle *Dalotia* (*Atheta*) *coriaria* and the entomopathogenic nematodes *Steinernema feltiae*, all of which are used in IPM programmes for the control of WFT and other pests.
- Initial research in the Netherlands has shown that lacewing larvae and *Orius* species have potential for control of *T. setosus*. So far the research on lacewings has been done on *Hydrangea* and that on *Orius* species has been done in the laboratory. Depending on further research planned in the Netherlands, it may be useful to test these predators against *T. setosus* on different host plants.
- No efficacy studies have yet been done comparing plant protection products against *T. setosus*. It would be useful to evaluate selected available and near-market products alone and in tank mixes and with selected adjuvants, to give growers information on both efficacy and potential phytotoxicity.
- UK growers are using sticky traps for monitoring *T. setosus* adults but no work has been done on which colour trap is most effective and whether numbers on traps relate to numbers on the crop. A semiochemical thrips lure (Lurem-TR) is available for attracting the adults of several flower-dwelling thrips species to sticky traps but it is not known whether this would also attract *T. setosus*, which is reported to be more of a leaf feeder than flower dweller. Current AHDB-research in project SF 174 is investigating a 'push-pull' strategy for control of various thrips species on strawberry. The research aims to 'push' thrips adults from the crop with a semiochemical product (Magipal) that is marketed as a natural enemy attractant but also repels pests, and 'pull' them to sticky traps using either Lurem or an experimental thrips

lure. If this research gives promising results, similar work on *T. setosus* on protected ornamentals and herbs may be worthwhile.

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