5. Major Insect and Mite Pests

Biosecurity

Biosecurity is a process to protect a geographic area or individual facility from pests and diseases. It includes reducing the risk of introducing new pests and diseases and eradicating or effectively managing the spread of those that have already arrived. Taking common sense precautions to prevent pests and diseases from entering the farm is a worthwhile investment. In the context of greenhouse floriculture, this should entail good sanitation and IPM practices as described in Chapter 4, *Integrated Pest Management and Crop Health* on page 47. The development of a biosecurity policy for visitors entering the facility also plays an important role in reducing potential for the introduction and establishment of new pests and diseases.

Quarantine pest problems

This chapter describes the most common insect and mite problems in greenhouse ornamental production. However, it is important to understand that some of the most destructive pests are much less frequently found, although their impact can be devastating when they are. Some of these pests are known to be a potential risk and are regulated as quarantine pests by the Canadian Food Inspection Agency (CFIA). A quarantine pest is "a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2004)." Other pests may have no known potential for damage until they occur, at which time the CFIA will determine the risk they present. If regulated pests are found, the law *(Plant Protection Act)* demands that it be reported to CFIA. A decision will then be made by CFIA as to what action must be taken to address the problem. Although this action can have serious financial impacts on individual growers, it is important to the industry that growers report suspected problems. Failure to do so could threaten the export of ornamental plants to countries such as the United States. Known quarantine pests likely to affect greenhouse floriculture production are noted in Chapter 6, *Occasional Pests* on page 77, and Chapter 7, *Major Greenhouse Diseases* on page 85. For more information on regulated pests and diseases, visit the CFIA website at *www.inspection.gc.ca* or contact your local CFIA office. See Appendix D. *Other Contacts* on page 155.

Thrips

Description and life history

Thrips are tiny, slender, agile insects that are about 1.5–2 mm in length when fully developed. Adults vary in colour from dark brown or black to yellow or straw-brown. Immature thrips are usually white or yellow with red eyes. Several thrips species, including eastern flower thrips, onion thrips and western flower thrips (WFT) are found in the greenhouse. WFT is the most common thrips species found in Ontario greenhouse crops, and the following information is largely focused on control of this species.

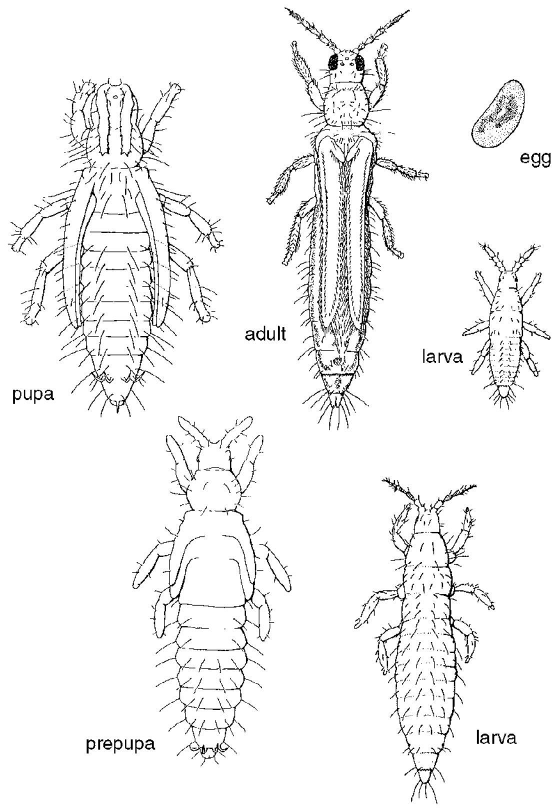
All thrips have a similar life cycle (see Figure 5-1. *Western Flower Thrips* on page 64. The adult female lays tiny white eggs inside the leaf tissue. The eggs hatch in 5–7 days and the white larvae emerge to feed on the leaves and petals. Before becoming adults, they pass through two larval stages – a prepupal stage and a pupal stage (in the soil or on the plant). Adults can live up to seven weeks. Development time from egg to adult can be as short as 12–13 days at 30°C and up to 19 days at 20°C.

Damage

Piercing/sucking mouthparts cause white streaked areas on leaves or translucent spots on flower petals. Feeding is characterized by tiny, black, fecal deposits on leaf surfaces. Adult females can also damage fruit quality in crops such as tomato, including patio tomatoes, by laying eggs in the fruit. Small whitish "ghost-spots" appear where eggs are laid, which causes uneven fruit ripening.

WFT also rapidly develop pesticide resistance. They can carry impatiens necrotic spot virus or tomato spotted wilt virus (INSV/TSWV), which can devastate many common greenhouse crops. Proper diagnosis is essential, as these viruses have a wide host range and produce a wide variety of symptoms. Control of INSV/TSWV is difficult, involving thrips population management, removal of infected plants, and good weed control inside and outside the greenhouse. Use indicator plants such as petunia or fava bean for early detection of INSV/TSWV.

Figure 5-1. Western Flower Thrips



Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Control strategies

Employ a regular monitoring program using yellow or blue (both very attractive colours to WFT) sticky cards and regular crop inspection.

Larval and adult stages of the thrips can be detected by tapping buds or flowers over a sheet of white paper and checking the thrips that fall.

Biological control

A number of biological control agents are available for thrips: for foliar life stages, the predatory mites *Neoseiulus cucumeris, Amblyseius swirskii, Amblydromalus limonicus, Amblyseius degenerans* and the predatory bug *Orius insidiosus; and for the soil-dwelling pupal stages, the predatory mite Hypoaspis (also called Gaeolaelaps or Stratiolaelaps),* the predatory rove beetle *Atheta coriaria (also called Dalotia coriaria), and the nematodes Steinernema feltiae.*

Use more than one in combination to gain the best control. Introduce them when pest levels are low, using the high end of the introduction rates suggested by the supplier.

Neoseiulus cucumeris

This buff-coloured predator feeds mainly on the first larval stage of thrips.

Neoseiulus cucumeris (N. cucumeris) is usually shipped to growers in a mixture that includes bran and bran mites. The bran provides food for the bran mites, which are themselves food for the predatory mites. The bran/mite mixture is available in small sachets or in containers from which the mixture is sprinkled directly onto the crop. The sachets serve as small rearing units from which predatory mites emerge over several weeks.

Always examine the bran mixture prior to use. It should not be mouldy or smell of ammonia, and live predatory and bran mites should be visible. Healthy predatory mites move rapidly, whereas bran mites move more slowly. It is very important to hang sachets in sheltered positions to minimize dehydration of the bag contents. Rates of application of this predator vary with crop and level of thrips infestation. Contact the biological control supplier, consultant or a greenhouse floriculture specialist for suggested rates.

Amblyseius swirskii

This predatory mite is very similar in size and appearance to *N. cucumeris*. It is sold in the same types of formulations (bulk mixtures and slow-release sachets) and feeds on the same life stages of the thrips. It is reported to be more effective than *N. cucumeris,* especially on crops that produce pollen such as ornamental peppers. However, some early experience in ornamental crops such as gerbera is also promising. *A. swirskii* is also effective against other pests such as whitefly.

Contact the biological control supplier, consultant or greenhouse floriculture specialist for suggested rates.

Amblydromalus limonicus

A. limonicus was introduced to Ontario in 2011 and has some advantages over *N. cucumeris* and *A. swirskii.* Like *A. swirskii* it feeds on both thrips and whitefly, but it is reported to have a broader temperature range in which it is active and effective, including temperatures as low as 13°C, and it feeds on both first and second larval stages of WFT.

Contact the biological control supplier, consultant or a greenhouse floriculture specialist for suggested rates.

Iphesius degenerans

This predator differs from *A. cucumeris* in its appearance and ability to tolerate less humid conditions. It is dark, very agile and reproduces very well on pollen.

It can be reared on castor bean plants, which can be release points for the predator within the greenhouse. It performs best in situations where it has a pollen source (e.g., greenhouse pepper including ornamental pepper) to encourage establishment. Because of this, it is unlikely to be the best option for most floricultural crops where product is usually shipped before significant amounts of pollen are produced.

Orius insidiosus

The minute pirate bug, *Orius insidiosus,* is a winged predator that consumes all mobile stages of thrips. Adults are black with white and cream markings on the wings. The youngest nymphs are yellow and the oldest are a dark mahogany brown.

Orius insidiosus also feeds on pollen, spider mites, aphids, whiteflies, moth eggs and young caterpillars. However, its preferred food source is thrips.

Pirate bugs are sensitive to day length. Do not release them in greenhouses before mid-March unless a minimum of 13 hours of light is available, such as when supplemental lighting is used.

Gaeolaelaps gillespiei, Stratiolaelaps scimitus (also called Hypoaspis)

These soil-dwelling mites provide additional thrips control by feeding on pupae in the crop media. For more details, see *Fungus Gnats and Shoreflies,* on page 72.

Dalotia coriaria (also called Atheta)

This soil-dwelling beetle was originally developed for control of fungus gnats and shoreflies, but also feeds on thrips pupae in the soil. For more information, see *Fungus Gnats and Shoreflies,* on page 72.

Nematodes (Steinernema feltiae)

This insect pathogenic nematode is especially effective at controlling thrips pupae in the growing medium and has become an important component of thrips biocontrol programs for Ontario growers, often being applied as a soil surface spray on a weekly basis. For more details, see *Fungus Gnats and Shoreflies,* on page 72.

Chemical control

Chemical control of WFT can be difficult. They tolerate most pesticides and feed either deep within the flower head or on developing leaves. This makes them a difficult target for insecticides, so thorough coverage is essential. General information regarding pesticide use for thrips control includes the following:

- At the action threshold (when thrips population levels dictate spraying to prevent economically damaging numbers from appearing), spray 4–5 days apart for three consecutive applications.
- Follow resistance management guidelines on the label.
- Rotate chemical classes and use a single chemical class only for the duration of the thrips' life cycle. This generally means using a different class every 2–3 weeks depending on time of year. Generation times are longer at cooler temperatures.
- When there is a limited number of effective products, use sparingly and only at critical times of the year or crop. Use IPM strategies to reduce pesticide use and the potential for resistance development.
- Apply pesticides in early morning and late afternoon, when flight activity of thrips is at a peak. This increases exposure of the thrips to the pesticides.

Further information

For more information on thrips, see OMAFRA Factsheet *Thrips in Greenhouse Crops: Biology, Damage and Management.*

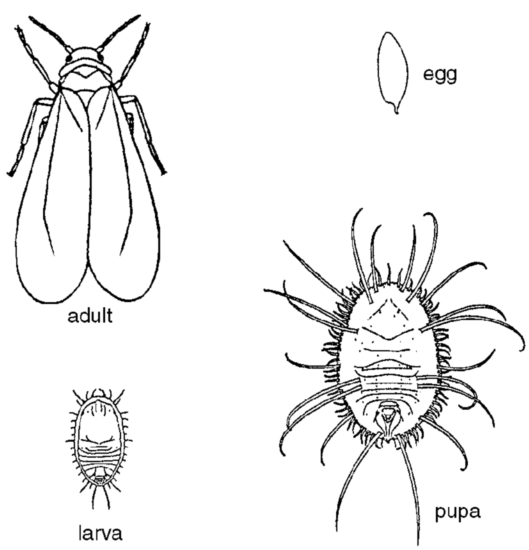
Whiteflies

Description and life history

Adult whiteflies are small, white, winged insects about 1.5–2 mm long. They lay eggs (which are too small to be seen clearly without a microscope) on the underside of the youngest leaves. A female whitefly might lay up to 300 eggs during her lifetime and can live up to two months. The nymphs or crawlers hatch in 5–10 days, are flat and scale-like and crawl around for a short while before becoming immobile.

Adults emerge after three nymphal stages and one pupal stage. Old pupal skins and adults may be found on the underside of lower leaves, which may have symptoms of wilt. On average, the whitefly completes its life cycle in 35 days at 18°C and in 18 days at 30°C. Whiteflies have no special overwintering stage and can usually survive if plant life is available.

Figure 5-2. Greenhouse Whitefly



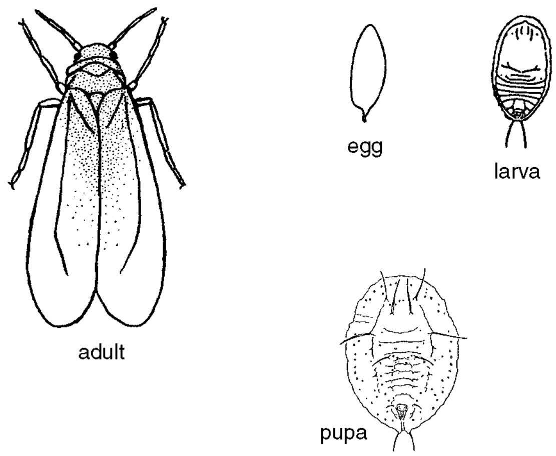
Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Species of whiteflies

Two species of whiteflies concern growers in Ontario: the greenhouse whitefly (GWF) and *Bemisia* (also called silverleaf whitefly or sweetpotato whitefly). They are depicted in Figure 5-2. *Greenhouse Whitefly* on this page, and Figure 5-3. *Bemisia Whitefly* on page 67. GWF and *Bemisia* adults look very similar, but with some differences:

- *Bemisia* is slightly smaller than GWF and its body is more yellow.
- At rest, *Bemisia* holds its wings tent-like above its body, while the GWF holds them flatter and more parallel to the surface on which it is resting.
- The major diagnostic differences between GWF and *Bemisia* appear in the pupal stages. The GWF pupa is white or cream-coloured, is raised off the leaf surface and is surrounded by a fringe of hairs, while *Bemisia* pupae are more yellow in colour, sit flat on the leaf and do not have a fringe. These features are best seen with a microscope, although with practice they can be seen through a 10× hand lens.
- In Ontario, *Bemisia* is most commonly found on poinsettia, entering the greenhouse on infested cuttings. It can also be found on other crops. However, it does not transfer easily from poinsettia, and when found on other crops it has usually arrived on infested plant material.
- Two “biotypes” of *Bemisia* have been found in North America. The “B biotype” has been a pest in greenhouses since the mid-to-late 1980s and is found most often on poinsettia. The “Q biotype” is Mediterranean in origin and was found for the first time in North America on poinsettia in 2004. It is reported to rapidly develop resistance to pesticides. It is also reported to have a wider host range than the “B biotype” and to be better as a vector of a range of plant viruses. These two “biotypes” are now considered to be separate species.

Figure 5-3. *Bemisia* Whitefly



Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Damage

Piercing/sucking mouthparts allow whiteflies to remove sap from the plant, reducing plant vigour.

Whiteflies excrete large amounts of a sugary substance called honeydew. Honeydew promotes the growth of a black sooty mould fungus on leaf and fruit surfaces, reducing photosynthesis and fruit quality respectively. The sooty mould itself does not damage the plants.

Bemisia is reported to transmit over 60 viruses and the GWF has been associated with the spread of beet pseudo-yellows virus in cucumbers.

Control strategies

Implement a routine monitoring program using yellow sticky cards and plant inspections.

Identify the whitefly species present on the crop.

Consider the use of trap plants (plants that are more attractive to whiteflies than the main crop) as an early detection tool or to attract whiteflies to a more localized area for easier control. Plants such as eggplant and tomato may be useful for this purpose, especially for GWF. However, be aware that other pest problems can develop on plants used in this way and if neglected, they can become more of a problem than a solution.

React promptly when whitefly adults are observed on either cards or terminal leaves.

Maintain good weed control inside and outside the greenhouse.

Biological control

Three parasitic wasps – *Encarsia formosa, Eretmocerus mundus* and *Eretmocerus eremicus* – are commercially available for whitefly control. *Encarsia formosa* is more effective against GWF, but also provides some control against *Bemisia*. *Eretmocerus mundus* is specific and very effective against *Bemisia*. *Eretmocerus eremicus* is more effective against *Bemisia* but can also provide good control of GWF. The predatory mites *Amblyseius swirskii* and *Amblydromalus limonicus* are reported to be very effective against all species of whiteflies, as well as thrips. A small black beetle called *Delphastus catalinae* is also available commercially, but is likely only effective where there are heavy populations of whitefly (a situation that most growers would want to control more quickly with pesticides, although in crops such as cut gerbera, it has proven to be very effective).

Good sanitation, weed control and low whitefly numbers at the outset are essential for successful biological control of whitefly.

Encarsia formosa

About 0.6 mm long, adult wasps kill whiteflies either by laying eggs into the immature stages or scales (mostly the third and fourth larval stages) or by directly feeding on the young whitefly nymphs. Adult *Encarsia* can live for a few days to a month depending on the temperature. Females lay 50–350 eggs in their lifetime. GWF turns black 10–14 days after being parasitized. On average, the adult wasp emerges two weeks later. When the adult develops fully, it cuts an opening in the top portion of the black scale before emerging. Parasitized *Bemisia* turn tan-brown and are less easily noticed. For biological control of *Bemisia*, *Eretmocerus* is a better alternative.

To use *Encarsia* successfully:

- avoid pesticides with long residual effects for at least three months before the initial release. Refer to Side-effects Lists provided by biocontrol suppliers.

- monitor the crop for whitefly presence at all production stages and follow population trends to place and time *Encarsia* releases more accurately.
- introduce *Encarsia* at the first sign of whitefly, or preventatively before whiteflies are detected. If whiteflies are present before the release of *Encarsia,* reduce populations with a low-residual pesticide.
- do not use *Encarsia* between December and February without adjusting light and temperature conditions to suit the parasite. Nevertheless, these months are the most difficult time to establish *Encarsia* in the greenhouse.
- distribute *Encarsia* in shaded parts of the plant where they are protected from direct sunlight.
- distribute cards relatively evenly but place more in areas where whiteflies have been observed. Achieve more distribution points by purchasing cards with fewer parasitized scales per card.
- during deleafing or pruning operations in vegetable crops, such as tomato, do not remove leaves with immature parasitized scales. Such removal slows build-up of *Encarsia* numbers and parasitism rate.
- continue introducing *Encarsia* until approximately 80% of the scales on older leaves are black. During warmer months when whiteflies migrate into the greenhouses, maintain or increase introductions.

Eretmocerus mundus and Eretmocerus eremicus
Adults are about 0.6 mm long and yellow in colour. They lay eggs under the whitefly larvae, usually the second or third stage. This wasp has a sex ratio of 1:1 (male:female). This is different from *Encarsia,* where all individuals are female. The effectiveness of this wasp is due to both parasitism and host feeding by the adult. The parasitized whitefly pupa is a yellowish-brownish colour (for both GWF and *Bemisia*). *E. mundus* is specific to *Bemisia*, whereas *E. eremicus* will feed on both whitefly species.

Amblyseius swirskii
This predatory mite is very similar in size and appearance to the thrips predator *N. cucumeris*. It also feeds on thrips, but unlike *N. cucumeris,* it is a very effective whitefly predator.

Amblyseius swirskii feeds on whitefly eggs and crawlers. As a result, it is very compatible with the parasitic wasps used for whitefly control, which target later life stages. It is sold in bulk mixtures or slow-release sachets.

It is reported to be very effective, especially on crops that produce pollen. Experience in ornamental crops such as gerbera is promising.

Contact the biological control supplier, consultant or a greenhouse floriculture specialist for suggested rates.

Amblydromalus limonicus
A. limonicus was introduced to Ontario in 2011. Like *A. swirskii* it feeds on both thrips and whitefly, but it is reported to have a broader temperature range in which it is active and effective, including temperatures as low as 13°C.

Contact the biological control supplier, consultant or a greenhouse floriculture specialist for suggested rates.

Delphastus catalinae
Delphastus is a predatory beetle. Both adult and larval *Delphastus* feed on whiteflies, particularly on the eggs and nymphs. *Delphastus* are reported to avoid parasitized scales, feeding primarily on the non-parasitized scales. This behaviour makes *Delphastus* compatible with *Encarsia*. Use these beetles to supplement the activity of *Encarsia* in reducing whitefly populations. Adult *Delphastus* live for 6–9 weeks. They are reported to require a minimum diet of 100-150 whitefly eggs per day to reproduce.

Physical control

Sticky traps

Use yellow sticky traps in various forms to trap large numbers of adult whiteflies. Large, yellow sticky cards can be placed in "hot spots," or alternatively, hang yellow sticky tape between posts or above plant rows. Such tapes will also trap fungus gnats, shoreflies, *Aphidius* spp. and *Encarsia,* especially under low whitefly populations. Be careful when using large quantities of sticky tape in conjunction with parasitoids, especially *Eretmocerus,* which is highly attracted to yellow.

Vacuuming

Hand-vacuum adults in "hot spots" to rapidly remove adult whiteflies.

Insect barriers

Install fine screens over vents and doorways to significantly reduce migration of outdoor populations into greenhouses. Where whiteflies move in from adjacent field crops (e.g., field tomato) in large numbers at certain times of the year (e.g., during harvest), consider screening as a first line of defence.

Chemical control

Rational and judicious pesticide use requires a regular monitoring program to determine whitefly population levels and the need to spray, rotating chemical classes, and incorporating non-chemical control strategies. Whiteflies have developed resistance to many pesticides. Careful use will extend the effective life of pesticides while delaying the build-up of resistance.

When using a systemic insecticide such as imidacloprid, ensure that it is applied correctly. The root system should be well-developed and the plant actively growing. If the plant is to be pinched, apply the product 10–14 days afterwards. Limit watering for a week after application to reduce the amount of leachate. Imidacloprid is very water-soluble and will be easily leached from the pot.

Further information

For more information on whiteflies, see OMAFRA Factsheet *Whiteflies in Greenhouse Crops: Biology, Damage and Management.*

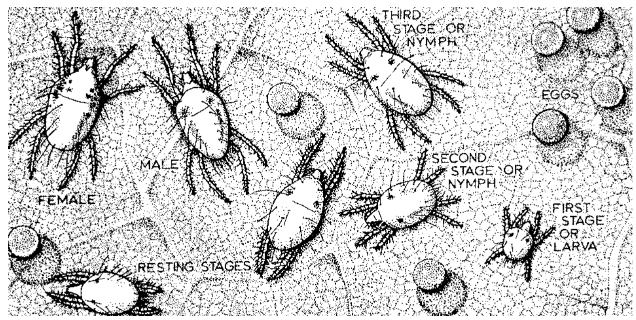
Two-Spotted Spider Mite

Description and life history

The two-spotted spider mite (TSSM) attacks many greenhouse crops. The eight-legged female adult is approximately 0.5 mm long with a rounded abdomen. The male is distinguished from the female by its smaller, narrower body and pointed abdomen. Adults range from pale yellow to orange to brown. The overwintering or diapausing stage is reddish-orange. Day lengths of 12 hours and less, decreasing temperatures and a deteriorating food source will induce diapause in spider mites. During diapause, spider mites can tolerate very low temperatures. A short spell of heating is not sufficient to break its diapause.

Close examination of leaf undersurfaces will show the mites to be miniscule moving dots. The two dark spots on the body of TSSM are the gut contents showing through the transparent body. After mating, each female mite lays approximately six pearl white eggs a day. Over an average lifetime, a female lays 100 or more eggs on the undersurface of foliage. Newly hatched mites pass through the typical six-legged larval stage and eight-legged protonymph and deutonymph stages. The last of these is an immobile resting stage, very tolerant of miticides. The life cycle from egg to adult ranges from 23 days at 15°C to just four days at 32°C (Figure 5-4. *Two-Spotted Spider Mite* on this page). Development is fastest under hot, dry conditions.

Figure 5-4. Two-Spotted Spider Mite



Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Damage

All active stages of the TSSM feed by piercing the lower epidermis of the leaf with sucking mouthparts. The feeding injury starts as a yellow "stippling." As mite numbers increase, the entire leaf appears stippled or light-coloured on the upper surface. Very heavily infested leaves become yellow and brittle, with obvious webbing on the leaves.

Some plants (e.g., hibiscus) exhibit a toxic response to TSSM feeding, with leaves yellowing and dropping from the plant even at quite low mite population densities. If infestations proceed without control measures, plants may be killed.

Mite populations seem to explode at certain times of the year, since the life cycle varies considerably with temperature. Other factors, such as humidity, plant nutrition and cultivar are important and at times can be used to help reduce mite outbreaks.

Control strategies

In ornamental crops, make regular crop inspections to detect early infestations before mites build up. Pay particular attention to susceptible varieties and crops. In crops such as rose, inspect both upper and lower canopies.

For vegetable crops, conduct a proper clean-up at the end of the crop to reduce initial infestations in the crop that follows. Do this just before the overwintering or diapausing phase of the spider mites, since the diapausing mites hibernate in the ground, hollow stems, pipe fittings, cracks and crevices during the fall and winter. The mites become active again during late winter and early spring. The red mite stage is generally pesticide-tolerant and not as readily fed upon by predators. When the red diapausing mites are detected, use soap sprays on lightly infested leaves and remove and destroy more heavily infested leaves.

Biological control

Control spider mites biologically using the predatory mite *Phytoseiulus persimilis*. Other predatory mites can be used against this pest, including some strains that are high temperature-tolerant or pesticide-resistant. For example, the predatory mite *Amblyseius californicus* is reported to better tolerate dry conditions, while *Amblyseius fallacis* is resistant to some pesticides. Many Ontario growers have had good success with these predators or others such as *Amblyseius andersoni*. Other biocontrol agents available for control of TSSM include the predatory midge *Feltiella acarisuga* and the predatory ladybeetle *Stethorus punctillum*.

Phytoseiulus persimilis

Phytoseiulus persimilis is about the same size as TSSM but is pale salmon to bright orange and pear-shaped. It does not have two spots and moves more rapidly on long legs. It feeds on spider mites and does not diapause.

Without spider mites, the predators die. This means new spider mite infestations require new introductions of the predator. Adult predators feed on about seven adults or 15–20 eggs per day. At 20°C, *P. persimilis* almost doubles the reproductive rate of TSSM. Control with *P. persimilis* is best between 20°C and 26°C. At temperatures above 30°C and humidities under 60%, predators do not thrive and seek cooler, more protected areas lower in the crop canopy. In contrast, TSSM thrive under these conditions.

Predators are available commercially either mixed with vermiculite or on bean leaves. With either carrier, treat infested plants at first sign of damage. Try to place a few predators onto every infested leaf. Before releasing the predators, ensure that they are alive and very active.

Cultural control

Misting plants and raising the humidity will help suppress spider mite populations. For example, at 20°C and 36% relative humidity, a female TSSM will lay about seven eggs per day, while at 95% humidity, approximately 30% fewer eggs are laid.

Chemical control

Because of their great reproductive potential, TSSM easily develop pesticide resistance. To effectively manage this pest using pesticides, observe these guidelines:

- Direct sprays to the underside of leaves where spider mites usually congregate.
- Ensure good coverage. Good coverage is essential to good control, particularly when using contact miticides such as Dyno-Mite, Floramite and Shuttle.
- Note that the webs in areas of high mite density can protect the mites and the eggs within and beneath the web. In such cases, use higher spray pressures to penetrate the web.
- Use non-chemical control options as much as possible to minimize the development of pesticide resistance.

Further information

For more information on spider mites, see OMAFRA Factsheet *Mite Pests in Greenhouse Crops: Description, Biology and Management.*

Aphids

Description and life history

Aphids are small (2–3 mm), soft-bodied insects with long legs and antennae. A pair of tube-like structures called cornicles projects from the posterior end. Several species may infest greenhouses, with colour patterns ranging between black, grey, red, yellow and green. The species most commonly found in greenhouse crops are the green peach aphid *(Myzus persicae),* the cotton or melon aphid *(Aphis gossypii),* the foxglove aphid *(Aulacorthum solani),* and the potato aphid *(Macrosiphum euphorbiae).*

The green peach aphid was the predominant aphid species in Ontario until the early 1990s, when the melon aphid started to become much more common. In the late 1990s, the incidence of potato aphid and foxglove aphid in Ontario greenhouses increased and currently (2014), the green peach aphid and the foxglove aphid are the most common aphid pests.

Adult aphids are predominantly wingless, although winged adults can develop under conditions of high population density. This adaptation serves as a dispersal mechanism, allowing aphids to move into a greenhouse from outside or to spread rapidly within a greenhouse.

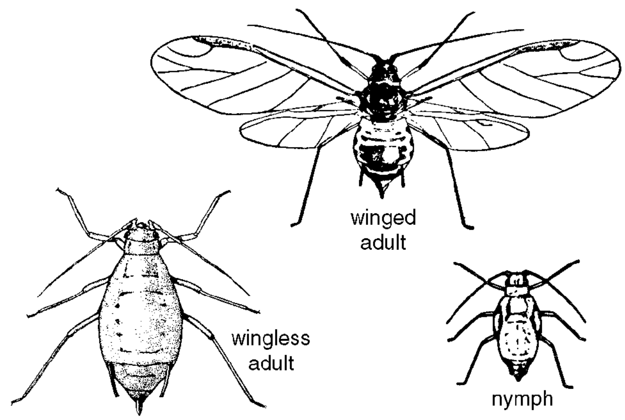
In a greenhouse situation, all aphids are female and give birth to live young. These offspring can reproduce within 7–10 days (see Figure 5-5. *Green Peach Aphid* on this page). One aphid can give birth to 60–100 young over a 20-day period. Aphids can rapidly achieve very large populations.

Damage

Aphids pierce plant tissue with their mouthparts and suck out the sap, causing deformed leaves and flowers. Distortion of the growing points of plants is particularly common with the foxglove aphid.

Aphids moult through a number of different stages before they become adults. The castoff skins they leave behind each time they moult are an indicator of their presence. They excrete a sugary, sticky substance called honeydew, which promotes the development of black sooty mould fungus. Some aphids can transmit plant viral diseases, such as cucumber mosaic virus in cucumber crops.

Figure 5-5. Green Peach Aphid



Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Control strategies

When monitoring for aphids, catch winged adults on yellow sticky cards.

For wingless aphids, inspect new foliage carefully and regularly to prevent large infestations.

Spot treating isolated infestations can prevent their spread to the rest of the greenhouse.

Biological control

Several types of biological control agents are readily available: the predatory midge *Aphidoletes aphidimyza,* the parasitic wasp *Aphidius* spp., and various lady beetles. *Aphidoletes* and lady beetles are usually used to supplement the activity of *Aphidius* and reduce the aphid populations in “hot spot” areas.

Aphidoletes aphidimyza

In the adult stage, *A. aphidimyza* resemble small mosquitoes or fungus gnats. Females lay up to 200 eggs in their lifetime. Eggs are laid close to aphid colonies, so the orange larvae have a readily available food source on hatching.

Eggs usually hatch after 2–3 days. After 7–14 days in the larval stage, they drop to the floor to pupate. The pupal stage usually lasts about two weeks. Adult *A. aphidimyza* feed on honeydew and larvae can kill 3–50 aphids per day. Under natural day lengths, *A. aphidimyza* enter diapause in September and remain ineffective until March.

Aphidius spp.

This parasitic wasp does not enter diapause and can be effective all year. During summer, other parasitic wasp species can parasitize *Aphidius,* reducing their impact on aphid populations. Optimum conditions for *Aphidius* are 18–25°C and 80% relative humidity. *Aphidius* completes its development from egg to adult in about 10 days at 25°C and 14 days at 21°C.

Several species of *Aphidius* are commercially available. *Aphidius matricariae* can parasitize about 40 aphid species, including the green peach aphid. It occurs naturally in Ontario and it is not unusual to find natural infestations in greenhouses where pesticide use has been reduced. *Aphidius colemani* is effective against both the melon and green peach aphids, but not against the foxglove or potato aphids. *Aphidius ervi* is the best choice against the foxglove and potato aphids.

Lady beetles (Hippodamia convergens, Adalia bipunctata and Harmonia axyridis)

Both adult and larval lady beetles feed on aphids and can eat large numbers during the course of their lifetime. Lady beetles enter diapause under short-day conditions. When day lengths are suitable, lady beetles must feed on aphids to maintain egg production. Eggs are orange and torpedo-shaped. They are laid in circular clusters on the underside of leaves and hatch in 2–5 days.

The larval stage lasts for approximately three weeks, after which they pupate. Adults emerge from pupal cases after 3–5 days. To increase the percentage of lady beetles remaining in the greenhouse, sprinkle a sweet liquid (e.g., diluted pop) over the beetles and release them in late evening. The sweet liquid provides an immediate energy and water source.

Harmonia lady beetles (also known as the multi-coloured Asian lady beetle) have become a pest in their own right in southern Ontario. Large populations have established outside, which has resulted in them becoming a nuisance pest for homeowners when they enter houses looking for overwintering sites. But more importantly, they are also a pest of grapes grown for wine, with adult beetles infesting ripe grape bunches and contaminating wine production. Their establishment in the outdoor Ontario environment has nothing to do with their use as a biocontrol agent in greenhouses, but rather as a result of their introduction into North America from Asia many years ago. However, the poor public perception of these insects has resulted in fewer commercial insectaries producing and selling them, even though they can be very effective.

Further information

For more information on aphids, see OMAFRA Factsheet *Aphids in Greenhouse Crops.*

Fungus Gnats and Shoreflies

Description and life history

Fungus gnats are grey to black flies about 3–4 mm long with long legs, thread-like antennae and large compound eyes that meet above the base of the antennae. The adult is a weak flier, frequently observed resting on the media surface. Each female lives about 10 days and lays about 150 white, oval eggs in the organic matter of the media. Eggs hatch in 2–7 days, depending on the temperature, producing white larvae that are 4–6 mm long.

The larvae have 12 abdominal segments and a distinctive shiny black head. The larvae pupate in the soil and remain immobile for 4–6 days, after which adult flies emerge. As with most insects, fungus gnats become more active and reproduce more quickly at warmer temperatures. The life cycle (see Figure 5-6. *Dark-Winged Fungus Gnats* on page 73) can be completed in 21 days at 24°C, compared with 38 days at 16°C.

Shoreflies, another common greenhouse pest, are often confused with fungus gnats. The adults are stouter than fungus gnats, stronger fliers and have four clear spots on their wings. Like fungus gnats, shorefly larvae (see Figure 5-7. *Shoreflies* on this page) live in soil, but lack the distinctive black head capsule. They prefer moister conditions than fungus gnats and are often found in wet areas under benches, with both adults and larvae feeding on algae.

Shoreflies are not usually a direct threat to greenhouse crops but can feed on roots in recirculating systems. Shorefly control requires controlling algae, either directly (by applying chemicals) or indirectly (by reducing moisture necessary for algal growth or reducing the high light levels the algae need, perhaps by the use of blackout skirts around benches).

Damage

Although fungus gnats generally feed on decaying organic matter in the soil, they can also feed on the young roots of plants. This is especially true when gnat populations are high.

Fungus gnats have occasionally been observed feeding on the youngest shoots of cucumbers. Root feeding by fungus gnats makes a plant susceptible to root diseases such as *Pythium* root rot. Fungus gnats and shoreflies have also been implicated in the spread of disease-causing organisms such as *Fusarium, Verticillium* and *Rhizoctonia*.

Control strategies

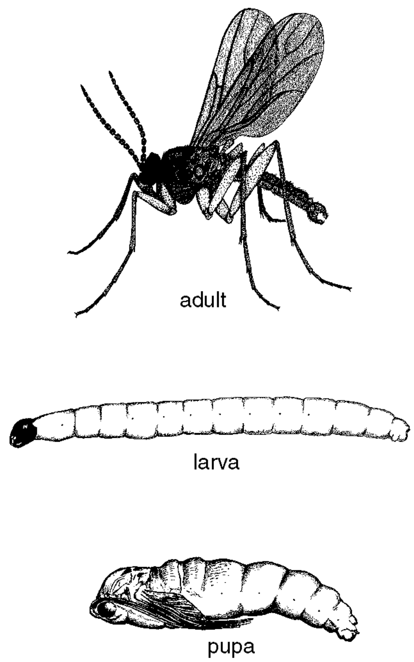
Sanitation inside the greenhouse and in the surrounding outside area is very important.

Avoid overwatering and maintain proper drainage to prevent water puddling – fungus gnats and shoreflies thrive in moist conditions.

Biological control

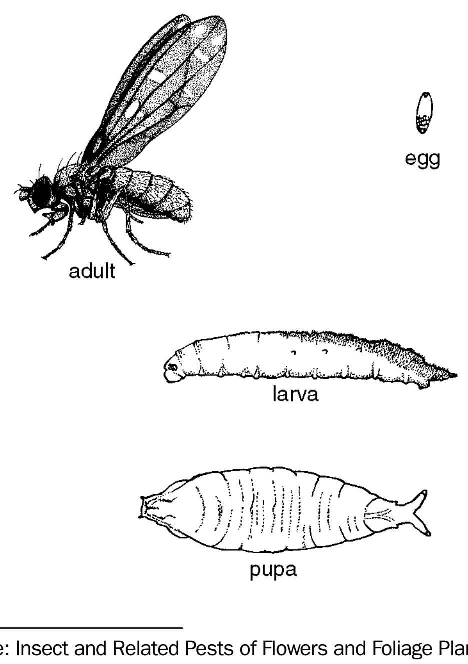
Biological control agents include two predatory mites, *Gaeolaelaps and Stratiolaelaps* (also known as *Hypoaspis),* a predatory beetle, *Dalotia* (also known as *Atheta) coriaria*, and a parasitic nematode, *Steinernema feltiae*.

Figure 5-6. Dark-Winged Fungus Gnats



Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Figure 5-7. Shoreflies



Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Gaeolaelaps, Stratiolaelaps (Hypoaspis)

These predators are soil-dwelling, brown mites that feed on fungus gnat eggs and larvae, algae, thrips pupae, springtails, nematodes, and larvae of various flies and beetles. They are hardy mites that can live approximately 24 days without food. They are not affected by low light conditions and have a life cycle of about 9–11 days under greenhouse conditions.

They are found mainly on the surface or in the top 1 cm of the plant media and work best when applied to the media just after plants are potted up or vegetable seedlings are planted out. *Gaeolaelaps* and *Stratiolaelaps* are most effective if introduced when fungus gnat populations are still low or non-existent.

Dalotia coriaria

The rove beetle *Dalotia* (*Atheta) coriaria* is a small, black, soil-dwelling beetle about 3–4 mm long. It is very active and both the adult and the three larval stages feed on fungus gnats (eggs and larvae), shoreflies (eggs and larvae) and thrips (pupae). It is produced and sold commercially, but is also naturally occurring and often found in greenhouses where pesticide use is reduced. It should be used in a similar fashion to *Gaeolaelaps* and *Stratiolaelaps* – introduced into the crop early to control soil-dwelling pests.

Nematodes

The nematode *Steinernema feltiae* is best used under higher population conditions. Nematodes enter the body openings of fungus gnat larvae and then release bacteria, which multiply and kill the larvae. Because nematodes are believed to be unable to multiply within the bodies of fungus gnat larvae, use several consecutive nematode applications to achieve control. Nematodes do not control shoreflies.

To use nematodes successfully, follow these strategies:

- Use cool water to mix the spray solution. Nematodes have limited energy reserves and these will be depleted more quickly at warmer temperatures.
- Shake or agitate nematode stock solutions regularly to incorporate oxygen into the water and to prevent nematodes from settling to the bottom of the tank. A commercial pond air pump or aquarium bubbler can perform both functions.
- Use the solution as soon as possible after mixing.
- Media temperatures should be 16–30°C.
- Never expose nematode suspensions to direct sunlight, which destroys the bacteria within the bodies of the nematodes.
- Plant media should be pH 3–8.
- Check the compatibility or residual activity of pesticides before applying to media that have been, or will be, treated with nematodes.

Chemical control

Soil drenches can effectively control the larvae.

Further information

For more information on fungus gnats and shoreflies, see OMAFRA Factsheet *Fungus Gnats and Shoreflies in Greenhouse Crops.*

Leafminers

Description and life history

Two main species of leafminers affect Ontario growers: the vegetable leafminer *(Liriomyza sativae)* and the serpentine leafminer *(Liriomyza trifolii)*. A third species, the pea leafminer *(Liriomyza huidobrensis),* which is a major pest in other parts of the world, has also been found in Ontario. Although the serpentine leafminer can complete development on tomato and cucumber, it prefers chrysanthemum, gerbera and gypsophila. Conversely, vegetable leafminer prefers tomato, cucumber and celery but will attack chrysanthemum and other plants in the absence of its preferred hosts. The pea leafminer has a wider host range and can also move into field-grown crops, including vegetable crops such as cole crops, lettuce and celery. The three species of leafminer are similar in appearance and biology.

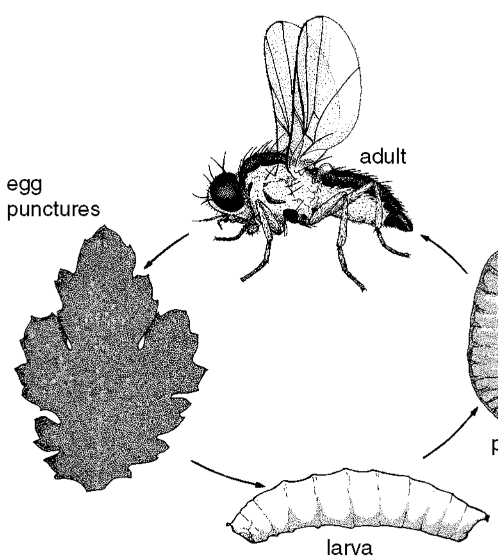
The adult leafminer is small (approximately 3 mm long), with black and yellow markings on the head and thorax. Adults become active at sunrise. Females feed on soft, succulent leaves by piercing the surface with their ovipositor, then lapping the liquid exuding from the leaf. The leaf wounds made by the female are called “stipples” and are easily visible as distinctive raised small circular scars on the leaf surface.

Female flies begin laying eggs 12–24 hours after emerging from the pupa. They lay about 250 eggs during their approximately 30-day lifespan. Eggs are laid in about one out of seven leaf punctures (or stipples). The optimal temperature for leafminer development is 30°C. At temperatures above or below 30°C, egg production by the female declines considerably. After 2–4 days, eggs hatch and the larvae begin feeding (or mining) in the leaf tissue.

The larvae mature in 4–7 days in summer, then cut a hole in the leaf surface and drop to the ground. Pupation takes place within a few hours, in the plant media or on plastic sheeting (where used). Pupation can also occur on the leaves. The pupal stage may last 5–10 days in the summer and up to 90 days during periods of low temperature (10–12°C) and scarce food supply. This may account for the winter survival of leafminers around the inside perimeter of the greenhouse, though no adult leafminers are evident. From the pupae, a new generation of adult flies emerges.

There is considerable overlapping of stages of the insect life cycle within any greenhouse. The complete life cycle of the leafminer (Figure 5-8. *Leafminer* on this page) can be 14 days at 30°C, 24 days at 20°C, and 65 days at 14°C.

Figure 5-8. Leafminer



Source: Insect and Related Pests of Flowers and Foliage Plants (1994). North Carolina Co-operative Extension Service, Ed. J. R. Baker.

Damage

Leafminer feeding may indirectly affect yield by reducing the plant's photosynthetic area and damaging water-conducting vessels (causing leaf desiccation and leaf drop).

Feeding damage by leafminers mars the appearance of ornamental crops, significantly reducing their economic value.

Control strategies

Inspect all new plant material entering the greenhouse.

Destroy infested seedlings, cuttings and plant parts or those showing evidence of stippling.

If growing in ground beds, steam-sterilize the entire greenhouse floor between crops.

Monitor the crop for pests with yellow sticky cards and regular crop inspections.

Eliminate weeds inside and outside the greenhouse. Weeds such as lamb's-quarters, chickweed, dandelion, plantain, common mallow and nightshade are good hosts for leafminers.

Do not over-fertilize the crop – excess nitrogen levels can increase leafminer problems.

Bag and remove detached leaves from the greenhouse as soon as possible. Leafminer larvae can complete their development in leaves even after they are removed from the plant.

Biological control

Biological control agents include the parasitic wasps *Diglyphus isaea* and *Dacnusa sibirica*. *Diglyphus* is likely to be a better choice in summer, when its numbers may be supplemented by naturally occurring populations migrating into the greenhouse from outside. *Dacnusa* is reported to perform better than *Diglyphus* during the winter.

Diglyphus isaea

Diglyphus is a small black wasp with a metallic green sheen and short antennae. After locating a mine, the female first paralyzes the larva, then inserts an egg through the leaf, placing it near the leafminer. It may deposit up to five eggs in a mine in this manner. The larva that hatches is initially colourless, then becomes yellow-brown and finally turquoise. Development time from egg to adult is about 11 days at 25°C. This is generally shorter than that of both the leafminer and *Dacnusa*.

Diglyphus can parasitize leafminers already parasitized by *Dacnusa*. It becomes the dominant species during summer, when warm conditions favour activity. Presence of short mines indicates *Diglyphus* activity, as the paralyzed leafminer stops feeding immediately. The presence of *Diglyphus* larvae can be detected by holding leafminer-infested leaves up to the light and examining with a hand lens.

Dacnusa sibirica

The adult is a small black wasp that differs from *Diglyphus* in having long, flexible antennae and lacking the metallic green sheen. Unlike *Diglyphus*, a female *Dacnusa* inserts an egg directly into the body of the leafminer larva. Each female lives for about two weeks, during which time she may lay up to 90 eggs. Eggs hatch within four days and the larvae mature within the leafminer pupae. Development time from egg to adult is about two weeks at 22°C. All *Dacnusa* development takes place within the leafminer's body, making the assessment of parasitism difficult.

Chemical control

Leafminers easily develop insecticide resistance.

Ensure good pesticide coverage of the crop.

Rotate pesticide classes every 2–3 weeks on crops for which registered pesticides exist. Currently, pesticide registrations exist only for ornamental crops.

Further information

For more information on leafminers, see OMAFRA Factsheet *Leafminers in Greenhouse Crops.*