# Fungus Gnat

## *Management in Greenhouses and Nurseries*

Fungus gnats, *Bradysia* spp., were initially considered minor insect pests, primarily found in house plants potted in growing medium. They were not considered a problem in ornamental cropping systems. Today fungus gnats are recognized as major insect pests in greenhouses and nurseries and are one of the few insect pests in which the damaging life stage — the larva in this case — is located within the growing medium. They are especially a problem under excessively moist conditions during propagation, when plant cuttings or plugs are initiating root systems.

Adults cause minimal plant damage, but females lay eggs that hatch into larvae that damage plants by root feeding. Both adults and larvae may spread plant pathogens.

## Biology and Damage

The fungus gnat life cycle consists of an egg, four larval instars, a pupa, and an adult. A generation may be completed in 20 to 28 days depending on temperature. Adults are winged, approximately 3 to 4 mm (0.011 to 0.015 inches) in length, with long legs and antennae. Adults tend to congregate near the growing medium surface and live from 7 to 10 days. Females deposit 100 to 200 eggs into the cracks and crevices of the growing medium. Eggs hatch into white, translucent, legless larvae that are approximately 6.0 mm (0.023 inch) long with a distinct black head capsule.

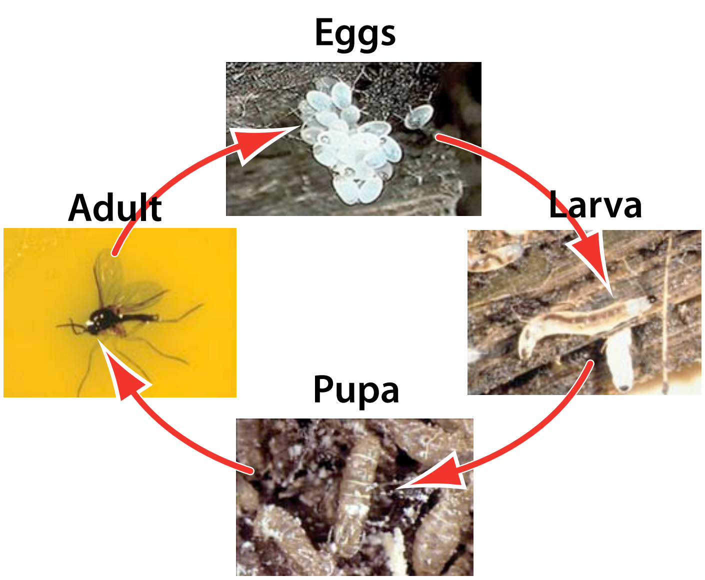


**Figure 1.** Fungus gnat life cycle

The larvae are located within the top 2.5 to 5.0 cm (1 to 2 inches) of the growing medium surface or inside plant tissue. Fungus gnat larvae feed on plant roots, primarily the root hairs, and organic matter in the upper 2.0 cm (0.78 inches) of the growing medium. They may be distributed throughout the growing medium profile, even at the bottom of containers near drainage holes. Fungus gnat larvae also may emerge from the growing medium to feed on leaves lying on the growing medium surface or tunnel into plant crowns.

The larvae prefer growing media with a "high" moisture content and require fungi as a supplemental food source in order to complete development. The type of food determines abundance and fitness of adults, and the reproductive capacity of females.

Fungus gnat larvae feed on a wide-range of ornamental plants grown in both greenhouses and nurseries, including *Capsicum* spp., *Cyclamen* spp., poinsettia (*Euphorbia pulcherrima*), *Geranium* spp., transvaal daisy (*Gerbera jamesonii*), *Gloxinia* spp., *Impatiens* spp., bedding plants, and vegetable transplants. Young plants and/or seedlings are especially susceptible to injury from larval feeding, more so than mature plants, unless fungus gnat larval populations are extremely abundant.

Larval feeding directly damages developing root systems and interferes with the ability of plants to absorb water and nutrients, resulting in stunted growth. Larvae also may cause indirect damage during feeding by creating wounds that allow entry of soilborne plant-pathogens.

Additionally, both larvae and adults can transmit fungal diseases, including *Botrytis* spp., *Pythium* spp., *Fusarium* spp., *Verticillium* spp., and *Thielaviopsis basicola* from infected to noninfected plants. Fungus gnat adults may carry the spores of certain foliar and soilborne plant-pathogens on their bodies, including *B. cinerea*, *Fusarium oxysporum* f. sp. *radicis-lycopersici*, *T. basicola*, *V. albo-atrum*, and *F. avenaceum*. Adults can then disperse spores throughout a greenhouse or nursery. Fungus gnat larvae have been shown to ingest the propagules of *Pythium aphanidermatum* and macroconidia of *F. avenaceum*, which they disseminate or introduce into young healthy plants during feeding. It also has been reported that the oospores of *Pythium* spp. are able to survive passage through the digestive tract of fungus gnat larvae and are intact and viable (able to germinate) after being excreted.

## Management

### Growing medium

The type of growing medium and components may influence fungus gnat populations, by providing a favorable substrate for development and reproduction. As the components of growing media become less uniform, porosity increases, which results in more open spaces on the growing medium surface. These open spaces provide locations for females to lay eggs. Females tend to lay eggs in crevices, which are more humid, thus enhancing hatchability and survival.

Growing media that contain a high level of microbial activity are preferred for fungus gnat development and reproduction. Also, growing media containing abundant organic matter tend to have larger pores that provide ideal egg-laying sites for fungus gnat females.

Differences in female oviposition preferences among growing media are likely due to the fungus species and activity of microbial colonies present in the growing medium. During the production cycle, decomposition of growing media containing hardwood bark increases water-holding capacity and decreases air porosity. This may provide a favorable site for females to lay eggs, potentially leading to increased fungus gnat populations. Coconut coir has been implicated as a substrate that may inhibit fungus gnats. However, it has been shown that fungus gnats survive and reproduce just as well in a coir-based growing medium as a peat-based growing medium.

Growing media vary in attracting fungus gnat adults. Less attractive growing media may result in an increase in plant injury because larvae feed on plant roots instead of fungi in the growing medium. Plant disease suppressive growing media may be more attractive to fungus gnats because of the greater microbial activity. Studies have shown that fungus gnat adults are attracted to particular growing media.

Adult fungus gnats are likely to be more attracted to or prefer moist growing media containing peat moss due to a higher level of fungal activity, and certain fungi serve as a food source. The moisture content of the growing medium is critical to larval survival. For example, fungus gnat populations are reduced in both extremely "wet" and "dry" growing media, with greater survival rates occurring in growing media with a 52 percent moisture content.

Many species of fungus gnats feed in compost piles so it is not surprising that they may enter greenhouses with compost or are attracted to compost already present in the greenhouse or nursery. It is possible that fungus gnats may be introduced into commercial greenhouse and nursery facilities in bagged soilless growing media or rooted plant plugs from wholesale distributors. Bagged soilless growing media may need to be pasteurized in order to avoid dealing with fungus gnat populations.

## Cultural Management

Water management and sanitation are essential in alleviating problems with fungus gnats in both greenhouses and nurseries. For example, nurseries that have water accumulating and algae present tend to have greater fungus gnat populations, which may result in more plant damage. Fungus gnats are typically more abundant in greenhouses and nurseries with soil floors than those with concrete flooring.

An approach to suppressing larval populations that has been consistently recommended includes allowing the soil or growing medium to dry out occasionally, particularly the upper 2.5 to 7.6 cm (1.0 to 3.0 inches). The "dry" surface is apparently less attractive to ovipositing females, and even if eggs are deposited, they fail to hatch because of a lack of moisture. But allowing plant material to become too dry is not a feasible option in either a greenhouse or nursery production system because it is essential to provide sufficient moisture for plant growth and development.

Another cultural strategy is to incorporate abrasive materials such as diatomaceous earth into growing media or apply it to the surface. Diatomaceous earth is composed of sharp skeletons of hard-shelled algae that form fossil deposits, which remove the cuticular waxes, absorb oils and waxes in the outer cuticle, or rupture the cuticle, causing dehydration. It has been suggested that incorporating diatomaceous earth into commercial growing media or applying diatomaceous earth on the growing medium surface would negatively affect fungus gnat adults as they emerge and/or prevent females from laying eggs. But studies have shown that neither practice has an effect on fungus gnats. As such, this strategy is generally not recommended.

Another option, placing a layer of sand (1.3 mm or 0.005 inches) over the top of the growing medium, was proposed as a way to reduce fungus gnat infestations by creating an unattractive surface for ovipositing females. But not even a 3.1 mm (0.012 inch) layer of sand was shown to be effective in preventing adult emergence or inhibiting females from laying eggs.

## Scouting

Scouting or monitoring is an essential component of pest management programs used in detecting the presence of fungus gnats early; before populations' build-up to damaging levels. Yellow sticky cards, placed near the growing medium surface, are typically used for monitoring fungus gnat adults. Potato disks or wedges placed on the surface of the growing medium are used to detect the presence of larvae. Larvae are attracted to and congregate underneath the potato disks. Potato disks have been shown to recover a significantly higher percentage of larvae (38%) than carrot disks (23%), and monitoring for 48 hours is more efficient in recovering larvae than 24 hours. Attempts have been made to correlate the number of adults on yellow sticky cards with larvae present on potato disks, but no such relationships have been established. There are no thresholds — the numbers of insect pests that justify the implementation of control measures — to assist greenhouse producers and nursery managers in making reliable estimates of larval densities in growing media. And there is no information pertaining to correlations between the density of fungus gnat larvae and plant damage, which would be useful in deciding when to initiate either insecticidal or biological management strategies.

## Insecticidal Management

Insecticides are typically used to deal with fungus gnats in greenhouses and nurseries. Insecticides currently labeled in the United States for use against both fungus gnat adults and larvae are listed in Table 1. Since the larvae are the life stage that directly causes plant damage, most insecticides are applied as a drench to the growing medium. These include microbial insecticides, insect growth regulators, and conventional insecticides (Table 1).

The microbial insecticide, *Bacillus thuringiensis* ssp. *israelensis* (Bti) tends to be more effective on first and second instars than the older (third and fourth) instars. Several different types of insect growth regulators are widely used to manage fungus gnats in greenhouse and nursery production systems. Because insect growth regulators are only active on the larvae, they must be applied before populations are abundant and reach damaging levels. Drench applications of the neonicotinoid insecticides including imidacloprid (Marathon), thiamethoxam (Flagship), and dinotefuran (Safari) have been shown to be effective against most larval instars.

The insect growth regulators pyriproxyfen (Distance) and cyromazine (Citation), and the pyrrole insecticide/miticide chlorfenapyr (Pylon) are effective against fungus gnat larvae. Adults may be controlled or suppressed with conventional insecticides such as those classified as pyrethroids in Table 1. But pyrethroid-based insecticides, in general, are harmful to natural enemies and nontarget organisms, which may disrupt existing biological control programs for other insect and mite pests.

## Biological Management

Biological control agents (natural enemies) such as predatory mites and beetles, and entomopathogenic nematodes have been used extensively to suppress fungus gnat larval populations in greenhouses and nurseries throughout the United States. Biological control agents commercially available in the United States are listed in Table 2. The soil-dwelling predatory mite, *Hypoaspis miles (=Stratiolaelaps scimitus)* is commercially available from most biological control distributors and is used in greenhouses to manage larval populations, but eggs and pupae are not attacked. Optimum development and reproduction of *H. miles* occurs at temperatures between 15˚C and 30˚C (59˚F and 86˚F). The rove beetle, *Atheta coriaria*, is commercially available and has also been investigated as a potential biological control agent of fungus gnats. Further studies are needed in order to fully evaluate the impact that rove beetle adults and larvae have on the population dynamics of fungus gnats. The entomopathogenic nematode, *Steinernema feltiae*, which is available commercially from a number of distributors, has been shown to be effective against fungus gnat larvae. The nematodes, however, must be applied before larval populations build-up to damaging levels.

The ability of the nematodes to control or suppress fungus gnat populations is influenced by a number of factors, including application rate, timing of application, host plant, and nematode strain used. In addition, the infectivity of the nematodes against larvae may differ depending on the growing medium type and moisture content, and the fungus gnat larval stages may exhibit differences in susceptibility to nematodes depending on the strain and even larval instars present.

Finally, temperature is a major factor that may influence control or suppression of fungus gnat larvae by *S. feltiae* because the nematode requires temperatures between 8˚C and 30˚C (46˚F and 86˚F) for infection, and 10˚C and 25˚C (50˚F and 77˚F) for reproduction. An issue associated with the use of biological control agents for control or suppression of fungus gnats is compatibility between or among the different natural enemies. Although there is limited information associated with assessing intraguild predation, it appears that *S. feltiae* is compatible with *A. coriaria*, but *A. coriaria* larvae may be fed upon by the predatory mite, *Hypoaspis aculeifer*.

## Summary

Fungus gnats (*Bradysia* spp.) are a major insect pest in greenhouse and nursery cropping systems because both the adults and larvae may cause direct and/or indirect plant damage resulting in possible economic losses. The challenge in dealing with fungus gnats is to approach management "holistically" by using strategies including scouting and growing medium selection, which are extremely important in alleviating problems with fungus gnats. Greenhouse producers and nursery managers who implement proper water management and sanitation practices — such as eliminating weeds and algae from production areas and properly timing the use of both insecticides and natural enemies — will experience fewer problems with fungus gnats in greenhouses and nurseries.

Table 1. The active ingredient (common name), trade name, classification, and mode of action of insecticides labeled for use against fungus gnat (*Bradysia* spp.) adults and larvae in greenhouses and nurseries within the United States.

| Common Name (active ingredient) | Trade Name | Classification | Mode of Action |
|---|---|---|---|
| **Adults** | | | |
| Bifenthrin | Attain/Talstar | Pyrethroid | Sodium channel blocker |
| Chlorpyrifos + Cyfluthrin | Duraplex | Organophosphate + Pyrethroid | Acetylcholine esterase inhibitor + sodium channel blocker |
| Cyfluthrin | Decathlon | Pyrethroid | Sodium channel blocker |
| Petroleum oil | PureSpray Green/ SuffOil-X | Horticultural oil | Suffocation or membrane disruptor |
| **Larvae** | | | |
| Acetamiprid | TriStar | Neonicotinoid | Nicotinic acetylcholine receptor disruptor |
| Azadirachtin | Azatin XL/Ornazin/ Molt-X | Insect growth regulator | Ecdysone antagonist |
| *Bacillus thuringiensis* ssp. *israelensis* | Gnatrol | Microbial | Mid-gut membrane disruptor |
| Bifenthrin | Talstar | Pyrethroid | Sodium channel blocker |
| Chlorfenapyr | Pylon | Pyrrole | Oxidative phosphorylation uncoupler |
| Chlorpyrifos | DuraGuard | Organophosphate | Acetylcholine esterase inhibitor |
| Cyromazine | Citation | Insect growth regulator | Chitin synthesis inhibitor |
| Diflubenzuron | Adept | Insect growth regulator | Chitin synthesis inhibitor |
| Dinotefuran | Safari | Neonicotinoid | Nicotinic acetylcholine receptor disruptor |
| Imidacloprid | Marathon | Neonicotinoid | Nicotinic acetylcholine receptor disruptor |
| Kinoprene | Enstar II/Enstar AQ | Insect growth regulator | Juvenile hormone mimic |
| Pyriproxyfen | Distance | Insect growth regulator | Juvenile hormone mimic |
| Thiamethoxam | Flagship | Neonicotinoid | Nicotinic acetylcholine receptor disruptor |

Table 2. Biological control agents (entomopathogenic nematode and predators) commercially available for use against fungus gnat (*Bradysia* spp.) larvae in greenhouses and nurseries within the United States.

| Biological Control Agent | Trade Name(s) | Type |
|---|---|---|
| *Steinernema feltiae* | Nemasys, Entoneem, Scanmask, and NemaShield | Entomopathogenic nematode |
| *Hypoaspis miles (=Stratiolaelaps scimitus)* | — | Predatory mite |
| *Atheta coriaria* | — | Predatory rove beetle |

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