TITLE: Identification and Biological Control of Top Pests and Diseases in the Morris Arboretum Greenhouse Complex

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ABSTRACT:

Pest and disease management is one of the major challenges faced on a daily basis in the Morris Arboretum greenhouse complex. However, the relatively high turnover rate of interns, volunteers, and seasonal staff means that many of the people working in the facilities aren't trained to be effective scouts or agents of pest and disease control. Increasing the number of people who are able to identify key pests and diseases has the potential to reduce the number and severity of pest and disease outbreaks that are faced each year. The purpose of this project is to create a guidebook for identifying and controlling the pests and diseases that are encountered most often in the greenhouses. Aside from illustrative photographs, the guide includes concise information on appearance, life cycle, common hosts, and characteristic damage, as well as a consolidated list of control options that are suited to our particular site. Due to the limited use of chemical pesticides in the greenhouse complex, emphasis is placed on biological control methods.

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INTRODUCTION

Scouting for pests and diseases is a daily event in the greenhouses at the Morris Arboretum. However, volunteers are often untrained with regard to pest and disease management, and the propagation and plant protection interns are replaced each year with new individuals that may have no knowledge on the subject. This means that many of the people working on the premises at any given time are ill-equipped for the job, lacking the skills and experience necessary to effectively identify, control, or even notice pests and diseases on the plants they're handling. Yet due to the tedious nature of examining each plant for signs and symptoms and the tendency to overlook plants that you see every day, increasing the number of effective scouts is crucial to reducing pest and disease pressure.

Many print and online resources on this topic already exist and are used in the greenhouse on a semi-regular basis. The main objective for this project, though, is to create a reference guide that is specific to the facilities at the Morris Arboretum and customized to the goals of the institution. For example, we tend to have a higher threshold for damage from pests because we aren't trying to meet the aesthetic demands of the marketplace. In addition, many of the techniques utilized by commercial greenhouses are not practical in a place where no specific crop is grown and only a few individuals of each plant species are present. The guide is not meant to be comprehensive because that would undermine it usefulness as a quick reference.

METHODS

In order to create a reference guide that could be used by future greenhouse volunteers and staff, it was necessary to first come up with a list of the most common and/or most damaging pests and diseases. This was accomplished by consulting with current greenhouse staff members and by reviewing past scouting logs. The scouting logs were particularly helpful because they provided a weekly snapshot of which plants were afflicted by which pests, including the location of the plant and an estimate of how much of the plant had been colonized by the pest or disease. Eventually eleven classes of pests and diseases were determined to have the most impact. However, due to the difficulty in identifying many insects down to the species or even genus, the list was made using the common industry terminology for the pests and diseases. The following list includes the final selections, including the Latin names for the known species.

Pest Class	**Latin Name**
Aphids	*Myzus persicae* (green peach aphid)
Fungus Gnats	*Bradysia, Orfelia, & Lycoriella* species
Mealybug	*Pseudococcus longispinus* (long-tailed mealybug)
Scale	*Coccus hesperidium* (brown soft scale) *Saissetia coffeae* (hemispherical scale) *Ceroplastes* species (wax scale) *Pulvinaria acericola* (cottony maple scale) *Pulvinaria floccifera* (cottony camellia scale) *Pinnaspis aspidistrae* (fern scale) *Lepidosaphes ulmi* (oystershell scale)
Spider Mites	*Tetranychus urticae* (two-spotted spider mite)
Tarsonemid Mites	*Phytonemus pallidus* (cyclamen mite) *Polyphagotarsonemus latus* (broad mite)
Thrips	*Echinothrips americanus* (echinothrips) *Heliothrips haemorrhoidalis* (greenhouse thrips)
Whitefly	*Trialeurodes vaporarium* (greenhouse whitefly)
Disease	**Pathogen**
Downy Mildew	*Peronosporaceae* species (water mold)
Peach Leaf Curl	*Taphrina deformans* (fungus)
Powdery Mildew	*Erysiphales* species (fungus)

Each class of pest or disease on this list is dedicated one to two pages on which the following characteristics are summarized: species, common hosts, expected locations (such as the fernery, hoop houses, or propagation room), primary seasons, appearance, life cycle, damage, and control methods. Pictures and diagrams are included on each page to illustrate these characteristics. While effort was made to include as many photos as possible from the plants in our care, it was often necessary to use pictures from other resources to achieve the magnification necessary for a clear picture.

In terms of control, mechanical, chemical, and biological options are provided. Chemical pesticides and fungicides apart from insecticidal soap and horticultural oil were not considered because (1) information regarding these products is often obsolete after very little time and (2) they are rarely used in our pest and disease management program. Also, the biological control options presented in the reference guide are not a comprehensive list of the products currently available because many of them are not effective solutions in our particular circumstances. Instead, there are only entries on the biological control products that we have used or intend to use. It was more important to make the book concise and useful on a day-to-day basis than to provide all potentially relevant information. Due to the nature of biological controls, it was also necessary to include some limited information regarding their identification and instructions for use. The following is a list of beneficial insects that were dedicated space in the book:

Pest Class Controlled	**Beneficial Species**
Aphids	*Aphelinus abdominalis* (parasitic wasp) *Aphidius colemani* (parasitic wasp) *Aphidius ervi* (parasitic wasp) *Aphidius matricariae* (parasitic wasp) *Chrysoperla/Chrysopa spp.* (green lacewings)
Fungus Gnats	*Steinernema feltiae* (parasitic nematode) *Stratiolaelaps scimitus* (predatory mite)
Mealybug	*Chrysoperla/Chrysopa spp.* (green lacewings)
Spider Mites	*Amblyseius fallacis* (predatory mite) *Phytoseiulus persimilis* (predatory mite)
Tarsonemid Mites	*Amblyseius californicus* (predatory mite) *Amblyseius cucumeris* (predatory mite) *Amblyseius swirskii* (predatory mite)
Whitefly	*Encarsia formosa* (parasitic wasp) *Eretmocerus eremicus* (parasitic wasp)

Much of the information regarding biological controls was gathered by attending two conferences on the topic – one in Baltimore in August and another in Lancaster in November – as well as meeting with various professionals in the industry. Representatives from NorthCreek Nurseries, PeaceTree Farms, New York Botanical Garden, BioBest, and BioWorks were particularly helpful in addition to a meeting with a private consultant named Suzanne Wainwright-Evans.

Aside from the identification and control information for each pest and disease, I also found it useful to include an introduction and appendix to the book. The introduction includes general concepts and tips for scouting, prevention, and control while the appendix offers a chart of our most important annual pest outbreaks by season and location (see figure 1).

Figure 1: Pest & Disease Pressures by Season

Spring (March-June)	**Summer** (June-September)	**Fall** (September-December)	**Winter** (December-March)
Green peach aphids on succulents and herbaceous plants (Glass Rooms)			Green peach aphids on succulents and herbaceous plants (Glass Rooms)
Black aphids on ferns (Fernery, Glass Rooms)	Black aphids on ferns (Fernery)	Black aphids on ferns (Fernery)	Black aphids on ferns (Fernery, Glass Rooms)
		Fungus Gnats on amaryllis bulbs (Glass Rooms)	Fungus Gnats on amaryllis bulbs (Glass Rooms)
Long-tailed mealybug (Glass Rooms, Pit House, Fernery)	Long-tailed mealybug (Fernery)	Long-tailed mealybug (Fernery)	Long-tailed mealybug (Glass Rooms, Pit House, Fernery)
Mealybug on rhododendrons (Hoop Houses)			
Scale (Glass Rooms, Fernery, Pit House, Hoop Houses)	Scale (Glass Rooms, Fernery, Hoop Houses, Outside)	Scale (Glass Rooms, Fernery, Hoop Houses, Outside)	Scale (Glass Rooms, Fernery, Pit House)
TSSM (Hoop Houses, Medicinal House)		TSSM (Hoop Houses, Outside)	
Tarsonemids on brugmansia (Glass Rooms)	Tarsonemids on brugmansia (Outside)		
	Echinothrips (Hoop Houses, Outside)	Echinothrips (Hoop Houses, Outside)	
Greenhouse thrips (Glass Rooms)			Greenhouse thrips (Glass Rooms)
Greenhouse whitefly (Glass Rooms)		Greenhouse whitefly (Glass Rooms)	Greenhouse whitefly (Glass Rooms)
Peach leaf curl on flowering cherries (Outside)	Peach leaf curl on flowering cherries (Outside)		

RECOMMENDATIONS

All members of the greenhouse staff learned new concepts in the field of pest and disease management throughout the course of this project. The list below includes a few specific items that I found to be particularly important in my research and that I would like to emphasize here in no particular order.

1. Rootshield Plus – This product, made by BioWorks, is a biological fungicide used to control root-borne diseases like *Phytophthora*, *Rhizoctonia*, *Pythium, Fusarium,* etc. When I started working in the greenhouse, Rootshield Plus granules were only mixed into media for seeds and cuttings. After talking with representatives from BioWorks and owners of other greenhouses during a conference, though, we discovered that it can and should be used more broadly. The granules should be mixed into all media for propagation and potting and the wettable powder should be used as a drench in between granular applications.

2. Dipping cuttings – Another technique used by commercial propagators is dipping cuttings in some type of pesticide before sticking them. In our case the pesticide is horticultural oil diluted to 0.5%. This is important because even if cuttings don't exhibit visible signs of pest presence upon arrival, the environmental conditions of our propagation room might induce small pest populations to emerge and reproduce. Dipping cuttings in oil before they are stuck is better than spraying them with oil after pests are noticed because (a) full coverage can be achieved and (b) the cuttings haven't had a chance to put on tender new growth that might be ill-affected by the oil. It should be noted, though, that process of dipping cuttings should be very brief. Immersing cuttings in the oil mixture for more than a moment or two can cause them unnecessary stress. Some discretion should be used to avoid exposing extremely sensitive plant species to oil.

3. BioBoxes – These foldable hanging cardboard boxes are valuable for elevating beneficial insects and arthropods to the same level as the pests. Before discovering these boxes, we were only able to sprinkle the beneficials on top of leaves and pots and hope they wouldn't fall off or become sodden after watering. BioBoxes are particularly crucial when releasing beneficial insects that have a parasitic function, such as *Aphidius* species for aphids or *Encarsia formosa* for whitefly because the parasites are delivered as "mummies" and require a few days to fully emerge. These boxes do have a few drawbacks, though. They are not waterproof, can have holes in the bottom as a result of their folding feature, and have a tendency to tear or fall off plants because of their lightweight construction. In reality, a better product probably exists and might prove to be a worthwhile investment.

4. Ant control – Ants are a side effect of having honeydew-producing pests, such as aphids, soft scales, mealybugs, and whitefly. As these pests feed, the ratio of proteins to sugars in plant sap is not the same as is required by the pests, so the excess sugars are excreted in the form of honeydew. The ants, in turn, protect the honeydew-producing pests, even going so far as to carry them around to more secure areas. If ants aren't controlled before releasing beneficial insect, then the ants will fight the beneficials and drastically reduce

their effectiveness. Ant bait such as boric acid should be used to reduce ant populations before attempting to use biological controls.

5. Record keeping – Keeping accurate logs of all pest- and disease- related happenings in the greenhouses is time consuming and inconvenient. However, this project has shown the importance of maintaining this information in the long-term. More effort should be made to keep track of pests, their location, the date of sighting, and any controls methods used. It is also useful to note when fertilizer applications take place, when trap or indicator seeds are planted, when sticky cards are hung, and when preventative beneficials are released. Improving the manner in which we log this information might make record-keeping more consistent. For example, it might be easier to keep a clipboard with a log sheet on the wall rather than logging items into an excel sheet on the shared drive because a clipboard is more accessible and convenient. Regardless, this is an area for continued improvement.

6. Training volunteers – The greenhouse is lucky enough to have some amazing volunteers that often run out of work to do and are eager to help out in any way possible. By training volunteers to scout, they would not only be able to recognize pests on the plants they are potting up but also be able to help monitor during seasons when other tasks are impossible. Volunteers make up a large part of our work-force and often stay at the arboretum much longer than seasonal staff and interns. A short investment of time to train them in pest and disease management could make them even more valuable than they already are.

7. New biological options and applications – While learning about all of the biological control products on the market I was pleasantly surprised to find that my supervisor. Shelley Dillard, and fellow greenhouse staff member, Steve Pyne, were both remarkably well-versed in the products available for pest control. Remaining up-to-date on biological control methods is important, though. New beneficials and new ways of using those beneficials are being discovered all the time and as more and more chemical pesticides are restricted or eliminated from use, the industry will put greater emphasis on those biological alternatives. While the end product of this project is a printed guide, it should not impede its users from researching and adopting new techniques for pest and disease management in the future.

CONCLUSION

The Morris Arboretum greenhouse attracts people from extremely varied backgrounds, but pests and pathogens refuse to wait for new people to be trained. Hopefully this reference guide will allow those with even very limited experience to contribute more fully to our pest and disease management program.

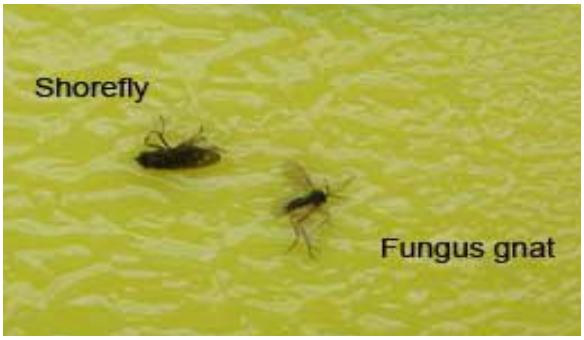
APPENDIX

Fungus Gnats

Species
Bradysia, Orfelia, & Lycoriella species

Common Hosts
Main locations: glass rooms
Primary seasons: fall and winter
Hosts: particularly noticeable on seed flats and amaryllis bulbs

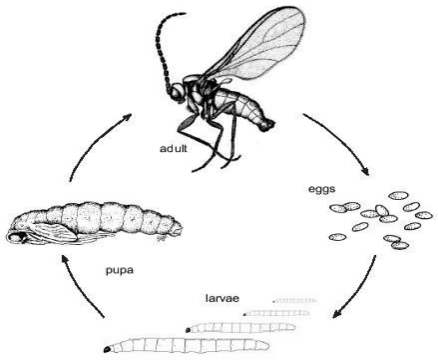
Appearance & Life Cycle
Adult fungus gnats are small (up to 1/8th inch), delicate, dark flies somewhat resembling tiny mosquitos. A single Y-shaped vein on the wings is useful for differentiating them from other small flies. Fungus gnats are weak fliers and often run or make short skipping flights across soil and other surfaces. Eggs are usually laid as clusters or strings in cracks of the soil surface. Immature stages (larvae) occur primarily within the top 1/2 inch of soil and are rarely observed. Although the larvae feed primarily on soil fungi, they also feed directly on root hairs and on leaves lying on the soil. They occur most often in damp, humid environments.



Fungus gnats can be difficult to distinguish from other small flies, but they do have a distinct form.

Damage
Fungus gnat adults are primarily an aesthetic issue on plants that are gifts for donors (such as amaryllis). However, the larvae can cause damage to small seedlings or cuttings by feeding on the roots and should be controlled.

<u>Wilting, stunting, damping off</u> - fungus gnat larvae feed on plant roots and can cause small plants to die. These effects are exacerbated by the fact that the larvae spread such diseases as pythium, phytophthora, botrytis, fusarium, and verticillium.



In the fungus gnat life cycle, larvae are the primary concern for damage and disease transmission.

Prevention and Control
Control is difficult because of their concealed habit.

- Mechanical - yellow sticky traps can be used to attract adults. To test for the presence of larvae, place slices of potato on the soil surface. Maintaining a lower level of water in the substrate will also ensure that most larvae are unable to survive.
- Chemical - sprays or dips using insecticidal soaps and/or horticultural oils diluted to 1-2% can reduce adult populations, but won't control larvae.
- Biological - The parasitic nematode, *Steinernema feltiae*, is often used alongside a predatory mite, *Stratiolaelaps scimitus,* to control fungus gnats.


Slices of potato can be placed on the soil surface to test for the presence of fungus gnat larvae. The larvae are attracted to feed on the potato.

Fungus Gnat BioControls

Parasitic Nematode Species
Steinernema feltiae

Predatory Mite Species
Stratiolaelaps scimitus (previously known as *Hypoaspis miles*)

Target Pests
S. feltiae and *S. scimitus* both target fungus gnat larvae and thrips pupae in the soil.

Mechanism for Control
Juvenile stages of *S. feltiae* enter fungus gnat larvae through natural body openings. They multiply within the host and release a symbiotic bacterium whose toxin kills the fungus gnats in one to two days by blood poisoning. The infective juveniles then exit the dead body and search for new hosts to infect. In the case of *S. scimitus*, control is achieved in the same way as other predatory mites. They suck out the juices from fungus gnat larvae.

Optimum Conditions
The parasitic nematode, *S. feltiae*, requires temperatures between 59 and 90˚F, but is more active in the range of 70-79˚F. They also need a moderately moist substrate. The predatory mite, *S. scimitus*, prefers 60-72˚F and similarly moist conditions.

Usage Notes
- Use *S. feltiae* alongside *S. scimitus* for best control. They are compatible with each other and will complement each other's abilities.
- The parasitic nematodes are released by stirring them into a watering can and drenching pots or flats with the mixture. Do this before sprinkling the predatory mites in the area so the mites have an opportunity to get settled.
- These two BioControls can be used preventatively. In fact, every year when we order amaryllis bulbs to give to donors, we should be releasing *S. feltiae* and *S. scimitus* in all of the newly planted pots, then using the excess in seed flats and cutting pans.
- Hanging yellow sticky cards near plants and placing potato slices on soil surfaces can help confirm a reduction in the population of fungus gnats.

Stratiolaelaps scimitus adult attacking a fungus gnat larva.


Steinernema feltiae nematodes swarming a fungus gnat larva to enter via a natural opening.

Steinernema feltia nematodes are packaged with a carrier that can be mixed in water to drench pots.

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