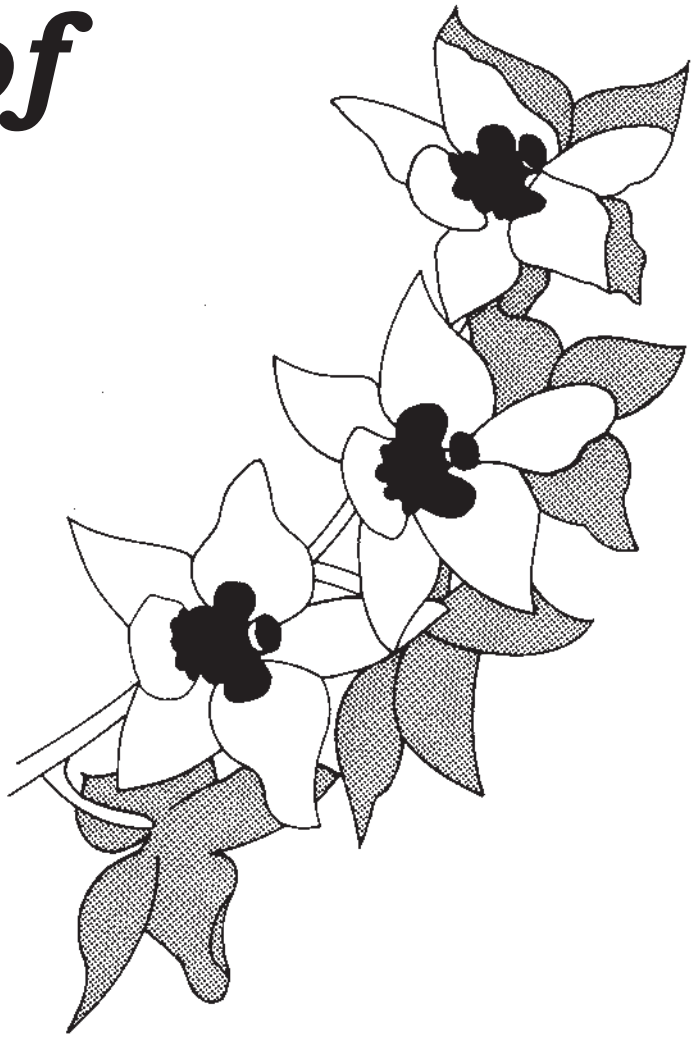
COMMON SENSE
PEST CONTROL QUARTERLY

VOLUME XXXIV, NUMBER 1-4, SPECIAL ISSUE (PUBLISHED JANUARY 2021)

Pests of Indoor Plants



Drawing by Joyce Hawley

An Invitation to Join

B · I · R · C

The Bio-Integral Resource Center

BIRC, A NON-PROFIT CORPORATION, WAS FORMED IN 1979 to provide practical information on the least-toxic methods for managing pests. The interdisciplinary BIRC staff and an international network of advisors and research associates have designed highly effective alternative solutions to a wide variety of pest problems throughout the world. This work has been based on the principles of 'Integrated Pest Management' or 'IPM'.

IPM IS A DECISION-MAKING PROCESS that considers the whole ecosystem in determining the best methods for managing pests. The objective of an IPM Program is to suppress the pest population below the level that causes economic, aesthetic, or medical injury. IPM strategies are designed to be the least disruptive of natural pest controls, human health, and the general environment. Horticultural, physical, mechanical, biological, least-toxic chemical, and educational tactics are integrated to solve pest problems with a minimal reliance on pesticides.

THE IPM APPROACH HAS GAINED FAVOR with government and business because it is cost-effective. Community groups and pest management professionals are enthusiastic about IPM programs because the use of toxic materials is reduced while better pest control is achieved.

BECOME A MEMBER OF BIRC! Membership in the Bio-Integral Resource Center supports our ongoing research program devoted to evaluating and disseminating alternative strategies for the many pest problems still being treated exclusively with pesticides. Membership support also enables BIRC's technical staff to continue to provide information and assistance to individuals and organizations endeavoring to change pest control policy and practices in their communities and places of work.

BIRC MEMBERS RECEIVE ONE OR BOTH OF OUR JOURNALS, the *Common Sense Pest Control Quarterly* and *The IPM Practitioner.* Members are entitled to consultations by phone or correspondence on an individual pest problem each membership year. Just write a description of the problem and send it to BIRC. Our technical staff will research the problem and provide you, if possible, with least-toxic solutions. BIRC memberships are tax-deductible to the extent allowed by law.

MEMBERSHIPS. Individuals can join BIRC for $30/yr and receive *Common Sense Pest Control Quarterly*, or they can pay $35/yr to receive the *IPM Practitioner.* Dual Members pay $55/yr and receive both journals. Institutional rates are $50/yr for the Quarterly, $60/yr for the Practitioner and $85/yr for both journals. Sustaining Members pay the Dual Membership fee and may also choose to donate to sustain BIRC activities. FEI# 94-2554036

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Got A Pest Management Question?

If you have a specific pest management question, first check our website, www.birc.org. Often you will find a publication that covers your problem. If you do not find the solution on our website, you can write us with a description of the pest and the problem. Include scientific names of the pest. You can also email this information to birc@igc.org. We will respond as quickly as possible.

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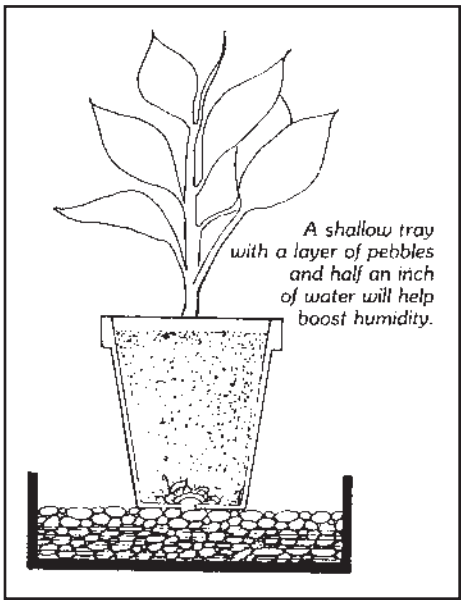
Least-Toxic Solutions for Indoor Plants–Plant Vampires

By William Quarles

This issue of *Common Sense Pest Control Quarterly* profiles pests and problems of plants indoors. Plants kept indoors can range from the African violets above the kitchen sink to specialized and exotic plants in greenhouse environments such as orchids and *Cannabis sativa*. Key to success with plants indoors is proper choice of plant and location. Most plants need water, light, a growth medium that furnishes minerals, and carbon dioxide for photosynthesis. However, a particular species may prefer more or less of these essentials. For instance, cylamen, gardenia, geranium, and others like to be grown in full sunlight. Usually, these plants do better in windows facing south. In areas of diffuse light, dumb cane, snake plant, and philodendron can thrive. In dark apartments you may have to turn to Aspidistra or other plants that prefer low illumination. Another alternative for a dark apartment is to establish artificial lighting. Fluorescents are best for providing longterm, economical plant growth (Faust 1973; Poincelot 1974; Lancaster and Biggs 1998).

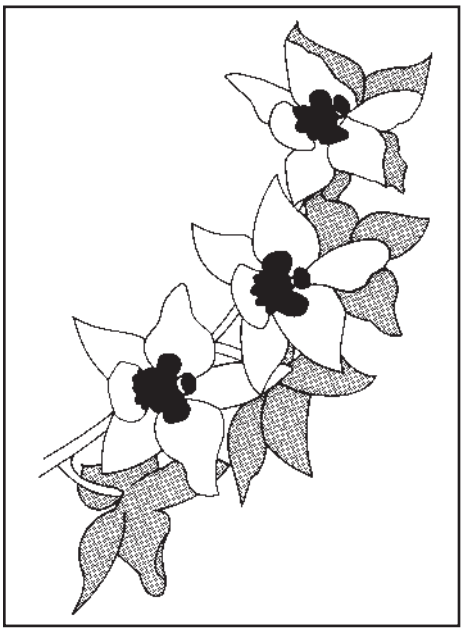


Since indoor plants are basically living in a desert, major problems come from balancing the water requirements. The most common mistake is overwatering, which can lead to root rot and diseases. Wet pots can also encourage fungus gnats. Another mistake is allowing the plant to desiccate in the dry indoor environment. Desiccation can encourage attacks of spider mites or wilting.

The amount of water needed depends on the container. Plastic pots have to be watered less often. Clay pots are porous and dry out quicker. To decide when to water, stick your finger into the top inch of the container mix. If the potting mix feels dry, it is probably time to water. A related factor is humidity, orchids and many other houseplants originated in the tropics and like high humidity. Orchids will thrive if misted regularly. High humidity can also be obtained by setting pots into a tray filled with pebbles. Water is added to the tray, but the water level is kept below the top of the pebbles (Olkowski et al. 1991; Faust 1973).

Houseplants do not need to be fertilized often. Fertilizer such as fish and seaweed emulsions provide nutrients in a slow release form. Encapsulated synthetics such as Osmocote® can do a similar job. If you have lots of houseplants, you might consider making batches of compost tea. The microbials in the tea will help prevent growth of pathogens, and will provide slow fertilization (Quarles 2001).

Many problems can be forestalled by close scrutiny of the plant before it is purchased. Look closely for signs of insect or mite infestations, such as shriveled, curled leaves,



Drawing by Joyce Hawley

Orchids thrive when misted regularly.

colonies of aphids, webbing of spider mites, and signs of disease. After a new plant is purchased, it should be held in a quarantine area for at least three weeks until you are sure it is safe to move it to the final location (Olkowski et al. 1991).

Insect and Mite Pests

Many common houseplant pests are insects or mites that live by sucking nutrients from the plants. These plant vampires include aphids, mealybugs, scales, mites, thrips, and whiteflies. Many of these sucking pests secrete a sweet honeydew that attract ants, which are themselves a household nuisance.

Since these houseplant pests have similar lifestyles, they can be kept in check by a management plan with similar components. Proper attention to monitoring, cultural, physical, biological and least-toxic chemical controls can keep your plants healthy. This integrated approach can also be used to protect outdoor gardens from these pests.

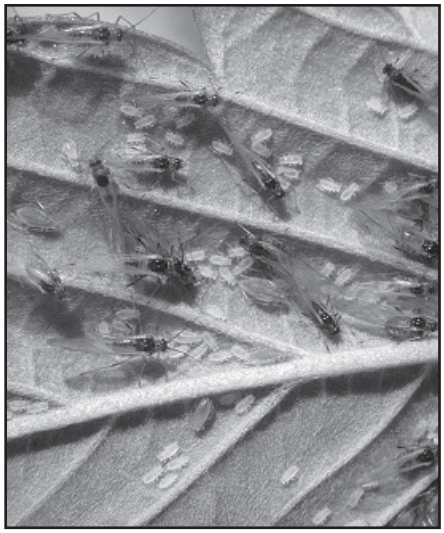


Photo courtesy Professor Whitney Cranshaw

Cannabis* aphids, *Phorodon cannabis

Other pests associated with houseplants are fungus gnats, millipedes, sowbugs and others that are attracted to detritus and moisture in the growth medium. In this article we will summarize major elements of houseplant and greenhouse pest management.

Biocontrols

Biocontrols are available for a number of houseplant pests. Biocontrols can be useful when you have a large enclosed collection of plants. Greenhouses, for instance, typically employ biocontrols on a regular basis. However, if you have just a few small isolated plants, biocontrols might not be useful, since plants would have to be caged to contain mobile life stages. Biocontrols for the pests mentioned here can be found in BIRC's *2015 Directory of Least-toxic Pest Control Products* (BIRC 2015).

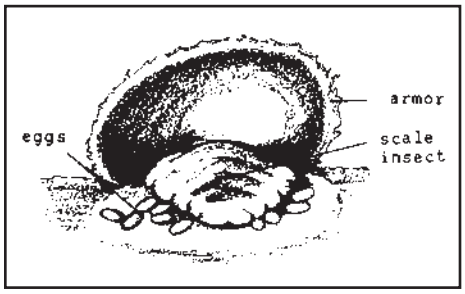
Aphids

Aphids are green, black, red, pear-shaped insects that accumulate on growing tips and flower buds of houseplants. They can cause distorted leaves and buds. Common species found on houseplants include the green peach aphid, *Myzus persicae*; the cotton aphid, *Aphis gossypii*; and the potato aphid, *Macrosiphum euphorbiae*. Favorite plants are chrysanthemums, carnations, orchids, roses, cyclamen, amaryllis, azelea, begonia, and others (Gill and Sanderson 1998).

Aphids become problems when plants are overfertilized, causing large surges of succulent, inviting growth. Infestations can be pruned off the plant and discarded. High velocity water sprays will wash away the problem. Insecticidal soap (see below) is effective for aphids. Predators such as lacewings and ladybugs, and parasitoids such as *Aphidius* sp. are useful in greenhouses (Fournier and Brodeur 2000; Dreistadt 2016).

Scales

There are more than 6000 species of scales in 20 different families. Scales are usually either armored (Diaspididae) or soft scales (Coccoidae). Both soft scales and armored scales are protected by a shell or waxy coating. The outer shell of armored scale can be removed from the insect's body; the shell of soft scale is part of its body. Armored scales do not produce honeydew, while soft scales do. Armored scales such as Boisduval scale, *Diaspis boisduvalii*; and proteus scale, *Parlatoria proteus*, can be significant pests of orchids. Other armored scales



Armored scale

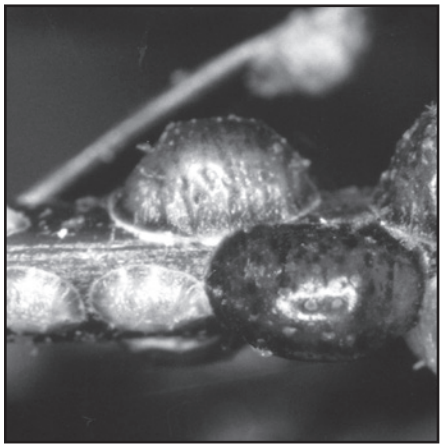


Photo by Helga Olkowski

Hemispherical scale, *Saissetia coffeae*

found on houseplants include oleander scale, *Apidiotus nerii*; cymbidium scale, *Lepidosaphes machili*; and latania scale; *Hemiberlesia lataniae* (Watson 2002; Gill and Sanderson 1998).

Like aphids, scales cause plant damage by sucking juices and nutrients. Generally, adult females are wingless, do not move on the plant, have a hard body or shell-like covering, and lay their eggs beneath this shell. The shell is about 1/16 inch or 2 mm in diameter. Eggs hatch into young crawlers, or nymphs that superficially look like mites, but have only three pairs of legs, where mites have four. After the first nymphal stage, scales usually become stationary, and a waxy covering is secreted, which covers the body. Though most adult and nymphal stages of scales are stationary, some species of soft scales remain mobile as adults (Gill and Sanderson 1998).

The very distinctive scale coverings are helpful in learning to identify the various scales species. Adult males do not develop a shell, are wingless or have two wings, lack mouthparts and do not feed, retain their legs and do not live very long (Steiner and Elliott 1983).

Brown soft scale, *Coccus hesperidum*, secretes large amounts of honeydew and can be a pest of many houseplants. Scales can be physically removed by scraping them off the plant. Severely infested areas can be pruned away. Large areas of infestation can be treated with insecticidal soap or oil. Biological controls are useful in greenhouses or in plants grown inside screening. These include parasitoids such as *Aphytis melinus* and predators such as *Lindorus* sp. and *Harmonia axyridis* (Olkowski et al. 1991).

Mealybugs

Mealybugs are a mobile form of scale insect (Pseudococcidae). These 2-4 mm long insects have segmented bodies, and secrete a waxy coating and excrete honeydew. A severe infestation can make a plant look like it is covered with cotton. Favorite feeding places for many

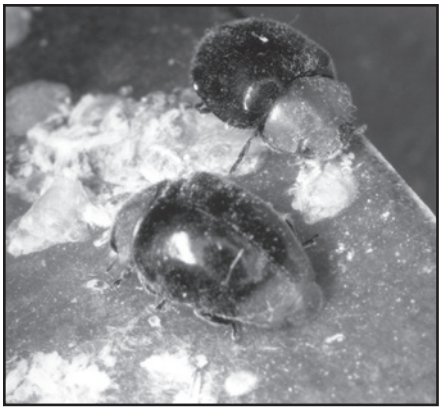
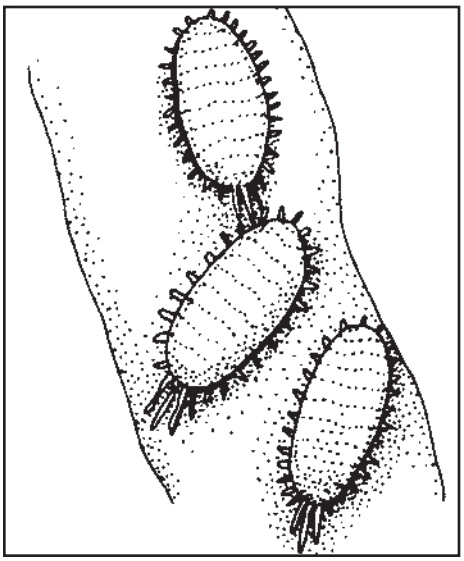


Photo by Helga Olkowski

Mealybug destroyer, *Cryptolaemus montrouzieri*

species are on the undersides of leaves, in leaf axils, and along leaf veins. Unlike scales, that become fixed on the plant as nymphs or adults, mealybugs are mobile in all life stages. They can walk from plant to plant, spreading an infestation, and they have a diverse biology. For instance, the citrus mealybug uses waxy secretions to protect eggs, while the long-tailed mealybug does not lay eggs, but gives live birth (Gill and Sanderson 1998).

Like aphids, mealybugs thrive on plants with a large nitrogen content. Common mealybugs found on houseplants include the long-tailed mealybug, *Pseudococcus longspinus*; the citrus mealybug, *Planococcus citri*; and the obscure mealybug, *Pseudococcus obscurus*. Mealybugs attack coleus, hoya, jade, poinsettia and other houseplants. Root-infesting mealybugs are associated with African violet and gardenias. Specialty mealybugs such as the orchid mealybug, *Pseudococcus microcirculus*, can occur on orchids (Watson 2002; Olkowski et al. 1991).



Pest mealybugs

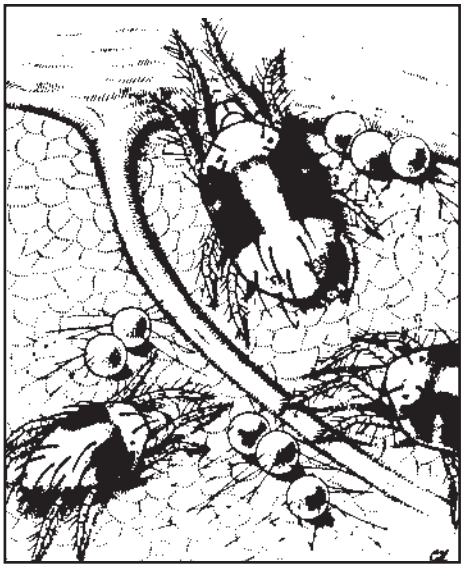
Mealybugs can be killed by swabbing them with alcohol (Finkel-Strauss 1977). Insecticidal soaps can also be used (see below). However, before applying these treatments be sure to test a small area of the affected plant for phytotoxicity. Commercially available insecticidal soap is generally benign to plants, but some plants can be harmed by soap (Miller and Uetz 1998).

Insecticidal soap is usually sprayed as a 1-2% water solution, but it has been used as a root drench for root mealybugs on plants such as African violets. Biocontrols such as the mealybug destroyer, *Cryptolaemus montrouzieri*, are useful for mealybug control in greenhouses (Olkowski et al. 1991).

Mites

Spider mites are microscopically tiny (1/64 to 1/32 inch long; 0.4 to 0.8 mm), pinkish, red, brown, yellow, or green. They are smaller than the period at the end of this sentence, and mites, unlike insects, have 8 legs. Eggs are spherical and translucent. Spider mites live in colonies that contain hundreds of mites, and they leave pin-prick holes and a webby deposit on the underside of the leaves.

One of the most common species on houseplants is the two-spotted mite, *Tetranychcus urticae*. The damage made by spider mites shows first as needle-like puncture marks made when they suck the sap from plant parts. Initially, the tops of damaged leaves appear stippled with tiny silvery or yellowish dots. Later, the punctures become brown and sunken. On ornamentals, mites cause mainly cosmetic damage, but can kill plants if populations become very high on annual plants (Gill and Sanderson 1998). Mites can be controlled by pruning out severe infestations, or treating with insecticidal soap or oil. Mites can also be discouraged by sprays of water (Lawson and Weires 1991; Osborne 1984)(see below).



Two-spotted mite, *Tetranychus urticae*

In greenhouses, biocontrols include predatory mites such as *Phytoseiulus persimilis*, and *Amblyseius* spp.; predatory bugs such as *Orius* spp., lady beetles such as *Stethorus* sp., and the mite midge, *Feltiella acarisuga* (BIRC 2015).

Thrips

Adult thrips are very small winged insects, about 1/25 inch long (less than 1.5 mm) and look like tiny, long, brown or black slivers of wood. Life stages include eggs, larvae, pupae, and adults. Eggs are laid in flowers, on foliage, or inside plant tissue. Hatching larvae of some species feed on foliage, then drop to the ground to pupate. Emerging adults fly back up to the foliage to feed and to mate. Other species pupate on the plant. Adults and larvae have similar long, thin shapes, except adults have fringed wings, larvae have none. Thrips range in color from translucent white or yellowish to dark brown or blackish, depending on the species and life stage (Dreistadt 2016; Gill and Sanderson 1998).

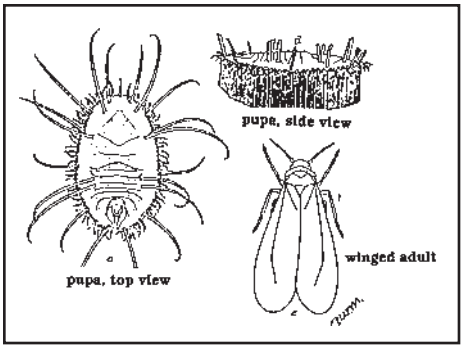
Thrips found on indoor plants include greenhouse thrips, *Heliothrips haemorhoidalis*; flower thrips, *Frankliniella bispinosa*; western flower thrips, *Frankliniella*

occidentalis; and cuban laurel thrips, *Gynaikothrips ficorum* (Watson 2002). Orchid growers encounter thrips most often in flowers. Species such as greenhouse thrips lay eggs in plant tissue, forming blisters. Young larvae feed on the underside of leaves. Infested leaves appear silvery and are spotted with black excrement. Thrips can also carry plant viruses that can cause damage. Treatment with insecticidal soap or oil will often take care of thrips problems (see below). Sprays of neem or spinosad are also effective. Greenhouse biocontrols include lacewings, predatory mites, and *Orius* bugs (Olkowski et al. 1991; Quarles 2005ab).

Whiteflies

Whiteflies are tiny, sap-sucking insects. The life stages are eggs, larvae, pupae, and adults. Larval stages look like scale insects, and these stages were misclassifed as scales for many years. Larvae are also called nymphs. Adults are about 1.5 mm long, are covered with a white, waxy powder, and have two sets of wings and thus are not true flies. In the case of the silverleaf whitefly, progression from egg to adult takes 18-30 days. Adults live 10-22 days, and females lay can lay an average of 200 eggs on favorable host plants (Steiner and Elliott 1983).

Whiteflies cause damage through viral transmission, the excretion of honeydew, which creates favorable conditions for sooty mold fungi, or by direct stress damage to the plants. Pests of houseplants include greenhouse whitefly, *Trialeurodes vaporariorum*, on many herbaceous ornamentals; and silverleaf and sweetpotato whiteflies, *Bemisia argentifolii* and *B. tabaci*, which have a very large host range (Olkowski et al. 1991).



Life stages of the whitefly, *Bemisia* sp.

Whiteflies can be controlled with sprays of soap or oil (see below). Neem sprays can be useful when infestations are severe. Biocontrols for whiteflies are available for greenhouse situations. Predators such as the lady beetle, *Delphastus* spp., lacewings, predatory bugs such as *Macrolophus* sp., and parasitoids such as *Encarsia* spp. and *Eretmocerus* spp. are sold commercially (Butler et al. 1993). See the BIRC Directory of Least-Toxic Pest Control Products, which is online at birc.org.

Sticky Traps

If you have several containerized plants growing in the same area, yellow or blue sticky traps can be used to trap out adult flying forms of houseplant pests (see Resources). Thus, adult thrips, whiteflies, fungus gnats and other insects can be captured. Blue sticky traps are more attractive to thrips, and yellow traps are more attractive to whiteflies. Sticky traps are very useful for monitoring in greenhouses (Gill and Sanderson 1998).

Soap and Water

Soaps are salts of fatty acids. Fatty acids are found naturally in many animal or vegetable fats. Heating fats with a metal hydroxide produces soap. Sodium and potassium hydroxides are generally used, because the resulting soaps are water soluble. Grandma's lye soap was often produced from lard and sodium hydroxide. This was a rough product, often containing unreacted traces of lye. The familiar everyday bars of hand soap are highly purified sodium salts and the fatty acids often come from plant sources. Liquid soaps are usually potassium salts. Formulations of these liquid soaps are sold commercially as insecticides (see Resources).

Insecticidal soap has a history at least as old as the homemade soaps concocted by American pioneers. Insecticidal soaps disrupt insect cell membranes, denaturing proteins and causing the cells to rupture and collapse. The resulting desiccation is lethal to an insect.

Soaps are virtually nontoxic to the user unless ingested in large amounts. Even at high doses they have no serious systemic effects, although they can cause vomiting and general stomach upset. The oral LD_{50} in rats of Safer® Insecticidal Soap is greater than 16,500 mg/kg (Olkowski et al. 1991).

Soaps show relative selectivity in the range of insects they affect. Soft-bodied mites and sucking insects such as aphids, scale crawlers, whiteflies and thrips are the most susceptible. Some insects, including adult beetles, bees, wasps, flies and grasshoppers, are relatively unaffected.

A 1% to 2% solution of regular household soap or detergent can be used to kill insects, but its reliability is less predictable than soaps specifically formulated as insecticides. A 1% solution is about 3 Tablespoons of soap per gallon of water. Such homemade solutions are also more likely to burn plants and affect plant growth than are the commercial insecticidal soap products.

Commercially available insecticidal soap is largely due to Dr. G.S. Puritch, who worked at Safer Inc. in the 1970s. Puritch found that the toxicity of fatty-acid salts (soaps) peaked when the saturated fatty-acid molecule contained about 10 carbon atoms, or when an unsaturated fatty acid contained 18 carbons (Olkowski et al. 1991).

As mentioned above, many of the common houseplant pests, such as mealybugs, aphids, scales, mites, thrips and others, are very susceptible to insecticidal soap. When using an insecticidal soap, test the dosage on a small number of plants or on a small portion of the plant to be treated to evaluate its toxic effects. In general, insecticidal soap is not phytotoxic. According to Olkowski et al. (1991), "plants such

as African violets that have hairy leaves tend to hold the soap solution on their leaf surfaces, where it can cause burning. You can minimize this effect by rinsing the soap off the plant after treatment. This should be done within ten minutes to several hours after application, depending on the sensitivity of the plant, the temperature (the higher the temperature, the more likely the plant is to react negatively) and the strength of the soap solution. You will have to experiment to discover what works best."

Horticultural Oils

According to Olkowski et al. (1991), "written records of the use of oils as pesticides date from as early as the first century A.D., when the Roman scholar Pliny the Elder wrote that mineral oil controlled certain plant pests. It was also recognized that oils could damage plant tissue. By 1763, petroleum oil and turpentine were in common use as insecticides. Whale oil was used against scales as early as 1800 in the United States, and an oil mixture of kerosene, soap and water was used against caterpillars in the 1860s."

Petroleum based horticultural oils are commercially available at your local horticultural nursery. These are highly purified petroleum oils that contain added surfactant. These can be mixed with water and sprayed as insecticides. Vegetable oils can also be used as insecticides. A 1-2% oil suspension in water is an effective insecticide. To make a 1% solution, add about 3 Tablespoons of oil to a gallon of water along with a few drops of soap.

In general, oils kill all stages of insects by smothering them. Oils kill eggs by penetrating the shells and interfering with metabolic processes, or by preventing respiration through the shells. Oils have also been used as least-toxic fungicides (Quarles 2019).

Because oils act physically rather than by poisoning metabolism, their acute toxicity to mammals is low. When sprayed however, they can cause skin and eye irritation, so protective clothing, gloves and goggles should be worn during application.

When oils are used you should make sure that the plants are not under water stress when they are sprayed and that the relative humidity is low to moderate (45% to 65%) so the oil spray evaporates from the leaves fairly quickly. Horticultural oils are used in commercial nurseries to control pests on bedding and house plants. As with any insecticide, you should always test the material on a small portion of the plant before treating the entire specimen. The cooler and shadier the conditions when the oil is applied, the better (Olkowski et al. 1991).

Essential Oils

Essential oils of cloves, rosemary, peppermint, and other aromatic plants have been commercialized as insecticides and miticides. Some of them are labeled for organic use and for exotic materials such as *Cannabis sativa*. An example is Ecotec®, which contains rosemary, geraniol, and peppermint oil. The product PestOut® combines clove essential oil with garlic

Resource Box

Resources*

Distributors of Least-Toxic Products and Biocontrols—Arbico, 10831N Mavinee Drive, Suite 185, Oro Valley, AZ 85737; 800-827-2847; arbico-organics.com**. Harmony Farm Supply,** 3244 Gravenstein Hwy, No. B, Sebastopol, CA 95472; 707-823-9125, harmonyfarm.com. **Hydrogardens,** 8765 Vollmer Road, Colorado Springs, CO 80908; 719-495-2266, hydro-gardens.com. **IPM Labs,** PO Box 300, Locke, NY 13092; 315-497-2063, ipmlabs.com. **Nature's Control,** PO Box 35, Medford, OR 97501; 541-245-6033, naturescontrol.com; **Rincon-Vitova,** PO Box 1555, Ventura, CA 93002; 805-643-5407; rinconvitova.com

Essential Oil formulations— Brandt (Ecotec®, organic), 2935 South Koke Mill Rd., Springfield, IL 217-547-5800; brandt.com. JH Biotech (PestOut®, GC Mite®), 4951 Olivas Park Drive, Ventura, CA; 805-650-8933; jhbiotech.com. Bayer (Requiem®), 2 TW Alexander Drive, Research Triangle Park, NC 27709; 919-549-2597; cropscience.bayer.com.

Horticultural Oil (from petroleum)—Sun Oil Company (Sunspray®), 1801 Market Street, Philadelphia, PA 19103; 610-859-5742; sunoco.com; Brandt (horticultural oil) see Brandt above. Gardens Alive (Eco-Oil®). See Gardens Alive below

Seed Oil—Stoller Enterprises (Natur'l Oil®), Inc., 4001 W. Sam Houston Pky N., Suite 100, Houston, TX 77043; 713-464-5580; stollerusa.com. See Distributors above.

Neem Formulations with Azadirachtin (AZA)—Garden Essentials® (100% cold pressed neem oil, organic); 11620 Sterling Avenue, Suite A, Riverside, CA 92503; 951-351-1880; thegardenessentials.com. Agro Logistic (DeBug Turbo®, organic), PO Box 5799, Diamond Bar, CA 91765; 714-990-9220, agrologistic.com. Certis (Azatin® XL), 9145 Guilford Rd. Suite 175, Columbia, MD 21046; 301-604-7340; certisusa.com; see Distributors above

Neem Oil Formulations (no azadirachtin)—Certis (Triact® 70% neem oil), see Certis above

Safer® Soap—Woodstream, 69 N. Locust St., Lititz, PA 17543-0327; 800-800-1819, 717-626-2125, woodstreampro.com; see Distributors above

Spinosad—Gardens Alive (Bullseye™), 5100 Schenley Place, Lawrenceburg, IN 47025; 812-537-8650; gardensalive.com

Sticky Traps— BioQuip Products, 2321 Gladwick Street, Rancho Dominguez, CA 90220; 310-667-8800, bioquip.com. see Distributors above.

*A complete list of suppliers can be found in the **2015 Directory of Least-Toxic Pest Control Products** produced by BIRC.

and cottonseed oil)(see Resources). Essential oils kill insects by desiccation and generally have low toxicity to mammals. They can be effective as insecticides and some formulations leave no residue. Drawbacks are that they can be phytotoxic and have odors such as clove, and mint that some people do not like. They should be tested first for phytotoxicity before widespread application (Quarles 1999; Quarles 2000).

Orange oil (limonene) can be an effective insecticide for mealybugs and scale insects. Hollingsworth (2005) found that a 1% limonene formulation was more effective than 2% sprays of soap or oil. Limonene can be phytotoxic, though, especially to ferns, gingers and delicate flowers. According to Hollingsworth (2005), it caused no damage to ornamentals with waxy leaves, such as palms, cycads, and orchids.

Chenopodium ambrosioides has potential as a pest control product (Quarles 1992). Essential oil from *C. ambrosioides* was more effective than soap or oil for western flower thrips. It was more effective than neem or endosulfan for whitefly control, and caused less damage to beneficials than insecticidal soap (Chiasson et al. 2004a). The essential oil is also effective for mites (Chiasson et al. 2004b). An essential oil formulation modeled on *Chenopodium* has been commercialized as Requiem® and is labeled for thrips, aphids, whiteflies, spider mites and other sucking pests (Grossman 2020).

Biopesticides

Neem sprays are most effective for immature stages of insects such as moths and beetles that undergo complete metamorphosis. However, neem has also been used with success for aphids, whiteflies, thrips, and spider mites. Crude, cold pressed neem oil from neem seeds (Garden Essentials) is available and can work as an insecticide, miticide and fungicide. Processed formulations containing neem oil and azadirachtin (DeBug Turbo®) are best for insects. Processed formulations containing mostly triglycerides (Triact®) are best as fungicides, but can also kill mites and smother scale. Formulations containing no azadirachtin work generally in the same way as horticultural oil, smothering immature stages (see Resources). Many neem formulations are certified organic. Neem can also be combined with biocontrols in a greenhouse environment (Quarles 2005a).

Spinosad (see Resources) has low toxicity to mammals and can be very effective for control of thrips and caterpillars, but has little effect on mites. Some spinosad formulations are certified for organic production (Quarles 2005b).

Greenhouses have found use for biopesticide microbials such as *Metarhizium anisopliae* (MET-52), *Beauveria bassiana* (Botanigard) and others. These are applied for mites, thrips, whiteflies and other softbodied insect pests (Quarles 2013).

Conclusion

Plants grown inside are often infested with insects and mites that are essentially plant vampires—creatures that suck nutrients out of the plant and interfere with growth. These include aphids, scales, mealybugs, mites, thrips and whiteflies. Infestations on houseplants can be controlled by cultural methods and least-toxic pesticides such as soaps, oils, and biopesticides. Greenhouses also have the option of releasing biocontrols.

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Managing Mites on *Cannabis*

By William Quarles

One of the major indoor crops is *Cannabis sativa*. The estimated value of *Cannabis* crops in the U.S. each year is about $37 billion. That includes hemp products, medical marijuana, and recreational marijuana (Strickler 2018). Production of hemp in the U.S. is now legal in all states. Medical marijuana is legal in 35 states and recreational marijuana is legal in 15 states (Wikipedia 2021). The House of Representatives recently passed a law completely legalizing all uses of *Cannabis sativa.* Whether federal legalization will move forward is uncertain (Edmundson 2020).

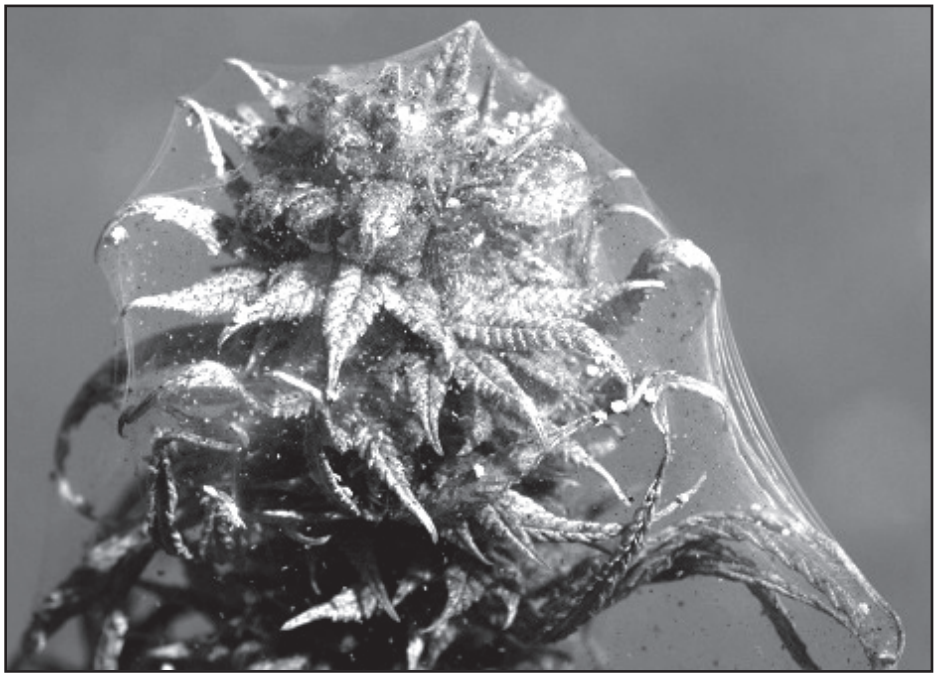


Photo courtesy Professor Whitney Cranshaw

Spider mites, *Tetranychus urticae*, have damaged this bud of *Cannabis*. Biological controls and least-toxic pesticides can control spider mite damage.

Cannabis Grown Inside

Cannabis can be grown indoors in greenhouses or grow rooms, or outside as a field crop. *Cannabis* grown inside has a different spectrum of pests and diseases than that grown outside. Plants are often grown hydroponically, which can predispose them to Pythium root rot and algae. High humidity in the grow rooms can encourage powdery mildew, botrytis and other foliage diseases. Most insect pests can be excluded, but spider mites, fungus gnats and other small arthropods may make their way inside. Flower and leaf pests inside are spider mites, aphids, whiteflies, thrips and leafhoppers. Mealybugs, scales, and true bugs can infest marijuana greenhouses. Thrips can be problems in rockwool growing rooms (McPartland 1996).

IPM methods include monitoring, sticky traps, pruning of infested material, biological controls, and application of state approved least-toxic pesticides. Possible pest entryways such as cracks and crevices should be sealed (Quarles 2006; Murray 2018).

The grow room should be isolated physically from the rest of the structure. Ventilation systems should have filters to exclude insects and disease spores. When working with plants, clean clothes free of spores and possible insects should be used. Water should be purified by filtration or treatment with peroxide or UV light (Rosenthal and Imbriani 2012).

Mites on *Cannabis*

Two kinds of mites can be serious pests of *Cannabis*—the two-spotted mite, *Tetranychus urticae*, and the hemp russet mite, *Aculops cannabicola*. Since plants grown inside are packed close together, mite infestations can quickly spread through the whole crop. Spider mites are microscopically tiny (1/64 to 1/32 inch long; 0.4 to 0.8 mm), pinkish, red, brown, yellow, or green. They are smaller than the period at the end of this sentence, and mature mites, unlike insects, have 8 legs. Eggs are spherical and translucent. Spider mites live in colonies that contain hundreds of mites, and they leave pin-prick holes and a webby deposit on the underside of the leaves. A bad infestation may cause leaf yellowing, premature leaf death and defoliation (Dreistadt 2016; Ohlendorf and Flint 2000).

The damage made by spider mites shows first as needle-like puncture marks made when they suck the sap from plant parts. Initially, the tops of damaged leaves appear stippled with tiny silvery or yellowish dots. Later, the punctures become brown and sunken. As infestations develop, high populations of mites can cause leaves to shrivel, and flower buds may be covered with their webbing. (McPartland et al. 2000).

Monitoring

To look for spider mites, inspect the underside of leaves, particularly along the main ribs. Check the mature leaves first, as initial mite infestations appear on such leaves. Use a hand lens and look for eggs, mites, webbing and leaf punctures. Also check the areas where the leaf petioles join the stems and the branches attach to the main trunk of the plant. Mites can also be

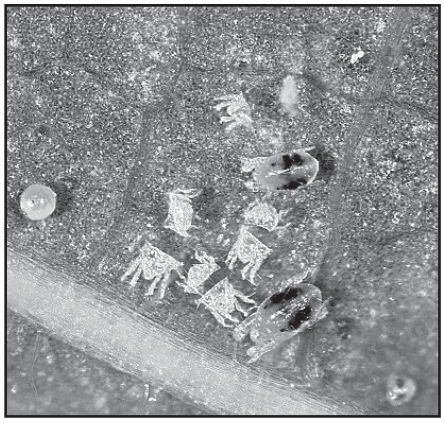


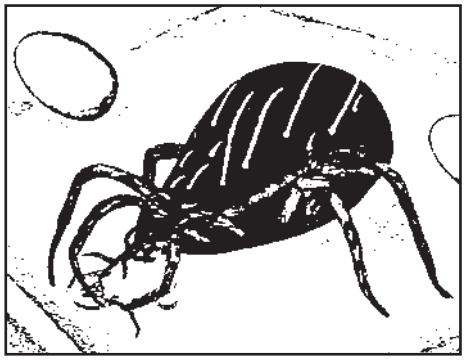
Photo courtesy Whitney Cranshaw

Two-spotted mite, *Tetranychus urticae*

monitored by tapping branches with a pencil to cause any mites to fall onto a clipboard containing a white sheet of paper. This process enables you to determine whether or not mites are present, capture specimens for identification, learn if beneficial predatory mites are present and assess relative numbers of pest mites versus predators (Ohlendorf and Flint 2000; Raupp et al. 1992). Predatory mites (phytoseiids) are shaped like tear drops. *Phytoseiulus persimilis* is bright orange. "Their legs are noticeably longer than their spider mite prey, and the two front legs are commonly extended forward like feelers...Predatory mites run in a circular fashion searching for food, while their prey usually move slowly and erratically" (Glenister 1994).

Predatory Mites

"Biocontrol should be established before spider mite populations explode" (McPartland et al. 2000). Predatory mites for spider mite control are purchased in containers, and distributed onto the leaves of mite-infested plants. Insectaries producing such predatory mites



Predatory mite, *Phytoseiulus persimilis*

will know which species are best for the control of your particular pest mites. They can also recommend how many mites to use per plant. Species include *Metaseiulus occidentalis*, *Amblyseius cucumeris*, and *Phytoseiulus persimilis* (Glenister 1994; BIRC 2015). These should be effective for two-spotted mite, but predatory mite biocontrols for the hemp russet mite are unavailable (McPartland et al. 2000).

Under optimal conditions, *P. persimilis* will control pest mites faster than other predatory mites because it eats 14-23 mite eggs per day, while other predatory mites eat about eight. *P. persimilis* is most effective under humid conditions with 60-90% relative humidity. It fails at high temperatures and 40% relative humidity. The western predatory mite, *Metaseiulus occidentalis*, is more effective under hot, dry conditions (Glenister 1994).

Predatory mites do not feed on foliage or become pests; thus if pest mites are not available when predatory mites are released, the predators starve or migrate elsewhere. If you wish to establish predators in a heavily infested greenhouse, use a soap spray or neem oil to bring pest mites to a lower level and then release predatory mites. A good guideline is that one predator is needed for every ten spider mites to provide control. More than one application of predatory mites may be required if you want to reduce pest populations rapidly. Concentrate releases in hot spots where spider mite numbers are highest (Glenister 1994; Olkowski et al. 1991). McPartland et al. (2000) recommend 25 predatory mites per m^2 as a spot treatment for moderate infestations in *Cannabis*, followed by 5 per m^2 every three weeks. Heavy infestations require 200 per m^2 in trouble spots, followed by 10 per m^2 every three weeks.

Other Biocontrols

Other commercially available predators are the lady beetle, *Stethorus punctillum* and the mite midge, *Feltiella acarisuga*. The mite midge is a fly that lays eggs near high density mite infestations. Larvae crawl slowly to an egg, nymph, or adult spider mite, sink in their

Resources*

Predatory Mites

Metaseiulus occidentalis—Biotactics, Inc., 25139 Briggs Road, Romoland, CA 92585; 951-943-2819, benemite.com; see Distributors in the first article, Arbico, Harmony, IPM Labs, Rincon-Vitova, Nature's Control

P. persimilis—Applied Bionomics Ltd., 11074 W. Saanich Rd., Sidney, BC, CANADA V8L 5P5; 250/656-2123, appliedbio-nomics.com; IPM Laboratories Inc., PO Box 300, Locke, NY 13092-0300; 315/497-2063, ipmlabs.com; Rincon-Vitova Insectaries Inc., PO Box 1555, Ventura, CA 93002; 805/643-5407; rinconvitova.com; Nature's Control, PO Box 35, Medford, OR 97501; 541/245-6033; naturescontrol.com

Predatory Beetles and Bugs

Orius spp.—Applied Bionomics (see above), IPM Labs (see above), Nature's Control (see above),

Stethorus punctillum—Applied Bionomics (see above), Rincon-Vitova (see above), Nature's Control (see above). See the list of Distributors in the first article.

Soaps and Oils

Horticultural Oil—Sun Oil Company (Sunspray®), 1801 Market Street, Philadelphia, PA 19103; 610-859-5742; sunoco.com; Brandt (horticultural oil), 2935 South Koke Mill Rd., Springfield, IL 217-547-5800; brandt.com. See the list of Distributors in the first article.

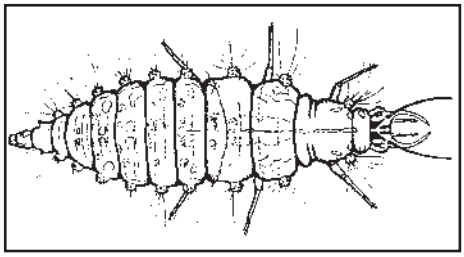
Insecticidal Soap—Woodstream (Safer®), 69 N. Locust St., Lititz, PA 17543-0327; 717-626-2125, woodstreampro.com; Harmony Farm Supply, 3244 Gravenstein Hwy, No. B, Sebastopol, CA 95472; 707-823-9125, harmonyfarm.com; See the list of Distributors in the first article.

Neem Oil—Certis (Triact®) 9145 Guilford Rd. Suite 175, Columbia, MD 21046; 301/604-7340, certususa,com. Agro Logistic (DeBug Turbo®, organic), PO Box 5799, Diamond Bar, CA 91765; 714-990-9220; agrologistic.com; See the list of Distributors in the first article.

Soybean Oil (Natur'l Oil®)—Stoller Enterprises, Inc., 4001 W. Sam Houston Pky N., Suite 100, Houston, TX 77043, 713-464-5580; stollerusa.com; See the list of Distributors in the first article.

*A more complete listing can be found in BIRC's *2015 Directory of Least-Toxic Pest Control Products* which is online at birc.org.

mandibles and start feeding. Eggs and larval mites are preferred food. One larval midge can eat 13 mites in 5 minutes and up to 380 mites in 17 days. Larvae are yellow, orange, or red (Quarles 1997). General predators such as the big-eyed bug, *Geocoris* sp., the minute pirate bug, *Orius* sp., and lacewing larvae, *Chrysoperla* spp. also help with biocontrol (Olkowski et al. 1991).



Lacewing larva, *Chrysoperla* sp.

Integrated Control

Less-toxic chemical controls such as insecticidal soap or horticultural oil are effective against mites. Heavier infestations may require frequent sprays of insecticidal soap 2-3 times a day for several days (Olkowski et al. 1991; Quarles 2005b). These mites can be controlled by application of neem oil containing azadirachtin. The neem oil will not kill the predatory mites so they can be applied at the same time. Neem is best applied to foliage, but predatory mites can be applied to mite populations in flowers. Predatory mites are also effective for the occasional infestation of greenhouse thrips or western flower thrips (Quarles 2006b; Bernardi et al. 2013; McPartland and Hillig 2003).

Conclusion

Mites on *Cannabis* can be managed by a combination of cultural controls, biocontrols, and least-toxic pesticides such soaps, oils and neem. Because marijuana is still illegal at the federal level, pesticides allowed for *Cannabis* pest control vary from state to state. Pesticides frequently allowed are biopesticides, soaps and oils. Pest management agencies in each state will answer questions about which pesticides are permitted (Cranshaw 2015).

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Masks Save Lives

The San Francisco Bay Area started a mandatory mask requirement for coronavirus on April 17, 2020. The U.S. still does not have a mask mandate for the whole country. If we compare infection rates and death rates for areas that have had a mask mandate since April 17 with that of the whole U.S., we find that masks could be having a profound effect on infection rates and death rates.

On September 9, 2020 about 1.19% of the population of eight SF Bay Area Counties had tested positive for coronavirus. Marin County was not included in the calculations because the high number of infections and deaths in San Quentin Prison were not representative of the general population and would have biased the results.

On that date 1.93% of the U.S. population had tested positive. The number of cases in the Bay Area as a percentage of the population were about 61% of those seen in the U.S. as a whole.

On that date 0.0143% of the population in the eight counties had died from coronavirus. The coronavirus had killed about 0.06% of the U.S. population by September 9. The percent of the population that had died in the eight Bay Area counties was 24.7% of the U.S. as a whole.

Death rates as a percentage of the population were about 75% less in the Bay Area. Although other factors might be in play, strict adherence to masks and other public health measures can be credited at least in part for the reduction.

Infection rates as a percentage of the population were reduced nearly 40% in the Bay Area. The reason for the difference between reduced infection rates (40%) and reduced death rates (75%) is unclear. One theory is that the masks reduce the total amount of virus inhaled, reducing the severity of the infection. —*Bill Quarles*

Managing Fungus Gnats on Indoor Plants

By William Quarles

If you have houseplants, you may be occasionally plagued by hordes of small flies. These flies dart about foliage, walk about nearby surfaces, and may appear on your windowsill, as they are attracted to light. Quite likely, these tiny flies are fungus gnats. Though they can be more of a nuisance than a threat to a home or an office containing a few plants, they can be serious pests in commercial greenhouses where the large number of plants produce a favorable situation for a population explosion.

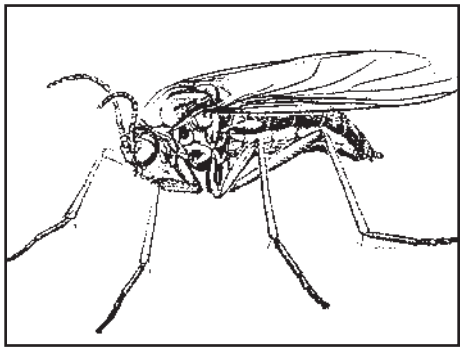
Major pests of floriculture are the species *Bradysia coprophila* and *B. impatiens* (Harris et al. 1996). The IPM methods described below minimize pesticide resistance and can provide excellent management of the pest.

Monitoring

To monitor for adult fungus gnats, yellow sticky traps are inexpensive and convenient. To make sticky traps more effective for monitoring fungus gnats, traps are sometimes oriented horizontally and close to the soil to catch adults emerging from pupae near the soil surface (Jagdale et al. 2004; Harris 1993).

Sticky traps will catch and remove adult fungus gnats, but do not monitor for larvae. A convenient monitoring method for the larvae is to embed a 1/2 inch (13 mm) thick slice of potato with about 1 inch (25 mm) diameter into the surface of the potting medium. Potatoes are removed after 48 hours and larvae are counted. Larvae are white or clear, about 1/4 inch (6 mm) long, and have black heads (Cabrera et al. 2003).

There may be no correlation between sticky trap catches and populations of the truly destructive life stages—the larvae. For instance,



Adult fungus gnat, *Bradysia* sp.

Harris et al. (1995) found no adult fungus gnats in sticky traps when the larval populations on potato slices were highest. When large numbers of flying adults are noticed, problems with larvae could be concurrent, or could be seen within a couple of weeks.

Cultural Controls

To discourage fungus gnats, water plants as little as possible (Cloyd and Dickinson 2005). If the top of the potting soil is covered with a thin layer (1/4-1/2 inch; 6-12 mm) of sand, females will be discouraged from egglaying. This can be an easy way to correct a problem involving a few plants growing at home (Hungerford 1916). Another physical treatment is soaking the growth medium in a soap solution. This approach has also been used to kill root-infesting mealybugs, and might also have some effect on larval western flower thrips that have dropped to the soil surface to pupate (Gibson and Ross 1940).

Sanitation

Sanitation is very important for fungus gnat management in greenhouses. Gnats can breed in soil or organic matter underneath the greenhouse benches (Ludwig et al. 2003). So, keeping areas beneath benches clean of plant debris, old plants, spilled potting mix and weeds will help discourage gnats. Screening with about the mesh size used to exclude leafminers will help keep immigrating fungus gnats out of greenhouses (Harris 1993). Covering soil underneath benches with plastic might discourage fungus gnats from laying eggs and may prevent pupation of larval western flower thrips.

Greenhouse production managers should make sure growth media and planting plugs are not contaminated with fungus gnat eggs and larvae (Cloyd and Zaborski 2004). The type of potting media is important. Composted hardwood bark media encourages fungus gnats more than some of the artificial media such as Metro Mix, Ball-Mix and Pro-Mix. Of the artificial media, gnats may lay eggs more frequently in Metro-Mix (Jagdale et al. 2004; Meers and Cloyd 2005).

Nematodes

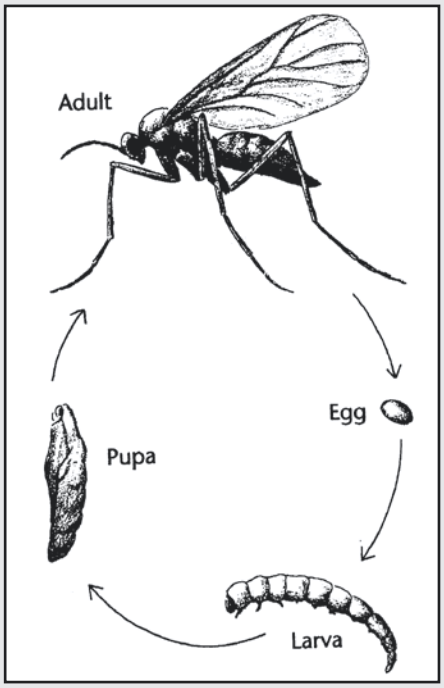
Commercially available nematodes such as *Steinernema feltiae* and *S. carpocapsae* are effective against fungus gnats (see Resources). Researchers have found that effectiveness varies with the nematode, plant species, growing medium, temperature, and timing of the application (Jagdale et al. 2004; Georgis et al. 2006).

Harris et al. (1995) tested *S. feltiae* (1.25 and 2.5 billion/ha*); S. carpocapsae* (1.25 and 2.5 billion/ha); kinoprene (Enstar II), *Bacillus thuringiensis israelensis* (BTI), and diazinon. Treatments were in pots containing Metro Mix and poinsettias, *Euphorbia pulcherrima*. Effects were monitored with potato slices for larvae and sticky traps for adults. The most effective treatment was *S. feltiae* (2.5 billion/ha). Fungus gnat eggs were not attacked, mortality was highest for 2nd and 4th larval instars, and about 1/3 of the pupae were infected. Nematodes can give longterm protection, since they can remain active in the soil mix for up to 90 days.

Box A. Biology and Damage

Many fungus gnat species have similar characteristics. The description below is for *Bradysia coprophila*. Fungus gnat adults are all very small, sooty-gray or nearly black, long-legged, slender flies, commonly called "gnats," measuring about 1/8 to 1/10 inch (2.5 to 3.2 cm) in length. They are poor fliers, but can run around swiftly on the surface of a plant or the growing medium. They have a distinctive "Y" shaped vein on their wings. Females move around less than males, hanging out on the undersides of leaves and near the surface of the planting medium (Harris et al. 1996).

Life stages are egg, 4 larval stages, pupa, and adult. Adults live about 3-7 days and generally do not feed. Mating is pheromone driven, and tiny eggs (1/100in; 0.25 mm) are laid in clusters on the surface of the planting medium near plant stems. The number of eggs can range from 75-150. Females are attracted by soils and soil mixes with high organic content and moisture (Harris et al. 1996).



Fungus gnat life stages

Eggs hatch in about four days. Larvae are white or translucent with black heads. Mature larvae are about 1/4-inch (6 mm) long. They feed on the fungi and algae on pot surfaces, under benches and bench surfaces. Larvae prefer to eat fungi, but will feed on healthy or diseased plants. In containers, larvae feed on root hairs and roots in the upper strata (upper one inch; 2.5 cm) of the pots, and they later burrow into the stems and leaves, causing eventual destruction of the plants. In mushroom houses larvae tunnel into the mushrooms, effectively destroying crops if they are widespread. Both adults and larvae can spread fungal disease pathogens (Harris et al. 1996). The pupae are about "one-sixth of an inch long, pale yellow, with darker wing pads and still darker head…just prior to the adult's emergence, the pupa works its way to the surface of the soil to allow the escape of the gnat or adult" (Weigel and Sasscer 1936).

Temperature is a factor in development. Gnats do not develop below 10°C (50°F) or above 35°C (95°F). From egg to adult at 18°C (64.4°F) takes 18-23 days; at 23°C (73.4°F), it takes 27-33 days. Altogether, they spend roughly 3 days as adults, 4 days as eggs, 10-14 days as larvae, and 3 days as pupae (Harris et al. 1996).

In glasshouse grown fuchsias, *Steinernema feltiae* applied by hydraulic sprayer at 780,000 nematodes/m^2 (7.8 billion/ha) resulted in a decrease of 92% in the numbers of *Bradysia* sp. adults emerging from the containerized growth medium. The nematodes were well distributed in the potted compost medium, and they persisted over the 64-day experimental period (Gouge and Hauge 1995).

Predatory Mites

Geolaelaps introduced at a high rate of 6000 mites/plant to the sawdust substrate of hydroponically grown greenhouse cucumbers reduced numbers of larvae and adults of *Bradysia* spp. over a 10-week period. About 1600 mites/plant also reduced emergence of adults of western flower thrips to about 30% of that in the controls over a 40-day period. An inoculative introduction of 125 mites/plant to cucumber plants in selected rows in a commercial greenhouse reduced peak numbers of *Bradysia* spp. to about 20% of those in untreated rows (Gillespie and Quiring 1990).

In another experiment, the predatory mite *Hypoaspis miles* [*Stratiolaelaps miles*] was released from laboratory cultures into young crops of pot-grown Cyclamen and poinsettias in six small greenhouses in the UK as a biological control agent against *Bradysia* spp. In both crops, rates of 55 mites/pot and above gave satisfactory control of sciarids with no later resurgence of the pest. Mites persisted in the pots until the end of the trial. In separate tests, *S. miles* was found mostly in the top 1 cm (0.4 in) of compost and persisted for up to 7 weeks in the absence of food (Chambers et al. 1993).

These predatory mites develop faster at warmer temperature, lay 2-3 eggs a day, and are relatively long lived. With food, 60% of males and females can survive for nearly 5 months. All larval instars of sciarids are attacked by mites, but smaller larvae are preferred. Egg predation is negligible, and pupae are not attacked (Wright and Chambers 1994).

This mite is commercially available as an augmentative control for release in greenhouse environments (see Resources). The species name has seen several shifts since 1988. It was originally called *Hypoaspis miles* or *Geolaelaps miles*. Then, the name was changed to *Stratiolaelaps miles*. Finally, mite taxonomists decided that commercial mites were actually *S. scimitus* (Cabrera et al. 2005). Most commercial suppliers still list it as *Geolaelaps* or *Hypoaspis* (BIRC 2015).

Bacillus thuringiensis israelensis (BTI)

Mixing *Bacillus thuringiensis* var. *israelensis* (BTI) with potting soil can kill fungus gnat larvae that feed there. The easiest way to do this is to mix it with water and drench the soil. Valent markets BTI for fungus gnats as Gnatrol® (see Resources).

BTI works best on small fungus gnat larvae. Cloyd and Dickinson (2006) found that BTI is not effective on the 2nd and 3rd larval instars of the fungus gnat, *Bradysia* sp. Greenhouse producers must make applications before fungus gnat populations build up and before overlapping generations develop (Cloyd and Dickinson 2006).

Insect Growth Regulators (IGRs)

Drenches of Insect Growth Regulators (IGRs) can also help control fungus gnat larvae. Organic formulations of neem oil containing azadirachtin (Garden Essentials and Debug Turbo) are commercially available. Other IGRs effective for fungus gnats include diflubenzuron (Adept®), methoprene (Apex® 5E), kinoprene (Enstar®), pyriproxifen (Distance®) and others. On the plus side, IGRs are generally compatible with nematodes and predatory mites (Ludwig and Oetting 2001; Ludwig et al. 2003; Parrella and Murphy 1998). On the downside, IGRs and other chemicals can produce signs of phytotoxicity (Kim et al. 2004).

Since growth-regulators work on immature insects, and have no effect on adults, some adults may linger for a while. But the pest population as a whole is doomed, since young larvae will not live to reproduce (Olkowski 1988).

Conclusion

Fungus gnats can be controlled by IPM methods. In the home environment, less frequent watering or covering the top of containerized growth media with a layer of sand might be enough. In greenhouses, biocontrols are probably the best solution. If monitoring shows a developing problem, nematodes or predatory mites added to growth media can provide protection against fungus gnats and other herbivorous pests throughout an entire growing cycle. There is no danger of resistance developing and no problems with phototoxicity. If the pest is not chemically resistant and there are no problems with phytotoxicity, IGRs may represent a practical solution. Broadspectrum insecticides should be avoided.

Resources*

Biocontrols

BTI (Gnatrol®)—Valent USA, PO Box 8025, Walnut Creek, CA 94596-8025; 925-256-2700, valentbiosciences.com, see Resources in the first article for distributors

Nematodes (*Steinernema feltiae*; *S. carpocapsae*)— BioLogic, PO Box 177, Willow Hill, PA 17271; 717-349-2789, biologico.com; Hydro-Gardens (see below), Rincon-Vitova Insectaries Inc., PO Box 1555, Ventura, CA 93002; 805/643-5407' rinconvitova.com; see Resources in the first article for distributors

Predatory Mites (*Hypoaspis miles, Stratiolaelaps*)—Applied Bionomics Ltd., 11074 W. Saanich Rd., Sidney, BC, CANADA V8L 5P5; 250-656-2123, appliedbio-nomics.com; see Resources in the first article for distributors

Insect Growth Regulators

Azadirachtin—Certis (Azatin®), 9145 Guilford Rd. Suite 175, Columbia, MD 21046; 301-604-7340; certisusa.com; Agro Logistic (DeBug Turbo®, organic), PO Box 5799, Diamond Bar, CA 91765; 714-990-9220; agrologistic.com

Kinoprene (Enstar®)—Wellmark International, 1501 E. Woodfield Road, Suite 200 West, Schaumberg, IL 60173; 800-248-7763, zoecon.com

Methoprene (Apex®)—Wellmark International (see above)

Pyriproxifen (Distance®)—Valent (see above)

Traps

BioQuip Products, 2321 Gladwick Street, Rancho Dominguez, CA 90220; 310/667-8800, bioquip.com; Hydro-Gardens, Inc., PO Box 25845, Colorado Springs, CO 80936; 719-495-2266, hydro-gardens.com; See see Resources in the first article for distributors.

*For a list of other suppliers, Check BIRC's *2015 Directory of Least-Toxic Pest Control Products* which is online at birc.org

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