Commercially Available* Biological Control Agents for Common Greenhouse Insect Pests


By: Heidi Wollaeger and Dr. Dave Smitley, Michigan State University Extension and Dr. Raymond Cloyd, Kansas State University
# Commercially Available Biological Control Agents for Aphids

## Parasitoids

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Aphelinus abdominalis</td>
<td>Aphidius colemani</td>
<td>Aphidius ervi</td>
<td>Aphidius matricariae</td>
<td>Aphidoletes aphidimyza</td>
<td>Adalia bipunctata</td>
<td>Chrysopa carnea</td>
<td>Chrysoperla rufilabris</td>
<td>Hippodamia convergens</td>
</tr>
</tbody>
</table>

- **Parasitizes** a wide-range of aphid species.
- **Can tolerate** higher temperatures than most *Aphidius* species.
- **Slower to establish** than *Aphidius* species.
- **Release** 2 to 4 adult wasps per 10 square feet weekly or until 80-90% of the aphids are parasitized.

- **Parasitizes** smaller aphids such as green peach and melon aphid.
- **Can be reared** using banker plants (oat or wheat) infested with bird-cherry oat aphid (use a minimum of 4 banker plants per acre).
- **May be sold as a mixture with** *Aphidius colemani*.
- **Release** 400 to 2,000 adults per acre.

- **Parasitizes** larger aphids such as foxglove and potato aphid.
- **May be sold as a mixture with** *Aphidius colemani*.
- **Release** 400 to 2,000 adults per acre.

- **Parasitizes** green peach aphids.
- **Active at cooler temperatures** (50°F to 85°F; optimum 77°F) than *Aphidius colemani* (Optimum: 86°F).
- **Release** 400 to 2,000 adults per acre.

- **Larval stages** prey on all aphid species encountered in greenhouses.
- **Most effective at temperatures** between 68 and 80°F and a relative humidity between 70 and 80%.
- **Primarily active** at night.
- **Mainly used** against high aphid populations.

- **Both larvae and adult feed on many different aphid species.**
- **Used when aphid populations are high.**
- **Adults typically attempt to leave the greenhouse after release. Therefore, make releases in the evening.**
- **Release adults every 2 to 3 weeks.**

- **Larvae feed primarily on aphids but may also feed on mealybugs.**
- **Can consume up to 425 aphids per week.**
- **Release 5 to 10 eggs per plant or 1,000 eggs per 200 square feet.**

- **Tolerates a higher relative humidity (>75%) than *Chrysopa carnea*.**
- **Can consume up to 300 aphids per week.**
- **Release 5 to 10 eggs per plant or 1,000 eggs per 200 square feet.**

- **Feeds on 2,000 aphids during their lifetime.**
- **Multiple releases are usually required.**
- **Most effective when aphid numbers are high.**
- **Adults typically attempt to leave the greenhouse after release. Therefore, make releases in the evening.**
- **Release adults every 2 to 3 weeks.**

*All release rates are benchmarks—they will vary with crop type and infestation level.*

*Photo credits: 1Koppert Biological Systems, 2Bugwood.org or 3Evergreen Growers Supply.*

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# Commercially Available Biological Control Agents for Western Flower Thrips

## Predators

<table>
<thead>
<tr>
<th><strong>Amblyseius swirskii</strong></th>
<th><strong>Neoseiulus (=Amblyseius) cucumeris</strong></th>
<th><strong>Orius spp.</strong></th>
<th><strong>Stratiolaelaps scimitus</strong></th>
</tr>
</thead>
</table>

- **Predatory Mite**
- Feeds on both 1st and 2nd instar larvae.
- Tolerates higher temperatures than *Neoseiulus cucumeris*.
- Will also feed on the eggs and nymphs of whiteflies.
- Feeds on pollen in the absence of prey.
- More expensive than *Neoseiulus cucumeris*.

- **Predatory Mite**
- Most widely used predatory mite for western flower thrips.
- Feeds on the 1st instar larvae.
- Make releases early in the crop production cycle.
- Active at temperatures between 70 and 75 °F; prefers a relative humidity around 65%.

- **Minute Pirate Bug**
- Feed on larvae and adults of western flower thrips.
- May also feed on aphids and whiteflies.
- Can be used with ornamental pepper plants serving as banker plants (example: ‘Purple Flash,’ 100 per acre).
- More expensive than using *Neoseiulus cucumeris*.
- Most effective when temperatures are >60° F and day length is >12 hours.
- Release 0.5 to 1 per square foot.

- **Soil-dwelling Predatory Mite**
- Adults may kill up to 30 prey, including western flower thrips pupae or fungus gnat larvae, per day.
- Release 1,000 to 2,000 per square foot.

## Beneficial Nematode

<table>
<thead>
<tr>
<th><strong>Steinernema feltiae</strong></th>
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</thead>
</table>

- **Beneficial Nematode**
- Apply as either a foliar spray or drench to the growing medium. Drench applications target the pupa stage.
- Requires soil temperatures of 50 to 80° F to be effective.
- Apply early in the morning or late in the evening.
- Water crops both before after application to increase efficacy.
- For foliar sprays, apply 50 million per 1,000 square feet.
- Remove screens before making applications.

*All release rates are benchmarks – they will vary with crop type and infestation level.*

*Photo credits: *Koppert Biological Systems, Bugwood.org or Evergreen Growers Supply.*

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Commerciably Available Biological Control Agents for Twospotted Spider Mites

Predators

**Amblyseius andersonii**
- Feeds on alternative prey if twospotted spider mites are absent.
- Active at temperatures between 43 and 46° F.
- Release 10 mites per square foot.

**Amblyseius californicus**
- Slower acting than other predatory mites such as *Phytoseiulus persimilis*.
- More effective at higher temperatures (>80° F) and a lower relative humidity than *Phytoseiulus persimilis*.
- Used for long-term crops under warm, dry conditions.
- Release 10 mites per square foot.

**Amblyseius fallacis**
- Tolerates cooler temperatures than most predatory mites.
- Feeds on pollen in the absence of prey.
- Release 10 mites per square foot.

**Feltiella acarisuga**
- Larvae feed on all life stages of the twospotted spider mite.
- Females lay eggs near colonies of the twospotted spider mite.
- Adults fly around and can spread among a crop.
- Most effective when used in combination with other biological control agents.
- Optimal conditions are 68 to 80° F and a relative humidity >60%.
- Does not perform well when temperatures are >85° F.
- Release 10 adults per square foot.

**Galendromus occidentalis**
- Smaller than *Phytoseiulus persimilis*.
- Most effective at higher temperatures and a relative humidity between 40 and 80%.
- Survives well when twospotted spider mite populations are low.
- Feeds on twospotted spider mite, broad mite and cyclamen mite.
- Release 10 mites per square foot.

**Phytoseiulus persimilis**
- Main predatory mite used against the twospotted spider mite.
- Most effective at temperatures between 70 and 80° F and a relative humidity >60%.
- Does not perform well when temperatures are >85° F.
- At optimal temperatures, develops twice as fast as twospotted spider mite.
- Release 10 mites per square foot.

**Stethorus punctillum**
- Both larvae and adults feed on all life stages of twospotted spider mites.
- Release 10 adults per square foot.

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### Commercially Available Biological Control Agents for Fungus Gnats

#### Predators

<table>
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<tr>
<th>Predator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dalotia coriaria</td>
<td>Apply directly onto the surface of the growing medium.</td>
</tr>
<tr>
<td>Stratiolaelaps scimitus</td>
<td>Larvae and adults are predators and highly mobile.</td>
</tr>
<tr>
<td>Cryptolaemus montrouzieri</td>
<td>Both adults and larvae are very sensitive to light.</td>
</tr>
<tr>
<td></td>
<td>Adults can fly and spread within a greenhouse.</td>
</tr>
<tr>
<td></td>
<td>Release 1 adult per 10 square feet.</td>
</tr>
</tbody>
</table>

#### Predatory Rove Beetle
- Adults may kill 15 to 30 fungus gnat larvae per day.
- Feeds on eggs, larvae and pupae of fungus gnats.
- Apply directly to the growing medium.
- Previously known as Hypoaspis miles.
- May be used in combination with Steinernema feltiae.
- Release 1,000 to 2,000 mites per square foot.

#### Predatory Mite
- May be effective up to 4 weeks.
- Attacks the larval stages of fungus gnats.
- Requires a moist growing medium and growing medium temperature between 50 and 86°F.
- Apply early in the morning or late in the evening.
- Irrigate before and after application.
- Apply 50 million per 1,000 square feet as a drench.

#### Predatory Nematode
- Feeds on eggs, larvae and pupae of fungus gnats.
- Apply directly to the growing medium.
- Previously known as Steinernema feltiae.
- Release 1,000 to 2,000 mites per square foot.
- May be used in combination with Steinernema feltiae.
- Release 1,000 to 2,000 mites per square foot.
- May be effective up to 4 weeks.
- Attacks the larval stages of fungus gnats.
- Requires a moist growing medium and growing medium temperature between 50 and 86°F.
- Apply early in the morning or late in the evening.
- Irrigate before and after application.
- Apply 50 million per 1,000 square feet as a drench.

### Commercially Available Biological Control Agents for Mealybugs

#### Parasitoids

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<thead>
<tr>
<th>Parasitoid</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Leptomastix dactylopii</td>
<td>Females attack only the 3rd and 4th instars of the citrus mealybug.</td>
</tr>
<tr>
<td>Anagyrus pseudococci</td>
<td>Attacks both vine and citrus mealybugs.</td>
</tr>
<tr>
<td>Cryptolaemus montrouzieri</td>
<td>Both larvae and adults feed on all mealybug life stages.</td>
</tr>
<tr>
<td></td>
<td>Not effective at temperatures &lt;50°F.</td>
</tr>
<tr>
<td></td>
<td>Most active under warm, sunny conditions.</td>
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<tr>
<td></td>
<td>Less effective on tomato and other crops with glandular trichomes (hairs).</td>
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<tr>
<td></td>
<td>Repeated releases (introductions) are usually required.</td>
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<tr>
<td></td>
<td>Release 1 to 2 larvae or adults per square foot.</td>
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</tbody>
</table>

**All release rates are benchmarks — they will vary with crop type and infestation level.**

**Photo credits:** 1 Koppert Biological Systems, 2 Bugwood.org, 3 Evergreen Growers Supply, or used with permission from 4 Kent M. Daane, University of California.

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# Commercially Available Biological Control Agents for Whiteflies

## Parasitoids

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<tr>
<th><strong>Encarsia formosa</strong></th>
<th><strong>Eretmocerus eremicus</strong></th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Image of Encarsia formosa" /></td>
<td><img src="image2.png" alt="Image of Eretmocerus eremicus" /></td>
</tr>
<tr>
<td><strong>Parasitic Wasp</strong></td>
<td><strong>Parasitic Wasp</strong></td>
</tr>
<tr>
<td>◆ Most widely used parasitoid for greenhouse whiteflies.</td>
<td>◆ Parasitizes sweet potato and greenhouse whitefly.</td>
</tr>
<tr>
<td>◆ Most effective at higher temperatures (&gt;70° F).</td>
<td>◆ Females prefer laying eggs into 2nd or 3rd nymphal instars.</td>
</tr>
<tr>
<td>◆ May be ineffective on plants with honeydew (clear, sticky liquid).</td>
<td>◆ Tolerates higher temperatures and does more host-feeding than <em>Encarsia formosa</em>.</td>
</tr>
<tr>
<td>◆ Make releases when greenhouse whitefly populations are low.</td>
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</tr>
<tr>
<td>◆ Adult females will host feed on nymphs.</td>
<td>◆ Adult females will host feed on nymphs.</td>
</tr>
<tr>
<td>◆ Release parasitoids every 1 to 2 weeks.</td>
<td>◆ Release parasitoids every 1 to 2 weeks.</td>
</tr>
<tr>
<td>◆ Release 2 wasps per 15 square feet every 1-2 weeks for prevention.</td>
<td>◆ Release 2 wasps per 15 square feet every 1-2 weeks for prevention.</td>
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</tbody>
</table>

## Predators

<table>
<thead>
<tr>
<th><strong>Amblyseius swirskii</strong></th>
<th><strong>Delphastus catalinae</strong></th>
<th><strong>Dicyphus hesperus</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Image of Amblyseius swirskii" /></td>
<td><img src="image4.png" alt="Image of Delphastus catalinae" /></td>
<td><img src="image5.png" alt="Image of Dicyphus hesperus" /></td>
</tr>
<tr>
<td><strong>Predatory Mite</strong></td>
<td><strong>Predatory Beetle</strong></td>
<td><strong>Predatory Mirid Bug</strong></td>
</tr>
<tr>
<td>◆ Feeds on the eggs and nymphs of whiteflies and larvae of western flower thrips.</td>
<td>◆ Most effective when whitefly populations are high.</td>
<td>◆ Feeds on greenhouse whitefly.</td>
</tr>
<tr>
<td>◆ May also feed on pollen in the absence of prey.</td>
<td>◆ Can feed on &gt;150 whitefly eggs per day.</td>
<td>◆ Reared on mullein banker plants: requires a minimum of 8 weeks to establish a sufficient population.</td>
</tr>
<tr>
<td>◆ May also feed on pollen in the absence of prey.</td>
<td>◆ Will not attack parasitized whitefly.</td>
<td>◆ May be sensitive to pesticide residues.</td>
</tr>
</tbody>
</table>

*All release rates are benchmarks – they will vary with crop type and infestation level.*

*Photo credits: 1Bugwood.org, 2Evergreen Growers Supply, 3Wikimedia Commons or 4Biobest.*