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>
<thead>
<tr>
<th>Aphelinus abdominalis</th>
<th>Aphidius colemani</th>
<th>Aphidius ervi</th>
<th>Aphidius matricariae</th>
<th>Aphidoletes aphidimyza</th>
<th>Adalia bipunctata</th>
<th>Chrysopa carnea</th>
<th>Chrysoperla ryfilabris</th>
<th>Hippodamia convergens</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Parasitoid 1" /></td>
<td><img src="image2.png" alt="Parasitoid 2" /></td>
<td><img src="image3.png" alt="Parasitoid 3" /></td>
<td><img src="image4.png" alt="Parasitoid 4" /></td>
<td><img src="image5.png" alt="Parasitoid 5" /></td>
<td><img src="image6.png" alt="Parasitoid 6" /></td>
<td><img src="image7.png" alt="Parasitoid 7" /></td>
<td><img src="image8.png" alt="Parasitoid 8" /></td>
<td><img src="image9.png" alt="Parasitoid 9" /></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.

## Predators

<table>
<thead>
<tr>
<th>Aphidoletes aphidimyza</th>
<th>Adalia bipunctata</th>
<th>Chrysopa carnea</th>
<th>Chrysoperla ryfilabris</th>
<th>Hippodamia convergens</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Predator 1" /></td>
<td><img src="image2.png" alt="Predator 2" /></td>
<td><img src="image3.png" alt="Predator 3" /></td>
<td><img src="image4.png" alt="Predator 4" /></td>
<td><img src="image5.png" alt="Predator 5" /></td>
</tr>
</tbody>
</table>

- **Both larvae and adult feed on** many different aphid species.
- **Used when aphid** populations are high.
- **Multiple releases** are usually required.
- **Most effective** when aphid numbers are high.
- **Tolerates a higher relative humidity (>75%)** than *Chrysopa carnea*.
- **Feeds on 2,000** aphids during their lifetime.
- **Can consume up to** 425 aphids per week.
- **Used when aphid** populations are high.
- **Can consume up to** 300 aphids per week.
- **Release** 5 to 10 eggs per plant or 1,000 eggs per 200 square feet.

*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>Predator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amblyseius swirskii</strong></td>
<td>Feeds on both 1(^{st}) and 2(^{nd}) instar larvae.</td>
</tr>
<tr>
<td></td>
<td>Tolerates higher temperatures than <em>Neoseiulus cucumeris</em>.</td>
</tr>
<tr>
<td></td>
<td>Will also feed on the eggs and nympha of whiteflies.</td>
</tr>
<tr>
<td></td>
<td>Feeds on pollen in the absence of prey.</td>
</tr>
<tr>
<td></td>
<td>More expensive than <em>Neoseiulus cucumeris</em>.</td>
</tr>
<tr>
<td><strong>Neoseiulus (=Amblyseius) cucumeris</strong></td>
<td>Most widely used predatory mite for western flower thrips.</td>
</tr>
<tr>
<td></td>
<td>Feeds on the 1(^{st}) instar larvae.</td>
</tr>
<tr>
<td></td>
<td>Make releases early in the crop production cycle.</td>
</tr>
<tr>
<td></td>
<td>Active at temperatures between 70 and 75 °F; prefers a relative humidity around 65%.</td>
</tr>
<tr>
<td><strong>Orius spp.</strong></td>
<td>Feed on larvae and adults of western flower thrips.</td>
</tr>
<tr>
<td></td>
<td>May also feed on aphids and whiteflies.</td>
</tr>
<tr>
<td></td>
<td>Can be used with ornamental pepper plants serving as banker plants (example: ‘Purple Flash,’ 100 per acre).</td>
</tr>
<tr>
<td></td>
<td>More expensive than using <em>Neoseiulus cucumeris</em>.</td>
</tr>
<tr>
<td><strong>Stratiolaelaps scimitus</strong></td>
<td>Adults may kill up to 30 prey, including western flower thrips pupae or fungus gnat larvae, per day.</td>
</tr>
<tr>
<td></td>
<td>Release 1,000 to 2,000 per square foot.</td>
</tr>
<tr>
<td><strong>Orius spp.</strong></td>
<td>Most effective when temperatures are &gt;60° F and day length is &gt;12 hours.</td>
</tr>
<tr>
<td></td>
<td>Release 0.5 to 1 per square foot.</td>
</tr>
</tbody>
</table>

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

## Beneficial Nematode

<table>
<thead>
<tr>
<th>Nematode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steinernema feltiae</strong></td>
<td>Apply as either a foliar spray or drench to the growing medium. Drench applications target the pupa stage.</td>
</tr>
<tr>
<td></td>
<td>Requires soil temperatures of 50 to 80° F to be effective.</td>
</tr>
<tr>
<td></td>
<td>Apply early in the morning or late in the evening.</td>
</tr>
<tr>
<td></td>
<td>Water crops both before after application to increase efficacy.</td>
</tr>
<tr>
<td></td>
<td>For foliar sprays, apply 50 million per 1,000 square feet.</td>
</tr>
<tr>
<td></td>
<td>Remove screens before making applications.</td>
</tr>
</tbody>
</table>

*Photo credits: 1 Koppert Biological Systems, 2 Bugwood.org or 3 Evergreen Growers Supply.*
Commercially 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%.
- 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 adults 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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*Photo credits: ¹Koppert Biological Systems, ²Evergreen Growers Supply, ³Wikimedia Commons or ⁴Biobest.*

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### Commercially Available Biological Control Agents for Fungus Gnats

#### Beneficial Nematode
- **Steinernema feltiae**
  - Adults 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.
  - May be used in combination with *Steinernema feltiae*.
  - Release 50 million per 1,000 square feet as a drench.

#### Predators
- **Dalotia coriaria**
  - Apply directly onto the surface of the growing medium.
  - Larvae and adults are predators and highly mobile.
  - Both adults and larvae are very sensitive to light.
  - Adults can fly and spread within a greenhouse.
  - Release 1 adult per 10 square feet.

- **Stratiolaelaps scimitus**
  - 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.

### Commercially Available Biological Control Agents for Mealybugs

#### Predators
- **Cryptolaemus montrouzieri**
  - Both larvae and adults feed on all mealybug life stages.
  - Not effective at temperatures <50° F.
  - Most active under warm, sunny conditions.
  - Less effective on tomato and other crops with glandular trichomes (hairs).
  - Repeated releases (introductions) are usually required.
  - Release 1 to 2 larvae or adults per square foot.

#### Parasitoids
- **Leptomastix dactylopii**
  - Females attack only the 3rd and 4th instars of the citrus mealybug.
  - Effective at low mealybug populations.
  - Release 5 parasitoid adults per 10 square feet.

- **Anagyrus psedudococci**
  - Attacks both vine and citrus mealybugs.
  - Females attack 2nd through 4th instars.
  - Optimal temperature is around 86° F.

#### Predatory Mite
- **Steinernema feltiae**
  - 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.

#### Parasitic Wasp
- **Leptomastix dactylopii**
  - Females attack 2nd through 4th instars.
  - Optimal temperature is around 86° F.

#### Predatory Beetle
- **Cryptolaemus montrouzieri**
  - Both larvae and adults feed on all mealybug life stages.
  - Not effective at temperatures <50° F.
  - Most active under warm, sunny conditions.
  - Less effective on tomato and other crops with glandular trichomes (hairs).
  - Repeated releases (introductions) are usually required.
  - Release 1 to 2 larvae or adults per square foot.

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


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# Commercially Available Biological Control Agents for Whiteflies

## Parasitoids

<table>
<thead>
<tr>
<th><strong>Encarsia formosa</strong></th>
<th><strong>Eretmocerus eremicus</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image 1" /></td>
<td><img src="image2.png" alt="Image 2" /></td>
</tr>
</tbody>
</table>

- Most widely used parasitoid for greenhouse whiteflies.
- Most effective at higher temperatures (>70° F).
- May be ineffective on plants with honeydew (clear, sticky liquid).
- Make releases when greenhouse whitefly populations are low.
- Adult females will host feed on nymphs.
- Release parasitoids every 1 to 2 weeks.
- Release 2 wasps per 15 square feet every 1-2 weeks for prevention.

## 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 3" /></td>
<td><img src="image4.png" alt="Image 4" /></td>
<td><img src="image4.png" alt="Image 4" /></td>
</tr>
</tbody>
</table>

- Feeds on the eggs and nymphs of whiteflies and larvae of western flower thrips.
- May also feed on pollen in the absence of prey.
- Most effective when whitefly populations are high.
- Can feed on >150 whitefly eggs per day.
- Will not attack parasitized whitefly.
- Feeds on greenhouse whitefly.
- Reared on mullein banker plants: requires a minimum of 8 weeks to establish a sufficient population.

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