












Commercially Available* Biological Control Agents for Common Greenhouse Insect Pests

***Commercially available in the United States. Updated November 2015. Bulletin 3299.**

Commercially Available Biological Control Agents for Aphids

Parasitoids

Predators

<i>Aphelinus abdominalis</i>	<i>Aphidius colemani</i>	<i>Aphidius ervi</i>	<i>Aphidius matricariae</i>	<i>Aphidoletes aphidimyza</i>	<i>Adalia bipunctata</i>	<i>Chrysopa carnea</i>	<i>Chrysoperla rhyllabris</i>	<i>Hippodamia convergens</i>
								
Parasitic Wasp	Parasitic Wasp	Parasitic Wasp	Parasitic Wasp	Predatory Gall Midge	Ladybird Beetle	Green Lacewing	Green Lacewing	Ladybird Beetle
<ul style="list-style-type: none"> ◆ Parasitizes a wide-range of aphid species. ◆ Can tolerate higher temperatures than most <i>Aphidius</i> species. ◆ Slower to establish than <i>Aphidius</i> species. ◆ Release 2 to 4 adult wasps per 10 square feet weekly or until 80-90% of the aphids are parasitized. 	<ul style="list-style-type: none"> ◆ 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 <i>Aphidius colemani</i>. ◆ Release 400 to 2,000 adults per acre. ◆ May be sold as a mixture with <i>Aphidius ervi</i>. ◆ Release 400 to 2,000 adults per acre. 	<ul style="list-style-type: none"> ◆ Parasitizes larger aphids such as foxglove and potato aphid. ◆ May be sold as a mixture with <i>Aphidius colemani</i>. ◆ Release 400 to 2,000 adults per acre. 	<ul style="list-style-type: none"> ◆ Parasitizes green peach aphids. ◆ Active at cooler temperatures (50°F to 85°F; optimum 77°F) than <i>Aphidius colemani</i> (Optimum: 86°F). ◆ Release 400 to 2,000 adults per acre. 	<ul style="list-style-type: none"> ◆ 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. 	<ul style="list-style-type: none"> ◆ 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. 	<ul style="list-style-type: none"> ◆ 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. 	<ul style="list-style-type: none"> ◆ Tolerates a higher relative humidity (>75%) than <i>Chrysopa carnea</i>. ◆ Can consume up to 300 aphids per week. ◆ Release 5 to 10 eggs per plant or 1,000 eggs per 200 square feet. 	<ul style="list-style-type: none"> ◆ 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.




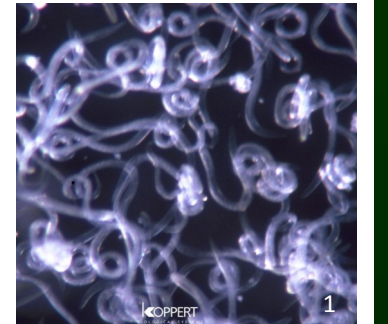
***All release rates are benchmarks – they will vary with crop type and infestation level.**

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

Commercially Available Biological Control Agents for Western Flower Thrips

Predators

Beneficial Nematode

<i>Amblyseius swirskii</i>	<i>Neoseiulus</i> (= <i>Amblyseius</i>) <i>cucumeris</i>	<i>Orius</i> spp.	<i>Stratiolaelaps scimitus</i>	<i>Steinernema feltiae</i>
				
Predatory Mite	Predatory Mite	Minute Pirate Bug	Soil-dwelling Predatory Mite	Beneficial Nematode
<ul style="list-style-type: none"> ◆ Feeds on both 1st and 2nd instar larvae. ◆ Tolerates higher temperatures than <i>Neoseiulus cucumeris</i>. ◆ Will also feed on the eggs and nymphs of whiteflies. ◆ Feeds on pollen in the absence of prey. ◆ More expensive than <i>Neoseiulus cucumeris</i>. 	<ul style="list-style-type: none"> ◆ 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%. 	<ul style="list-style-type: none"> ◆ 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 <i>Neoseiulus cucumeris</i>. ◆ Most effective when temperatures are >60° F and day length is >12 hours. ◆ Release 0.5 to 1 per square foot. 	<ul style="list-style-type: none"> ◆ 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. 	<ul style="list-style-type: none"> ◆ 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.**

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By: Heidi Wollaeger and Dr. Dave Smitley, Michigan State University Extension, and Dr. Ray Cloyd, Kansas State University

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Commercially Available Biological Control Agents for Twospotted Spider Mites

Predators

Amblyseius andersonii



Amblyseius californicus



Amblyseius fallacis



Feltiella acarisuga



Galendromus occidentalis



Phytoseiulus persimilis



Stethorus punctillum



Predatory Mite

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

Predatory Mite

- ◆ 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.

Predatory Mite

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

Predatory Gall Midge

- ◆ 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.

Predatory Mite

- ◆ 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.

Predatory Mite

- ◆ 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.

Predatory Beetle

- ◆ 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

Predators

Dalotia coriaria



Predatory Rove Beetle

- ◆ 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.

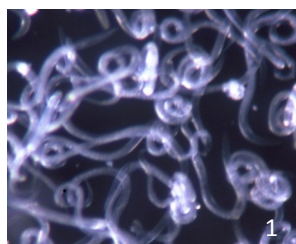
Stratiolaelaps scimitus



Predatory Mite

- ◆ 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.

Steinernema feltiae



Beneficial Nematode

- ◆ 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.

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

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Commercially Available Biological Control Agents for Mealybugs

Parasitoids

Predators

Leptomastix dactylopii



Parasitic Wasp

- ◆ 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 pseudococci



Parasitic Wasp

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

Cryptolaemus montrouzieri



Predatory Beetle

- ◆ 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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Commercially Available Biological Control Agents for Whiteflies

Parasitoids

Predators

Encarsia formosa



Eretmocerus eremicus



Amblyseius swirskii



Delphastus catalinae



Dicyphus hesperus



Parasitic Wasp

- ◆ 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.

Parasitic Wasp

- ◆ Parasitizes sweet potato and greenhouse whitefly.
- ◆ Females prefer laying eggs into 2nd or 3rd nymphal instars.
- ◆ Tolerates higher temperatures and does more host-feeding than *Encarsia formosa*.

Predatory Mite

- ◆ Feeds on the eggs and nymphs of whiteflies and larvae of western flower thrips.
- ◆ May also feed on pollen in the absence of prey.

Predatory Beetle

- ◆ Most effective when whitefly populations are high.
- ◆ Can feed on >150 whitefly eggs per day.
- ◆ Will not attack parasitized whitefly.
- ◆ May be sensitive to pesticide residues.

Predatory Mirid Bug

- ◆ Feeds on greenhouse whitefly.
- ◆ Reared on mullein banker plants: requires a minimum of 8 weeks to establish a sufficient population.

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