RINCON-VITOVA
INSECTARIES, INC.

Biocontrol Solutions for Greenhouses and Nurseries

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Biological control with beneficial insects makes dollars and sense. Costs of sprays, scheduling sprays when people are not present, managing residue and resistance problems, etc. can all be avoided. A savings of 50 to 75 percent in pest control costs is often reported in the first two years of transition to predominantly biological control. Plants live longer when not weakened by chemicals. Public and worker liability risks, even insurance costs, may be reduced. As if this were not enough, there are also valuable public relations benefits from using this "green," environmentally friendly alternative to chemical pest control.

GREENHOUSES AND NURSERIES, CHALLENGING ENVIRONMENTS

Greenhouse and nursery production frequently requires perfect-looking plants, flowers and fruit. Other challenges, related to the density and often the diversity of plants, and the constant movement of plants in and out, represent a unique horticultural environment, requiring unique pest control solutions. At Rincon-Vitova, we are prepared to help you every step of the way.

It is important to correctly identify pest species needing control, so as to select appropriate beneficial insect species for your beneficial bug army. If you are unable to make your own pest identifications with help from local extension agents, universities, pest control advisors, Rincon-Vitova provides identification services.

Greenhouse environments differ from outdoor environments in often filtering out some of the ultraviolet light that protects plants. Excessive nitrogen fertilization, another common fact of greenhouse production, also contributes to indoor plants growing up soft, and attractive to pests. When pests invade soft, weakly defended plants, the principles of invasion ecology take effect. The pests, freed of natural enemies, multiply rapidly on suitable host plants, quickly reaching pest status. Beneficial insect releases help restore the checks and balances found in natural ecosystems. The beneficial insects (all natural, none genetically engineered) supplied by Rincon-Vitova Insectaries establish a natural predator-prey cycle, putting the brakes on runaway pest population growth. In this new equilibrium, pest populations are kept at tolerably low levels by their natural enemies. Pest eradication is not a goal, as a few pests always need to be present as food for the beneficials, which might otherwise starve and have to be reintroduced.

GETTING STARTED

Initially, it may be necessary to knock down runaway pest populations to levels that small populations of newly-introduced beneficials can easily mop up. Use the least-toxic, low-

residual spray materials available, e.g. insecticidal soaps, botanicals like neem, microbials, and highly refined horticultural "summer" oils.

Chemical residues last longer in greenhouses than outdoors, as intense sunlight is necessary for rapid degradation of most pesticides. Thus, chemicals with little residual effect under outdoor open field conditions, may persist many weeks longer than expected in greenhouses. Diazinon and some pyrethroids may even be translocated from roots to plant leaves, and persist for months. Landscape and plantscape buyers who use biological control have problems carrying out their programs with nursery plant material containing residues. To minimize the possibility of poisoning beneficials with pesticide residues, it is best to wait at least one month after application of hard pesticides before beginning beneficial insect releases.

Chemical residues are particularly detrimental to Rincon-Vitova's parasites, e.g. Aphytis melinus, which attacks scale insects, Leptomastix dactylopli, which attacks citrus mealybug, and Encarsia formosa, which attacks greenhouse whitefly. Hence, keep pesticides off leaf surfaces in at least part of the greenhouse or nursery ecosystem. For example, an isolated corner where pests are not out of control can be used as a beneficial insect refuge (safe haven).

One of our most popular strategies is initially releasing large numbers of beneficials to colonize the greenhouse or nursery, and following up with a number of smaller releases to ensure long-term establishment of pest natural enemies.

MAINTAINING BIOLOGICAL CONTROL

Maintaining biological control in greenhouses and nurseries is an on-going process involving conservation of natural enemies and careful monitoring. Conservation of natural enemies is facilitated by phasing out hard pesticides interfering with biological control, as well by periodic maintenance releases of beneficials. Where possible, screening should be used to keep natural enemies in, and new pests out. Newly introduced plants should be checked for pests, and, if necessary, disinfested (e.g. with dips or sprays of soaps, oil, neem or other "soft" pesticides) before introduction to the nursery.

Rincon-Vitova Insectaries tries to make transitions from chemically-managed to biologically-managed ecosystems as smooth as possible by continually collecting new strains of beneficials from heavily sprayed ecosystems Though we do not specifically test natural enemies for ability to withstand chemical sprays, we believe that some of our insects, particularly green lacewings, great all-around predators, have been successful in transition situations due in part to this hardiness and ability to withstand some chemical residues.

Careful monitoring of pest and beneficial insect populations by a pest control advisor should be part of a biological pest control program. The most effective methods are visual observation, pheromone traps, sticky cards and beating trays. A vacuum sampling device is useful in many situations. Even when it seems that everything is under control, continued vigilance is needed to guard against entry of new pests. Expect the unexpected.
A map of the nursery, with the different plant species and varieties identified, can be very useful. Awareness of changing conditions of neighboring plants and weeds, especially near

the greenhouse, can help a manager anticipate intruding pests and beneficials. Plant species vary in hospitability to beneficial insects; some plants produce poisons that pests use to protect themselves. Knowing the correct identity of a problem plant and the surrounding environment can help us work with you in developing alternative strategies.

Researchers are developing methods for growing even more beneficial insect species to control an ever wider range of pest problems. Customers on accounts are informed through periodic mailings of new beneficial species, some of which are so scarce that only very small quantities can initially be provided for inoculation. In addition, where demand is sufficient, we can on special request collect or obtain rarer natural enemies not normally available commercially.

Technical bulletins are available for all the beneficials that we sell. A quality control specialist works to insure that the best possible product is sent out. Nevertheless, sometimes shipments of fragile insects can arrive injured or otherwise not meet expectations. As we stand behind all product shipped, please feel free to contact us should you ever feel that there is a problem or that a replacement may be necessary.

BENEFICIAL ORGANISMS FOR GREENHOUSES AND NURSERIES

These descriptions and guidelines for use are compiled from research, experienced pest control advisors and producers of beneficials. New information is regularly forthcoming. Check package inserts and Technical Bulletins. Use may vary between outdoor and greenhouse settings and interiors. Monitoring by experienced pest control advisors is necessary. Some organisms are only available seasonally or by advance commitment.

PREDATORS

APHIDOLETES APHIDOMYZA (APHID MIDGES)

This predator is effective against over 60 species of aphids, including green peach aphid. The midges are very successful in greenhouses where they collect under the leaves in dark areas. They are also used in gardens, nurseries and street trees, but do not do well in fields. Egg laying is heaviest in heavy aphid infestations and may be increased by spraying a honey and water solution on the leaves. The bright orange-yellow larvae inject a toxin into aphids and suck out the fluids. When daylight is less than 16 hours and temperatures drop in autumn, they may go into diapause, but will reappear in successive seasons up to four years later. This low light will affect the larva when it goes into its pupa stage. But if you are using Aphidoletes to clean up a few aphids, you wont be getting much reproduction. Now we can boldly encourage greenhouse operators to use Aphidoletes to suppress aphids year round. Also the low light diapause will be overridden by temperatures of 78° F (24° C) or higher. So Aphidoletes can be used in warmer greenhouses even with short day length and low light.Control of aphids is generally more effective when insecticidal soap sprays are avoided. Soap harms biological controls and disperses aphids so predators have more difficulty getting to them.

Recent guidelines call for 500 to 3000 cocoons per acre weekly depending on the infestation. A minimum of two releases of 250 cocoons per season are needed in about 500 square feet of greenhouse, depending on how rapidly and thoroughly control is sought.

Care and Distribution:: Aphid midge cocoons are disguised in a coating of moist vermiculite in which they are shipped. Adults emerge over three days, usually starting on arrival. When adults appear inside the lid, distribute contents in moist soil or root media in the shade under plants. If cocoons are left in dry areas exposed to sun, midges will not emerge.

CHRYSOPERLA (GREEN LACEWING)

Lacewing larvae attack many common pests including aphids, mealybugs, mites, whitefly and scale insects. Adult females lay 10 to 30 eggs per day. Both longtailed mealybug and sweet potato whitefly suppression have been demonstrated with regular release in greenhouses. Lacewing can reduce or control aphids in ornamentals. The more widely lacewing larvae are distributed, the better the control. Releases will generally colonize in a supportive habitat.

Lacewing releases should start when pest levels are low, then every one to four weeks as needed. Quantifies depend on the degree of infestation, presence of other biological controls, and other factors. A guideline is 5,000 to 50,000 per acre per season or 1,000 per 2,500 square feet of planted area. When the plant canopy is touching, distribute squares or tapes every third to tenth plant, alternating plants with each release.

Care and Distribution: Lacewing arriving as eggs should be incubated in a warm place (approximately 80º F and not near a direct heat source or in an oven). The tiny larvae start crawling 1 to 4 days after arrival, depending on the age of the eggs and the temperature. Hatching happens sooner at 80º to 90º F and can be delayed by holding at around 60ºF. If air is dry, put a damp sponge or cotton in a larger paper bag with the lacewing container. Do not wrap in plastic.

Loose Lacewing Eggs: Eggs are usually shipped in a carrier of rice hulls with food, but can be shipped as straight eggs with or without food. Rice hulls provide surface area for larvae to crawl on before release. A paper cone funnel is convenient for distributing larvae in the mixture on plant infestations.

Lacewing Cards: One card has 2,500, 5,000 or 10,000 eggs and is perforated for division into 30-1 inch squares. The squares, yielding approximately 100 and 200 larvae respectively, can be fixed among leaves or branches. When larvae are crawling on the 6 inch long by 3/4 inch wide tapes, peel off the paper on the ends and stick the ends together around branches.

Lacewing Larvae in Verticel Honeycomb Units: To distribute larvae from honeycomb units, peel back the covering little by little and tap larvae onto plants or lift them out and place them with a small brush. Each of the 500 cells contains a larva with a 1 to 2-day food supply. One larvae per plant is a guideline for a mild infestation. Larvae pupate in about 12 days at which time a second release may be needed.

CRYPTOLAEMUS MONTROUZIERI
(MEALYBUG PREDATORS)

This lady beetle attacks many species of mealybugs. It will also feed on aphids and immature scale insects when mealybugs are in low numbers. It may sometimes be less effective against longtailed mealybug being a high density feeder, but will reproduce when mealybug are present Both adult and larval stages are predatory, but don't mistake "crypt" larvae for mealybugs since both have a white, waxy coating. Two releases of approximately 1 beetle per square foot of planted area or 2 to 5 per infested plant is a guideline when mealybug populations are small. Subsequent monthly releases may be needed.

Care and Distribution: Do not refrigerate these tropical beetles! "Crypts" are shipped as adults ready for release by sprinkling on infestation sites.

DELPHASTUS PUSILLUS
(WHITEFLY PREDATOR)

These tiny, black beetles can eat several hundred whitefly per day, supplementing activity of whitefly parasites where pest densities are high. Spider mites are a probable alternate host. They provide good eventual control, since each generation is 50 to 100 times greater in number than the previous one.

Care and Distribution: Delphastus are shipped as adults for immediate release. Use is still experimental, but guidelines for greenhouses start at 50 beetles per 2,000 to 5,000 sq. ft. when used as an inoculation.

HIPPODAMIA CONVERGENS
(Convergent lady beetle)

This general predator feeds on aphids, mites and a variety of other soft-bodied insects. Their yellow eggs are laid in clusters. Larvae consume pests for about 16 days before pupating. Pupae remain on upper leaf surfaces for about a week until adults emerge.

Care and Distribution: Lady beetles are shipped as adults and should be released in the evening near food sources. If release is delayed a clay or two, they can be refrigerated. Pre-release care can include spraying bag or cotton wick with water and or prespraying release spot with a 5% sugar solution. A rule of thumb for releases is 1 lady beetle per sq. ft.

HYPOASPIS MILES (=Geolaelaps sp.)
(FUNGUS GNAT PREDATOR)

Root-feeding fungus gnats can be controlled by this brown mite that feeds on small soil-dwelling insects, including thrips larvae. The mites produce a new generation every week and are easy to establish. They are used at a rate of 1/4 teaspoon of mixture per 2 plants or 1-2 liters per 1,000 sq. ft. One early introduction is enough for the season.

Care and Distribution: Distribute immediately or, if holding overnight, keep in a cool room (50º to 60º F). The adult mites are mixed in sawdust and can be shaken out in shady moist soil or media.

RHYZOBIUS LOPHANTHAE (=Lindorus lophanthae)
SCALE DESTROYER

This small black lady beetle with orange head and thorax is an effective scale predator occurring in southern US and occasionally available commercially. Adults and larvae feed only on scale insects, both hard and soft, and will eat mealybug larvae; the beetle larvae do not like soft scale with excessive honeydew. Release approximately 1 beetle per 1-2 sq. ft

Care and Distribution: These hardy adult beetles are released immediately.

AMBLYSEIUS CUCUMERIS
(THRIPS PREDATOR)

This predatory mite attacks the immature stages of the western flower thrips and onion thrips. Control is not generally apparent until 2 or 3 months after releases begin. Distribute 1 to 10 predators per square foot per week depending on plant size and foliage density; experimentation is encouraged. Releases should start when thrips populations are low (less than 10% of leaves with adult thrips or 25% of leaves with larvae).

Care and Distribution: Adult thrips predator mites are shipped loose in bran or packaged in sachets with all life stages, called controlled release system (CRS) bags, for hanging on plants where sprinkled bran may be less effective. Distribution should be thorough and heaviest during hot, dry months.

ORIUS
(Minute Pirate Bug)

These small black and white bugs are naturally occurring in many crops and are predacious as adults and immatures. They prey on thrips, mites, scale pests, whitefly, lepidopterous eggs, psyllids, aphids, etc. Nymphs are yellow, amber or brownish. Only the white circular caps of the eggs are visible in plant tissue. Beneficial members of the Anthocoridae family are less harmed by insecticides than other beneficials. Day length of a t least 13 hours and presence of host are needed for reproduction. Quantities used range from 5,000 to 30,000 per acre.

Care and Distribution: Adults are packaged in buckwheat hulls. Release as soon as possible after delivery in spring when pest levels are low.

PHYTOSEIULUS SPP. & NEOSEIULUS SPP.
(PREDATORY MITES)

There are several commercially available species of predatory mites that attack the two-spotted spider mite. Predatory mites should be introduced at the first sign of spider mite damage, reintroduced two weeks later, and then at regular intervals until a balance is reached between pest and predator mites and damage is stopped. Distribute from 05 to 3 per sq. ft. depending on foliage density and how hairy the leaves are, 2 predators per damaged leaf or 2 per plant if plants are small.

Phytoseiulus persimilis is preferred in greenhouses and fields, favoring mild humid conditions up to 80º F. Galandromis (=Metaseiulus) occidentalis fares better when temperatures exceed 90º F. Neoseiulus (=Amblyseius) californicus can be very successful in greenhouses when pest mite populations are low. It thrives in a minimum of 60% relative humidity and can tolerate temperatures up to 90º F. Combinations of species can be used in settings with varied micro-climates. Good control of a moderate spider mite infestation should be achieved within 4 to 6 week, though persistent pesticide residues delay establishment.

Care and Distribution: Distribute predatory mites immediately or, if holding overnight, keep in a cool room (around 50º to 60º F). Mites are shipped in the adult stage in vermiculite or bran for sprinkling on infested foliage. They will adhere better to leaves covered with morning dew or misted.

PREDATORY NEMATODES

Substrains of the Steinernamatidae and Heterorabiditae nematode families are predators that attack insects, insect pupae and insect larvae in places that are constantly moist. Among more than 250 susceptible insect pests are cutworms, white grubs, thrips, fungus gnats and other root zone pests. The nematode enters the host and kills it within 24 to 48 hours, then reproduces within and searches for new hosts thus providing long-term control. One million are enough for 2,000 to 3,000 sq. ft. and 1 or 2 applications per year are usually enough.

Care and Distribution: Nematodes are best applied in the evening, directly into the soil or growing media, after mixing them in water. In larger areas, a sprayer is helpful. They are perishable, but can be stored temporarily in the refrigerator.

PARASITES

APHIDIUS MATRICARIAE (APHID PARASITE) This parasite of green peach aphid can be released early in the spring. Developed in greenhouses and interiors to supplement programs using Aphidoletes aphidomyza. Increasingly cost-effective programs are becoming available.

Aphytis melinus (Red scale parasite) California red, Aonidiella amantii, and oleander (ivy) scale, Aspidiotus neroli, are among a number of species attacked by Aphytis melinus. It does not parasitize all red scale pests. The tiny yellow wasp lays her eggs on the soft body under the waxy shell of young scales. Programs depend on number and age of scale pests present.

Care and Distribution: Do not refrigerate! Release immediately, preferably in the morning.

DIGLYPHUS ISAEA (LEAFMINER PARASITE) This ichneumon wasp is a natural enemy of 18 species of leafminer, especially in greenhouses and warmer climates. It attacks its host in the tunnel and lays one or more eggs on or near it. The egg develops in the tunnel and turns into a new wasp which uses the dead larva as food. A biological program should also include trapping and use of IGR sprays or horticultural oils.

Care and Distribution: One parasite for every 10 new mines per developed plant per week should begin during the first 6 weeks of an infestation, or 500 to 1,000 per acre. Monitoring of

leaves for emerging parasites will show if parasitism is high enough (at least 90 %) to suppress leafminers.

LEPTOMASTIX DACTYLOPII
(CITRUS MEALYBUG PARASITE)

This tiny, delicate wasp parasitizes the common citrus mealybug as a valuable part of their control. It is capable of finding the last mealybug. Though it prefers a sunny, warm, humid environment, it has been used successfully in areas of low humidity. Hosing plants with soap and water followed by a release of Cryptolaemus will reduce heavy populations giving a subsequent release of the parasites a head start. Good control should be achieved in 2 to 3 months. Under ideal environmental conditions, distribute 2 per square yard or 5 per infested plant, usually once or twice a year. Uneven commercial availability.

Care and Distribution: Do not refrigerate or hold in hot or humid condition. Release immediately.

ENCARSIA FORMOSA
(GREENHOUSE WHITEFLY PARASITE)

Tiny parasitic wasps, no bigger than a pencil point, lay their eggs inside 3rd and 4th instar larval stages of whitefly found on the underside of leaves. Parasitized whitefly larvae turn black which provides a way of assessing the success of the introduction. Works best in temperatures over 70º F (ideally 80º F), relative humidity below 70 % and high light levels (greater than 650 footcandles). Control is not immediate, especially where chemical residues exist. Initial introductions can be integrated with spot-vacuuming or spot-treatment.

Encarsia prefers to attack 2-week-old whitefly, so plans are best made for an initial series of 4 releases every 10-14 days to assure that the 3rd and 4th instar stages are present during at least 1 of the releases. Repeat this series if necessary, usually once or twice a year. Guidelines are at least 1 parasite per 10 potted plants or 1 per 10 square feet of planted area when there are less than 1 whitefly per 20 plants. Increase numbers up to 2 to 5 parasites per plant for larger plants, such as poinsettias, and for plants with hairy leaves or honeydew on them. If adult whiteflies exceed 10 per leaf, spot-spray new growth of infested plants with insecticidal soap or horticultural grade petroleum oil.

Care and Distribution: Shipping time and temperature affect how soon Encarsia parasites emerge from the black parasitized GHWF scale glued on cards. If emergence has not begun, cards can usually be stored up to 3 days at 40º to 50ºF, however, number emerging decreases with increased storage time and colder temperatures. Hang cards when emergence begins.

TRICHOGRAMMA SPECIES
(MOTH EGG PARASITES)

These tiny wasps lay their eggs inside (or sometimes feed on) the eggs of over 200 species of moths that cause damage as caterpillars. The progeny of the first release emerge after 8 to 10 days ready to attack more pest eggs. An increasing rate of parasitism with each generation

has been documented. Among the species currently available commercially, T. pretiosum is usually used in fields, flats, shrubs and vines and T. platneri for orchards on the West Coast.

Trichogramma parasitize only freshly deposited moth eggs, so the ideal time to release is when the moths are flying. For prevention or for control of low to medium infestations, generally one square of 4,000 parasitized eggs is used for each 4,000 square feet. In young tree and shrub plantings, start at 50,000 or 12 squares per acre. Depending on the biology of the target host, releases are often planned weekly or biweekly for 3 to 6 consecutive weeks, timed as close as possible to moth flights. Don't miss making a release during egg-laying of the first generation of moths. Pheromone traps and degree-day calculations can help in planning the schedule.

Care and Distribution: Trichogramma are shipped in the form of parasitized moth eggs, usually glued to a perforated card. There are 125,000 eggs on a card and each card can be broken into 30 one-inch squares with approximately 4,000 eggs per square. The wasps will emerge in 2 to 5 days, depending on the holding temperature, which should ideally be 80º F. Holding temperature can be manipulated to speed up or slow down emergence. Squares are usually held during the incubation period individually in paper cups or other container from which swarming, mated female wasps can be released.

REFERENCES

1. Hussey, N.W. & N. Scopes editors. 1985. Biological Pest Control: The Glasshouse Experience. Inexpensive book from Cornell University Press about biologies of important indoor pests and their natural enemies with information not readily available elsewhere.

3. Bio-Integral Resource Center (BIRC). 1991. Least-Toxic Pest Management: Greenhouses & Indoor Plants. Collection of 10 articles from BIRC's Common Sense Pest Control Quarterly and IPM Practitioner publications, a wealth of information on indoor pest problems. Many techniques described are used at the San Francisco Conservatory of Flowers in Golden Gate Park. $16. Much of BIRC's information is contained in Taunton Press' Common-Sense Pest Control a 715 page book available from BIRC (P.O. Box 7414, Berkeley, CA 94707).

4. Croft, Brian A. 1990. Arthropod Biological Control Agents and Pesticides. 723 page book, published by John Wiley & Sons (NY), is an essential reference where pesticide selection decisions are being weighed against disruption of biological control. Charts help in making recommendations.

5. Costello, R. A.,et al. 1992. Integrated Control of Greenhouse Pests. 19-page how-to booklet. Request free (limited availability) Extension systems Branch, British Columbia, Ministry of Agriculture, Fisheries and Food, 808 Douglas Street, Victoria, B.C. VSW 211 or call 604-387-3498. Or order copy from Rincon-Vitova.

Other Rincon-Vitova Publications:
Biological Control Solutions for Interior Plantscapes
Safe Ways to Control Landscape Pests
Bulletins about other crop systems and about each organism.