BioGreenhouse

Plant health

Conservation of lacewings in and around greenhouses

Lacewings are important natural enemies of several agricultural pests. All larvae and the adults of certain species are polyphagous predators and therefore have the potential to be used for biological pest control in greenhouses. Currently however, only a limited number of *Chrysoperla* spp. are being mass-reared and marketed by the biological control industry, while the main application method for lacewings in the greenhouses is augmentation release. Food supplements, food attractants and hibernation boxes are available for enhancing lacewing conservation. Here, the main tools for conserving lacewing populations are briefly reviewed with an emphasis on those that could be applied in and around the greenhouse.

Biological control with lacewings

Chrysopids (green lacewings) are the main species assessed in worldwide literature for use in biological control, while the efficiency of hemerobiids (brown lacewings) has barely been addressed. Among chrysopids, *Chrysoperla* spp. represent the most important biological control agents in agroecosystems, with *Chrysoperla carnea sensu lato* playing the dominant role (Figure 1). Scattered information on promising candidates for biological control belong to other than *Chrysoperla* species, such as to the genera *Pseudomallada*, *Chrysopa* and *Ceraeochrysa*. Lacewings are applied to the field by means of inoculative/inundative releases, and conservation methods. They are mainly released in thousands as eggs or larvae, since immatures are cheaper than adults or cocoons to produce in high numbers. Eggs mixed with rice hulls or vermiculite are manually dispersed to ensure their uniform distribution in the field, while larvae can either be manually dispersed by placing rearing units on the plants, or directly applied on the plants (e.g. formulated mixed with rice hulls in bottles).

Figure 1. *Chrysoperla carnea sensu lato* adult.

To date, *Chrysoperla carnea*, *C. rufilabris*, and *C. comanche* are the only commercially available lacewing species in North America, whereas *C. carnea*, *C. externa* and *C. nipponensis* are available in Europe, Latin America and Asia respectively, with *C. carnea* being the top seller of all species. However, caution is needed with regard to correct species identification since *C. carnea sensu lato* consists of many cryptic species and therefore these are difficult to differentiate by morphological traits only.

Tools for lacewing conservation

Research on techniques for conserving lacewings and enhancing biological control have mainly focused on the evaluation of certain chemicals or blends as food sprays and adult attractants, and on different honeydews and pollens as food supplements. Culture methods such as intercropping and inclusion of flowering plants have also been recommended as useful conservation techniques.

Plant-provided foods

Adults of all lacewing species used in biological control feed on pollen and nectar. Moreover, larvae may supplement their diet with plant-provided food to enhance their growth and population numbers. In this respect, lacewings are more suitable for crops bearing extrafloral nectaries and flowering plants.

Food sprays

Mixtures of protein hydrolysates with honey or sugar have been used as high quality artificial food supplements (artificial honeydews). Bottles or bags containing yeast or pollen and nectar substitutes could be mixed with water and applied as a paste or sprayed on the plants. Factitious foods (e.g. eggs of *Ephestia kuehniella* Keller) have been shown to be an excellent source for larvae, and therefore may serve as supplementary or alternative food in the greenhouse.

Oviposition sites and shelters

Oviposition preference in lacewings is not clearly understood. Lacewing females lay stalked eggs on plants where young larvae can easily find their prey/food. Herbivore induced plant volatiles, and prey pheromones have been considered in this regard, however with contradictory results mostly depending on the species.

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In sweet pepper, brown lacewings prefer to oviposit on jute fibers over plants where the larvae are protected against cannibalism.

Conservation of naturally occurring lacewings

Overwintering shelters hosting diapausing adults can be used near the greenhouse to promote the early build-up of lacewing populations during spring. Such hibernation boxes (Figure 2) or 'lacewing chambers' are currently commercially available.

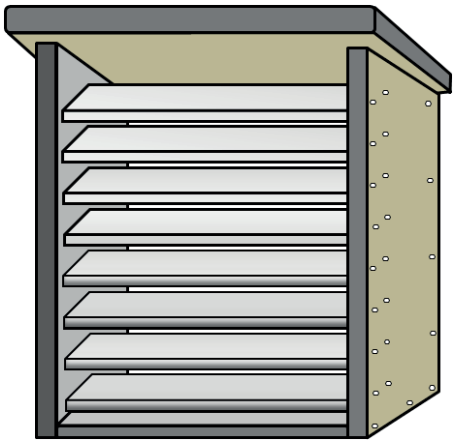

Figure 2. Lacewing hibernation box.

Semiochemicals

Certain chemicals (e.g. tryptophan) or blends have been tested in the field as attractants for lacewing adults. Less is known about manipulating lacewing behaviour (mainly oviposition) by testing sex or prey-alarm pheromones. Attractants may be used in the greenhouse to lure lacewings to alternative foods and oviposition sites or to stimulate oviposition by adults.

Selective use of pesticides

Among natural enemies used in biological control, lacewings are generally considered the most resistant to pesticides. Within the context of an Integrated Pest Management (IPM) program, lacewings are compatible with selective pesticides.

Food web complexities

Intraguild predation among lacewings and other predators is not as common in the greenhouse as in the field. However, in periods of prey decline or scarcity, cannibalism among juveniles may impose a limiting factor on lacewing population growth. The provision of alternative/supplementary food for the larvae, as well as of control methods to exclude intraguild predators (e.g. ants) from the crops, are recommended to reduce such adverse effects on lacewings establishment in the greenhouse.

Future directions

Lacewings are important biological control agents currently used in augmentative releases in the greenhouse. Due to their relative resistance to pesticides and tolerance for low temperatures they are ideal for use in ornamental crops (high pesticide input crops) and in moderately heated greenhouses. Conservation research should focus on the development of tools to sustain high populations of the released lacewings, and to restrict adults inside the greenhouse (Table 1).

Table 1. Lacewings pros- and cons- relative to greenhouse conservation tools

Pros-	Conservation tool
Generalist predators	Food supplements, food sprays, plant food
Easy mass-rearing	Food supplements (factitious food)
Resistance to pesticides	Use of selective pesticides (IPM programs)
Non prey adult food	Plant food (pollen, nectar), food sprays
Adult attraction to protein hydrolysates	Adult attraction to oviposition sites/food sources
Plantless oviposition	Oviposition enhancement on fibres
Cons-	
Adult pre-oviposition flight	Adult conservation
Larval cannibalism	Larval conservation in the absence of prey/food

References: Canard, M., Séméria, Y. and T. R. New 1984. Biology of Chrysopidae. Dr. W. Junk Publishers, The Hague, The Netherlands.

McEwen, P. K., New, T. R. and A.CE. Whittington 2001. Lacewings in the Crop Environment. Cambridge University Press, Cambridge, UK.

Pappas, M. L., Broufas, G. D. and D. S. Koveos 2011. Chrysopid predators and their role in biological control. Journal of Entomology, 8 (3), pp. 301-326.

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