Omnivorous predators for biological pest control in greenhouse crops

Omnivores are consumers that feed on both animals and plants. Many important biological control agents (BCAs) are true omnivores feeding on the same host plant of their prey. A major benefit of omnivores is their ability to establish on crops early in the growing season when prey is scarce or absent by feeding on plant provided food sources, such as pollen, nectar of plant sap. This enables them to respond quickly to new infestations of pests. So their ability to sustain populations on the sole plant resources may result in more effective pest control compared to species that are not able to survive in absence of prey. However, there is a need to carefully assess the benefit gained by omnivorous species acting as predators against any damage they may cause as plant feeders, since the beneficial value may be neutralized by any economic damage through phytophagy. More research is needed to better understand the behaviour of omnivores in complex ecosystems with multiple prey and plant resource in order to optimize their use as biological control agents.

Omnivorous predators for biocontrol

Omnivorous predators that are currently used for biological pest control in greenhouse crops are predatory hemipterans of the family *Anthocoridae* and *Miridae* and predatory mites of the family Phytoseiidae. Well-known and commercialised species in Europe are *Orius laevigatus* and *Orius majusculus*. They are able to survive in plant that provided pollen, such as sweet pepper, and are excellent predators of thrips (Figure 1). The most commonly used and commercially mass-produced species are currently *Macrolophus pygmaeus* in northern Europe and *Nesidiocoris tenuis* (Reuter) in southern Europe. Besides plant tissue, these predators feed on multiple pest species such as whiteflies, aphids, thrips, leaf miners, spider mites and Lepidoptera species, including *Tuta absoluta*. Omnivorous phytoseiid mites can develop well on most pollen and nectar provided by plants, and are effective predators of whiteflies, thrips and mites. Recently, it was found that the so-called “Type-IV” predatory mites are able to pierce plant cells and feed additionally on plant tissue.

Feeding behaviour

Among the predatory hemipterans, zoophytophagy varies considerable. Some of them (like *Dicyphus tamaninii* and *Dicyphus hesperus*) can reach adulthood on either plants or prey separately, but other need prey for their development. Because plant and prey diets differ greatly in their chemical composition, mixing them in the diet requires specific physiological and morphological adaptations: mouthparts, digestive tract, biochemical pathways, and appropriate enzyme complexes to efficiently explore different diets. They presumably ingest certain nutrients or hormones derived from plants, which they cannot derive from prey. Omnivore mirid predators possess salivary pectinases and amylases that are indicative of plant consumption and relatively high levels of peptidases. It is possible that this highly developed enzymatic profile allows them to assimilate nutrients beyond those readily available in plant tissues. The benefit of plant feeding has also a drawback, as in some cases it may result in plant damage. Particularly the use of *Nesidiocoris tenuis* as beneficial is controversial. In tomato, this species causes necrotic rings on stems, leaves and flower petioles as result of the mechanical destruction of cells by the stylet. This feeding can be dramatic for plant growth and production of fruits.

Figure 1. *Orius laevigatus* preying upon western flower thrips in a sweet pepper flower.

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How to enhance pest control

Predator populations can be manipulate by inoculative releases, habitat manipulation, and individual predator behaviour manipulation. Manipulating the habitat at different scale, ranging from the microhabitat, to field, field border, and landscape level can influence predator abundance and activity by a variety of mechanisms such as predator mobility, adhesiveness and dispersal tendency and provision of alternate food sources. Successful example of habitat manipulation applied to omnivore predators are the use of intercropping, companion plants, winter shelters, field borders, landscape diversification, etc. Recently it has been reported that companion plants can significantly reduce the damage of the mirid *N. tenuis* on tomato crop.

Omnivores often achieve higher population densities in habitats containing superior plant foods, such as pollen, seeds and fruits, compared with habitats without these supplies. Feeding on such plant materials often increases omnivore population density through local aggregation, enhanced reproduction and decreased mortality. Food sprays may attract naturally occurring predators or retain released ones. Also the addition of sucrose as dietary supplement might reduce plant damage caused by *N. tenuis* when prey is scarce without increasing its population because *N. tenuis* needs the prey to reach the adult stage.

Figure 2. *Dicyphus maroccanus* exploring a bean pod surface.

Tritrophic interactions

Zoophytophagous predators can induce plant defence responses and reduce herbivore performance. In particular, plants respond to the phytophagy by omnivorous predators by increasing levels of proteins involved in plant defence. For example on tomato oviposition of the predatory bug *Orius laevigatus* was shown to increase resistance against feeding by the thrips *Frankliniella occidentalis*, as well as the performance of two-spotted spider mites on plants previously exposed to *M. pygmaeus* was reduced, and plants exposed to the mirid bug *N. tenuis* were less attractive to the whitefly *Bemisia tabaci*, but more attractive to the parasitoid *Encarsia formosa* compared to clean plants. Hence, the suppression of populations of certain herbivores may be strengthened by the induction of plant defences by zoophytophagous predators.

Future research

More research is needed to manage the behaviour of omnivorous predators in order to optimize pest control while minimizing plant damage. More specifically we need:

- A deeper knowledge of the mechanism that rules the switching feeding behaviour of omnivores between plants and animals as food. The consumption of different types of prey, with diverse nutritional values, may have a distinct impact on the biology of omnivore predators. There is evidence that predators also choose to eat certain prey to balance their amino acid requirements, and therefore prey choice may be affected by previous feeding history.
- A better understanding of which omnivorous predators are most suitable for specific crops and their prey. Introduction to new crops can be explored, including ornamental plants.
- To study how plant quality through nutrition, endophytes or induced plant responses affect biological pest control with omnivores.
- Develop strategies to enhance establishment and reduce plant damage with companion plant and food sprays

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