Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

Predatory Mites

Utilization In Biocontrol

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Received: February, 2024; Accepted: March, 2024; Published: April, 2024

Introduction

Biological control serves as a crucial ecosystem service and forms a foundational element of integrated pest management (IPM), as highlighted by Naranjo *et al*. in 2015. Across various regions globally, the practice of augmentative biological control is widespread, particularly in greenhouse cultivation of vegetables, fruits, and ornamentals. Notably, 80% of the revenue generated from commercial biological control is observed in protected cultivation settings, as outlined by Pilkington *et al*. in 2010. Predatory mites, primarily belonging to the Phytoseiidae family, assume a pivotal role among the biocontrol agents deployed in this context.

Addressing pest control in vegetable and ornamental crops remains a significant global concern. To mitigate this issue, there is an increasing adoption of biological control practices, leading to a reduction in the reliance on chemical pesticides, as noted by van Lenteren in 2012. This shift is motivated by several factors, including the development of pesticide resistance among certain pests, consumer preferences for pesticide-free products, and the introduction of bumble bees for pollination in greenhouse crops like tomatoes. The latter is particularly incompatible with the use of chemical pesticides (Matson *et al*. 1997; Isman 2006; and; van Lenteren 2012). Numerous studies have explored natural enemies of pests to assess their suitability for biological control, and several of these have found application in various crops.

The management of arthropods is widely acknowledged to benefit from biological control methods (Altieri, 1999; Power, 2010). This study specifically concentrates on predatory mites categorized under the Phytoseiidae family, and the term "predatory mites" is consistently employed in the paper to denote mites within this family. These particular predators are employed for the regulation of mite pests and minor insects (McMurtry and Croft, 1997; Gerson *et al*., 2003).

Table1: The most important arthropod bio-control agents (by turnover) used in augmentative biological control (modified after van Lenteren 2012).

Species	Family	Target(s)	Year of first commercial use
Amblyseius swirskii	Phytoseiidae	Whiteflies, thrips, mites	2005
Phytoseiulus persimilis	Phytoseiidae	Spider mites	1968
Neoseiulus californicus	Phytoseiidae	Mites	1985
Macrolophus pygmaeus	Miridae	Whiteflies	1994
Encarsia formosa	Aphelinidae	Whiteflies	1926
Orius laevigatus	Anthocoridae	Thrips	1993
Nesidiocoris tenuis	Miridae	Whiteflies, *Tuta absoluta*	2003
Neoseiulus cucumeris	Phytoseiidae	Thrips	1985
Eretmocerus eremicus	Aphelinidae	Whiteflies	1995

The significance of predatory mites in biological control

The market for arthropod biological control agents has experienced a consistent growth rate of approximately 15% per year over the past decades, as highlighted by Ravensberg in 2015. To provide context, the global turnover of natural enemies was a mere US$30 million in 1997 (Bolckmans, 1999). This figure witnessed an increase to around US$50 million in 2000, as reported by van Lenteren in 2007, and surged to approximately US$400 million in 2010 (van Lenteren, 2012). By 2014, the market had expanded further, reaching an estimated US$600 million.

The introduction of *Amblyseius swirskii* into the market in 2006 played a pivotal role in driving this change. This particular species is capable of simultaneously managing thrips and whiteflies. It marked the first instance of a predatory mite being successfully utilized against whiteflies, which were predominantly controlled by parasitoids before this development (Nomikou *et al*., 2001).

Table 2: Mite species employed for biological control in Europe that are commercially accessible, adapted from van Lenteren's 2012 work.

Species	Target(s)	Year of first commercial use
Phytoseiidae		
Amblydromalus limonicus	Thrips, whiteflies	2011
Amblyseius andersoni	Mites, small insects	1995
Amblyseius swirskii	Thrips, whiteflies	2005
Euseius gallicus	Thrips, whiteflies	2013
Iphiseius degenerans	Thrips	1993
Neoseiulus barkeri	Thrips	1981
Neoseiulus californicus	Spider mites	1985
Neoseiulus cucumeris	Thrips	1985
Neoseiulus fallacis	Spider mites	1997
Phytoseiulus persimilis	Spider mites	1968
Transeius montdorensis	Thrips, whiteflies	2003
Typhlodromus pyri	Mites	1990
Laelapidae		
Stratiolaelaps scimitus	Sciarids, thrips	1995
Gaeolaelaps aculeifer	Sciarids, thrips	1995
Androlaelaps casalis	Poultry red mite	2012

Macrochelidae		
Macrocheles robustulus	Sciarids, thrips	2010
Cheyletidae		
Cheyletus eruditus	Poultry red mite, stored product pests	1985

Mass Rearing of Predatory Mites

Successful implementation of biological control predominantly involves the mass production and assessment of billions of predatory mites to ensure their efficacy. However, achieving cost-effectiveness is crucial in this process. Traditional rearing systems for phytoseiid mites, such as tritrophic systems involving plant materials, natural prey, and predators, present several drawbacks, being both laborious and expensive. Therefore, making mass rearing systems viable requires not only identifying effective and abundant species but also devising economical methods for their production at a low cost. This strategy hinges on a comprehensive understanding of the feeding habits and behavior of predatory mites in general.

The classification of phytoseiid mites based on their feeding habits includes specialized predators targeting *Tetranychus*/eriophyid/tydeid species, selective predators of tetranychid mites, generalist predators, and generalist mites with a preference for pollen feeding.

Generalist predators can be cultivated in large quantities using various prey species, such as phytophagous mites, different types of insects like mealybugs, whiteflies, and scale crawlers, as well as pollen. Some commercially produced predators used for biological control in greenhouses include *Amblyseius swirskii*, *A. andersoni*, *Neoseiulus barkeri*, *N. cucumeris*, and *N. californicus*. *Neoseiulus californicus*, in particular, has garnered significant attention. While it primarily preys on tetranychid mites, it can also consume other mite species, small insects, or pollen when its primary prey is unavailable. In an effort to reduce production costs, researchers have explored the use of factitious food items, such as alternative sources not typically found in their natural habitat but still capable of supporting their development and reproduction.

Moreover, various food items can serve as valuable supplements for supporting predator populations following their release into the crop. Predatory mites found in the soil, such as Rhodacaridae, Laelapidae, Ascidae, and Melicharidae, have been extensively cultivated using both natural and artificial foods, such as onion thrips (*Thrips tabaci*) and insect eggs.

Figure 1. Adult *Amblyseius swirskii* feeding on thrips larvae. Photograph by Steven Arthurs, University of Florida

Conclusion

Numerous studies focused on the agro-ecosystem management for biological control purposes and associated ecosystem services (less pesticides, well-being, human and animal health, fewer exotic natural enemies). Many surveys were and are still being carried out to characterize the predatory mite species occurring on non-crop plants and the relationships between this fauna and that found on crops. Even if not complete, a huge amount of information exists on the occurrence of predatory mite species on plants. Considering the dispersal of predatory mites within agro-ecosystems, progress has been made but factors affecting this dispersal are not clearly understood and studies on predatory mite traits associated with dispersal ability, might be a research track for future applications in biological control.

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