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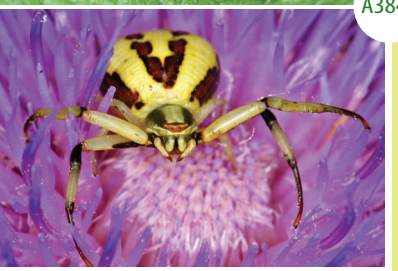

Biological control of insects and mites

An introduction to beneficial natural enemies and their use in pest management

Daniel L. Mahr
Paul Whitaker
Nino Ridgway

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preface

Why use biological control?

Since the late 1940s, insect control has relied heavily on synthetic chemical insecticides. Insecticides are relatively easy to use and have generally provided safe and effective pest control. They will certainly continue to be a component of most pest management programs. Many newer pesticides made available in the past decade or so are more selective and less hazardous than most of the older compounds. Nevertheless, most insecticides have at least some of these undesirable attributes: they usually present some degree of hazard to the applicator and other people who may come in contact with them; they can leave residues that some find unacceptable; they can contaminate soil and water and affect wildlife, aquatic life, and other nontarget organisms; they can interfere with beneficial organisms, such as pollinating insects and the natural enemies of pests; and insects can develop resistance to insecticides, effectively eliminating those materials as pest management options. In addition, organic standards prevent the small but rapidly growing number of organic growers and processors from using synthetic chemicals. For these reasons, many farmers and gardeners are exploring and adopting methods that reduce pesticide use.

Biological control represents one alternative to the use of insecticides. Biological control is the conscious use of living beneficial organisms, called natural enemies, for the control of pests. Virtually all pests have natural enemies and appropriate management of natural enemies can effectively control many pests. Although biological control will not control all pests all of the time, it should be the foundation of an approach called integrated pest management, which combines a variety of pest control methods. Biological control can be effective, economical, and safe, and it should be more widely used than it is today.

Why this publication?

Biological control relies on living organisms that must have food and shelter and that interact with the pests, the crop, and other environmental factors. The pest manager (a farmer, crop consultant, or gardener) should be able to recognize important natural enemies, understand their needs, and know how to maximize their effectiveness. This requires different knowledge and skills than are needed for chemical control. A good understanding of the relationships between pests, their natural enemies, and the environment is essential for success in biological control. The need for this type of knowledge is the rationale for this publication.

This publication provides an introduction to the biological control of pest insects and mites. Because successful biological control relies on knowledge of pests and their natural enemies, we include basic biological information on insects and discuss how insects become pests. We also discuss biological control in the context of other forms of pest control, examining the role of the environment in suppressing pests (natural control), as well as the various general methods for controlling insects.

A major portion of the publication is devoted to a survey of natural enemies. There are hundreds of important natural enemies in the North Central United States, and it is impractical to cover all of them in this publication. Instead, we provide examples from the more common groups of insect predators, parasitic insects, insect-parasitic nematodes, and insect pathogens. We include numerous photographs to help you recognize these beneficial organisms and suggest several sources of further information and images.

The remainder of the publication discusses the three broad approaches to biological control of insects: finding new useful natural enemies, enhancing the effectiveness of natural enemies by protecting them from harm and providing them with necessary habitat and other resources, and releasing additional natural enemies when those naturally present are not adequate.

Numerous books and thousands of scientific and nontechnical articles have been written on this subject. This publication is not an encyclopedic summary of all this information. Instead, we hope this overview stimulates you to seek additional information on the use of natural enemies for your specific pest control needs. Additional Extension resources relevant to the North Central states include biological control publications on pests of cabbage and related crops (NCR471) and greenhouse crops (NCR531) produced by the University of Wisconsin, and pests of field crops (E-2721), forests (E-2679), and home gardens (E-2719) produced by Michigan State University.

The first edition of this publication, now out of print, was printed in 1993. In the intervening years there have been many new developments in biological control, including the arrival of new pests such as soybean aphid, the development of new classes of insecticides that are less harmful to beneficial natural enemies, and the production of new resource materials available to farmers, foresters, and gardeners. The original authors (Mahr and Ridgway) thank Michelle Miller, Center for Integrated Agricultural Systems, College of Agricultural and Life Sciences, University of Wisconsin–Madison, for her dedication to the production of this revised edition, and Dr. Paul Whitaker, Department of Biological Sciences, University of Wisconsin–Marathon County, for researching and writing the new material.

I hope this publication helps you plan and conduct successful biological control.

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acknowledgements

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We thank 11 reviewers for their insightful comments and suggestions on this second edition. They are farmers Dan Specht, Harry Hoch, Linda Grice, Linda Halley, Kevin Shelley, and Sandra Whitney; and researchers Doug Landis, Michigan State University; Mike Hogan, Ohio State University–Extension; Rick Weinzierl, University of Illinois at Champaign-Urbana; Bob Wright, University of Nebraska–Lincoln; and Cliff Sadof, Purdue University. We also thank Mimi Broeske, Nutrient and Pest Management Program, University of Wisconsin–Madison, for suggestions on content. And we thank Tom Kalb, Kenosha County Cooperative Extension Office, Kenosha, Wisconsin; Susan Mahr, University of Wisconsin–Madison; and Rick Weinzierl and Bob Wright for reviewing and providing comments on the first version of the manuscript. The anonymous reviews of North Central States Extension entomologists were also appreciated.

This publication would be much less useful without the many excellent photographs of natural enemies that were supplied by several people. The contributors for each photograph are acknowledged at the end of the publication. We also thank the several people who supplied excellent photographs that we were unable to use. Additionally, we would like to thank Kerry Katovich, Susan Mahr, Steve Mroczkiewicz, Ken Raffa, Kammy Schell, Mike Strand, Dave Hogg, and Merritt Singleton, all of the Department of Entomology, University of Wisconsin–Madison, for providing living insects for photographic purposes. We appreciate the loan of museum specimens by Steven Krauth from the Insect Research Collection, Department of Entomology, University of Wisconsin–Madison, for illustration purposes. Commercial natural enemies were kindly provided for photographic purposes by Applied Bionomics Ltd., Sidney, BC; Gardens Alive!, Lawrenceburg, IN; IPM Laboratories, Inc., Locke, NY; and Biotactics, Romoland, CA.

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The authors of the first edition acknowledge the encouragement and support of Michelle Miller for this revised edition, and the authorship of Paul Whitaker for the expanded and updated text.

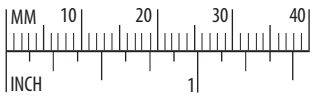
The creativity, hard work, and good humor of the Cooperative Extension Publications Unit of the University of Wisconsin-Extension, especially Linda Deith and Susan Anderson, is deeply appreciated.

A NOTE ABOUT SCIENTIFIC NAMES

Most natural enemies do not have common names. Therefore, we use scientific names throughout the publication. The section entitled "Classification" on page 8 provides an explanation of the nature and use of scientific names.

TERMS IN BOLDFACE

Important terms are printed in **boldface** where they first appear in the text and are defined in the Glossary (pages 103–105).



contents

CHAPTER 1

What is biological control?

Overview

Biological control is the intentional manipulation of populations of living beneficial organisms in order to limit populations of pests. Although biological control can be used to control weeds, the microorganisms that cause plant diseases, and even some vertebrates, this publication focuses on the biological control of insects and mites. In this publication, we refer to the beneficial organisms that attack pests as **natural enemies**, though you may also know them as "good bugs," beneficial insects, or beneficials. The natural enemies of insects are a diverse group of organisms that includes predators, parasitic insects, nematodes, and various microorganisms. The intent of biological control is not to eradicate pests, but to keep them at tolerable levels at which they cause no appreciable harm. In fact, because natural enemies require their prey or hosts for survival, biological control works best when there is always a small population of pests to sustain their natural enemies. This is a major difference between biological control and the use of pesticides.

There are three broad approaches to biological control:

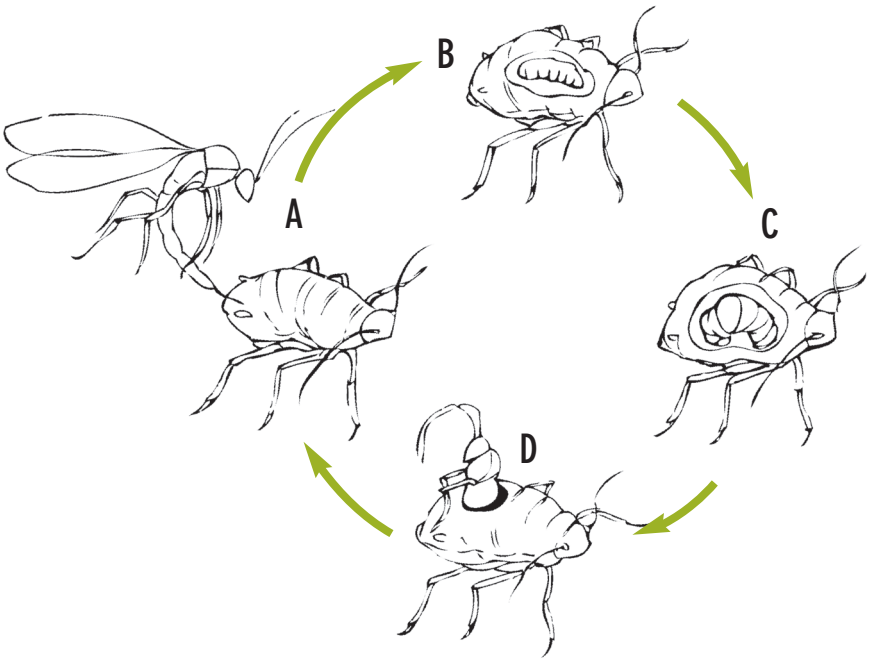
- **Classical biological control** (also called **importation of natural enemies**) involves the importation, screening, and release of natural enemies to permanently establish effective natural enemies in new areas. Classical biological control usually targets introduced (**non-native**) pests, most of which arrive here without the natural enemies that control their populations in their native lands. Native pests that are not adequately controlled by existing natural enemies may also be the target of classical biological control. These activities are tightly regulated and are conducted solely by federal and state agencies, unlike the following two approaches, which can be used by anyone.
- **Augmentative biological control** (or augmentation of natural enemies) typically involves the purchase and release of natural enemies that are already present in the United States but may not be numerous enough to adequately control pests in a particular location. The goal of augmentative biological control is to temporarily increase the number of natural enemies and, therefore, the level of biological control of the target pest.
- **Conservation biological control** (or conservation of natural enemies) improves the effectiveness of natural enemies through farming and gardening practices that provide necessary resources for their survival and protect them from toxins and other adverse conditions. These conservation practices will benefit all natural enemies, whether they are native, successfully established through classical biological control, or released for augmentative biological control.

These three approaches are discussed in greater detail in chapters 7–9, but a few historical examples may help clarify the three approaches to using natural enemies in biological control.

Many centuries ago, Chinese farmers observed that ants were helping to control insect pests in their citrus orchards by feeding on caterpillars, beetles, and leaf-feeding bugs. The farmers discovered that collecting the papery nests of these ants from trees in the countryside and moving them into their orchards improved control of some orchard pests. They also provided aerial bamboo runways among the citrus trees to help the ants move easily from tree to tree. These efforts to increase the numbers of ants in orchards and to heighten their efficiency as predators are the first recorded occurrence of biological control of insects. Specifically, the movement of ants from the countryside into the orchards is an example of augmentative biological control. The use of runways between trees increased the ants' access to prey while keeping them away from potential harm on the orchard floor, so this is also an example of conservation biological control.

In the mid-1880s, southern California's developing citrus industry experienced devastating losses from an introduced pest called cottony cushion scale. Growers tried every available chemical control, even fumigation with hydrogen cyanide, but nothing provided sufficient control; many growers removed their citrus groves because the damage was so serious. After determining that the scale insect was native to Australia and New Zealand, the United States Department of Agriculture sent an entomologist to that area to look for effective natural enemies. The entomologist found a small lady beetle, the vedalia beetle, which he sent to California. It reproduced rapidly in infested citrus groves and brought the cottony cushion scale under complete and lasting control. This was the first highly successful case of controlling a non-native pest by introducing its natural enemies from their native land, a technique now known as classical or importation biological control.

Figure 1. The generalized life cycle of a parasitic wasp, as exemplified by an aphid parasite. (A) Wasp lays egg in a host, in this case a young aphid. (B) As host feeds and grows, parasite larva feeds on host and also grows. (C) When parasite larva is full grown, it pupates within the host, which is now dead. (D) The parasite pupa transforms into an adult wasp, which emerges from the host. After mating, the young wasp seeks new hosts to parasitize.



Types of natural enemies

Natural enemies of insects include predators, parasitic insects, nematodes, and pathogens. Successful application of all forms of biological control requires familiarity with these natural enemies and their benefits and understanding how they fit into an overall pest management program. Although the types of natural enemies are discussed in more detail in chapters 4 and 6, a brief introduction is necessary here.

Predators may be insects or other insectivorous animals, each of which consumes many insect **prey** during its lifetime. Predators are often large, active, and/or conspicuous in their behavior, and they are therefore more readily recognized than are parasites and pathogens. Familiar predators of insects include lady beetles, praying mantids, spiders, birds, and bats.

Parasites of insects (also called **parasitoids**) are insects that lay their eggs in or on a **host** insect. When the parasite egg hatches, the young parasite larva feeds on the host (the pest) and kills it (figure 1). Usually that one host is sufficient to feed the immature parasite until it becomes an adult. Many parasites are host-specific, meaning they attack only one or at most a few closely related **species** of host. No insect parasites are harmful to humans or other vertebrates. Although very common, they are not well known because of their small size. One of the smallest, *Trichogramma*, is only about the size of the period at the end of this sentence.

End of sample.

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