# Biological Control of Pests
# 4-H IPM Project

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## CONTENTS




This manual was prepared by the 4-H IPM Committee: Donald G. Manley, Extension Entomologist; Edward C. Murdock, Extension Agronomist; John Thompson, County Extension Agent; W. Romando James, Extension 4-H and Youth Development Specialist; Donnie R. King, Extension 4-H and Youth Development Specialist; and R. Walker Miller, Extension Plant Pathologist.

# BIOLOGICAL CONTROL OF PESTS

Over long periods of time (thousands or even millions of years), a balance has been established in nature between predator and prey; between the eater and the eaten. Sometimes we like to assign the labels "good" and "bad." However, in nature there is no "good" and 'bad"; there is merely the natural scheme of things.

While organisms may not be inherently good or bad, they may have a positive or negative effect in their relationships with us. If the effect is negative, we frequently refer to the organism as a pest. If the relationship is positive, we call the organism beneficial.

## NATURAL CONTROL

Under natural conditions, most organisms die a natural death. There are natural "checks and balances" on populations of all living things. Weather is an important factor in natural control. It may be too hot, too cold, too wet, or too dry. Lack of food often causes death in nature; many organisms simply starve to death. Many organisms are killed by other organisms - predators, parasites, and pathogens (disease organisms). When organisms are killed by other organisms, this is called biological control. That is, their death is the result of a biological interaction. Natural biological control occurs all of the time; it is occurring all around us.

## CHEMICAL CONTROL

Although there are separate 4-H booklets on the use of pesticides and the topic of this project booklet is biological control, we need to review a few of the basics of chemical control.

Pesticides are necessary to grow enough food for all people living in the world today. They are our last line of defense against pest organisms. But they must be used wisely, something that we have not always done.

There are risks involved with pesticide use. These include their danger to people, their effect on the environment, their residual buildup, pesticide resistance, and their effect on nontarget organisms such as beneficial insects, birds, domestic animals, and sometimes the crop itself. When using pesticides, we must weigh the benefits against the risks and only use pesticides when necessary.

The main advantage of pesticides is that they work. They have been very effective tools in keeping pest organisms under control. And until recently, they have been an inexpensive means of pest control.

## BIOLOGICAL CONTROL

What is biological control? It is the regulation of pest organisms by their natural enemies, or the reduction of pest numbers by predators, parasites, and pathogens to levels below what they would be in the absence of these natural enemies. We have already said that biological control occurs naturally. What is the difference between natural control and biological control?

Natural biological control occurs with no interference or intervention by humans. Biological control, as we will be referring to it from this point on, involves human activities. There is some intervention by people that enhances the effectiveness of the natural enemies.

### HISTORY

Biological control is not a new concept. As early as 5000 B.C., the Chinese were placing bamboo poles between ant nests and fruit trees to make it easier for ants to prey on citrus scales. In the 1750s, the British and French transported mynah birds from India to Mauritius to control locusts. Well-thought-out biological control projects were becoming numerous in the mid to late 1800s.

From World War I until the 1960s when pesticides were plentiful and cheap, biological control was somewhat forgotten. However, since the 1960s, it has been making a comeback.

### ADVANTAGES

Biological control of pests offers a number of advantages over other pest-control strategies, particularly pesticides. It is safe to the applicator and the environment. There are no residues. Biological control is frequently very economical. Often we are merely manipulating something to favor naturally occurring control. Biological control is usually permanent, eliminating the need for continuous reapplication, as is necessary with pesticides. And, in many cases it is easily established. Another advantage is that biological agents are frequently very host specific.

### DISADVANTAGES

The major disadvantage of biological control is that it is often slow. If a pest population is already at or above economically damaging levels, pesticides are frequently the only suitable answer. Careful advance planning is usually necessary for successful biological control.

A second disadvantage is that biological control agents do not completely eradicate (eliminate) their host. If they did this, they too would die. Therefore, we must get used to the idea of having a few of the pest species around. However, biological control may be integrated with other pest-control strategies to keep pests below economic levels.

Another disadvantage is that there may be "crossovers." That is, the biological control agent may feed on a desired plant or insect also. Careful selection of the control agent will minimize this problem.

Finally, in the biological control of weeds, biological control agents are frequently effective only in single-weed situations and not in multi-weed complexes. This may be because the weed and the crop are so closely related that the control agent affects both pest and crop, or it may be because the control agent is too host-specific to control a wide variety of weed problems.

## BIOLOGICAL CONTROL AGENTS

When we speak of biological control agents, we are normally speaking of three types of organisms: predators, parasites (sometimes referred to as parasitoids), and pathogens (or diseases). In this section, we shall discuss these control agents in more depth.

### PREDATORS

A predator is generally defined as an organism that kills and consumes all or part of several individuals or hosts during its life cycle. Generally predators are larger than their prey and are very mobile. They are usually not very host specific. Since they feed on more individuals, fewer predators are generally required for control and, therefore, most have lower reproductive rates. Frequently both adults and immatures are predatory, and they tend to be active day and night. Lady beetles, frogs, birds, skunks, and bears are examples of predators.

### PARASITES

A parasite is generally defined as an organism that kills and consumes all or part of only a single individual or host during its life cycle. Parasites are generally smaller than their prey and tend to be more immobile. Parasites are usually very host specific. Since they feed on a single host, more parasites are usually required for control and, therefore, most have high reproductive rates. Parasites are usually active only during the day. Many wasps and flies are parasites.

### PATHOGENS

Pathogens are disease organisms. They are sometimes referred to as microbial parasites. They include viruses, bacteria, fungi, protozoa, and nematodes. A wide range of pest species (including plants, fungi, nematodes, bacteria, protozoa, and insects) are afflicted by disease-causing agents, which may prevent them from reaching damaging levels or greatly reduce their potential to cause injury.

Though people have long recognized the importance of pathogens under natural conditions, deliberate introductions of pathogens have not been widely attempted. The reason is that most pathogens require a very specific environment that is hard for people to create. When it is possible, it is usually too costly to be practical.

Recently, however, there have been great strides with microbial insecticides such as *Bacillus popilliae,* the milky disease of Japanese beetles, and *Bacillus thuringiensis,* a disease of many pest caterpillars, and with several fungal pathogens of weeds.

### CONSUMERS

Pest plants, or weeds, have a broad spectrum of natural enemies. Those that feed upon the pest plant are not easily classified under the headings of predators or parasites. For lack of a better term, we will refer to them as consumers. These consumers feed directly upon the host plant, frequently eating virtually all of the foliage. Consumers are frequently quite numerous. These consumers may be vertebrates (such as cows or goats), which use the plants as food. Or, more frequently, they are insects. These include beetles, caterpillars, and grasshoppers.

## CHARACTERISTICS OF EFFECTIVE NATURAL ENEMIES

A natural enemy must have a number of characteristics if it is to be successful in a biological control program. First, with the exception of fungal and bacterial pathogens, the natural enemy must have a high searching capacity. That is, it must have the ability to find its host. Even pathogens must have a mechanism for finding their host. This ability is most critical when the host is scarce or at low populations. And if the natural enemy is to be successful, it must keep the host at low population levels.

Along the same line, the distribution of the natural enemy must be similar to the distribution of the host. In other words, they must be able to occupy the same areas. It would do no good to import a natural enemy into an area where it could not survive, even if it were able to control the pest under different conditions.

A natural enemy should be fairly host specific. This is especially true of parasites and pathogens, but it is also true of predators and consumers. The life cycle of the natural enemy should be in synchrony with that of the host. Usually a predator or parasite population lags slightly behind that of the host.

Effective natural enemies usually have a very high reproductive rate and a short developmental period. In most instances the biological control agent will have a shorter life cycle than the host.

Another very important characteristic of biological control agents is that they must be easy to mass rear or grow under laboratory conditions. If not, they will be of little more benefit than the natural control. They should also be easy to disperse.

## SEQUENCE OF STEPS IN BIOLOGICAL CONTROL

There is a sequence of steps that should be taken in any biological control project. These steps ensure that the so-called beneficial does not turn out to be a pest in itself. The importation of kudzu for soil conservation is an example of this. Though it is effective in soil conservation, kudzu is now a serious pest. Under most conditions, none of the following steps should be eliminated.

### STUDY

The first step is to study the literature. Look for other areas where the "pest" is not a pest. One usually needs to look no farther than the origin of the host plant. In their native habitat, host and pest have usually reached a natural balance.

When an area is found where host and pest live in harmony, a team of scientists is usually sent to study why the pest is not serious there. The search nearly always includes exploration for natural enemies. Finding effective natural enemies in the host plant's native habitat concludes the first step.

### IMPORTATION OR INTRODUCTION

The next step in the biological control process involves importation of the natural enemy (or enemies). This involves a quarantine period for all imported organisms. Such questions as where it can live and reproduce, the spectrum of potential hosts, etc., must be answered. This step is necessary so that we do not import "solutions" that become more serious than the "problems."

### AUGMENTATION

This step, quite simply, is the rearing and release of natural enemies or pathogens. Natural enemies are generally reared in large numbers in laboratories and released in target areas. This step and the remaining step apply equally to natural enemies that are imported from other areas and to those that are already here.

Release of natural enemies may take one of these forms: inundation or inoculation. With inundation, the target area is flooded with a large number of the natural enemies. Ideally, such a release will bring the pest(s) under control quickly and it is hoped that the natural enemies will become permanently established in the area. With weed pathogens, reintroduction is usually required annually.

Inoculation of an area usually involves much lower numbers. It is designed to allow establishment of a biological control agent in an area. Or, such a release may be used merely to improve the natural enemy/pest ratio.

### CONSERVATION

The final step in the biological control process is one that is frequently overlooked. Yet, it is just as important as any of the others. If we do not conserve our natural enemies once established, we must continually introduce more, and this quickly becomes uneconomical.

Through conservation practices, we create conditions that enable the control agent to stay and live in the target area. We create conditions that favor natural biological control because ideally, once established, the biological control agent should stay and continue to provide natural control indefinitely without further intervention. Knowing the biology and ecology of the natural enemies is important, for this will enable us to provide suitable protective sites for survival, especially during the off-season. Cultural practices and selective use of pesticides can help conserve natural and introduced biological control agents.

## EXAMPLES OF INTRODUCED BIOLOGICAL CONTROL OF WEEDS

1. St. Johnswort *(Hypericum perforatum),* also known as Klamath weed or goatweed, was first reported as a problem in the western United States around 1900. It infested thousands of acres of rangeland that were too extensive and inaccessible for effective herbicide use. St. Johnswort reduced stands of desirable forage species by competing for essential growth requirements such as water, nutrients, and light. In addition, it was toxic to livestock, causing reductions in weight and vigor.

A leaf-feeding beetle *(Chrysolina quadrigemina: Chrysolina gemellata)* that could effectively control St. Johnswort was discovered in southern France and in England and was released in the western United States in 1945-46. This was the first attempt in North America to control a plant with a plant-feeding insect. Established stands of St. Johnswort were reduced by 99 percent, and the beetles continue to maintain weed populations below harmful levels. As a result of the release of these beetles, land values increased, the rangelands have a greater capacity for supporting livestock, and control costs for St. Johnswort are negligible.

2. Prickly pear *(Opuntia* sp.) was introduced into Australia in 1839, and by 1925 more than 60 million acres were infested. One-half of this acreage was infested so heavily that the land was useless. Chemical and mechanical control measures were effective but could not be economically justified.

A cactus moth *(Cactoblastis cactorum)* was introduced into Australia from Argentina in 1925, and it has provided excellent control of prickly pear. Since the introduction of the insect, millions of acres have been returned to productive uses.

3. Millions of acres of wheat in Australia were heavily infested with rush skeletonweed *(Chondrilla juncea).* In 1971, Chondrilla rust *(Puccinia chondrillina)* was introduced into Australia from Italy, and this plant pathogen has effectively controlled rush skeletonweed in wheat throughout Australia.

## EXAMPLES OF AUGMENTED BIOLOGICAL CONTROL OF WEEDS

1. Northern jointvetch *(Aeschynomene virginica)* is a problem weed in rice production. The fungal pathogen *Collecotrichum gloeosporioides aeschynomene* (c.g.a.) is often present on this weed, but it does little damage because it normally attacks too late in the growing season. However, spores of c.g.a. applied as a bioherbicide provide excellent control of northern jointvetch and are now being successfully marketed.

2. In 1981, Abbott Laboratories marketed the fungus *Phytophthora palmivora* for use as a bioherbicide to control strangler vine (*Morenia odorata)* in Florida citrus groves.

3. Livestock such as cattle and goats can effectively control some weed species. For example, in South Carolina and other areas, livestock are often used to control kudzu *(Pueraria lobata)* where herbicides cannot be used and where the use of livestock is practical.

Geese have been effectively used to control weeds in strawberries, cotton, other crops, and nurseries. There is no widespread use of “weeder geese” now, but they are used by organic growers and in some specialized agricultural enterprises. Twelve geese are equivalent to one person with a hoe, and four to eight geese per acre will provide adequate control of weeds.

The white amur, a herbivorous fish that feeds on many aquatic weeds, has provided successful control of weeds in ponds.

## EXAMPLES OF INTRODUCED BIOLOGICAL CONTROL OF INSECTS

1. The cottony cushion scale, *Icerya purchasi,* was accidentally introduced into California around 1868. By 1887, it had become such a serious pest of citrus that the entire citrus industry in California was threatened with destruction. The cottony cushion scale was a pest everywhere in its distribution except in Australia. Two natural enemies were introduced from Australia to California: the vedalia ladybeetle, *Rodalia cardinalis,* and a parasitic fly, *Cryptochaetum iceryae.* Both became established, especially the ladybeetle, and by 1889 had brought about complete suppression of the scale. This is frequently regarded as the classic example of introduced biological control.

2. The Oriental fruit fly, *Dacus dorsalis,* was accidentally introduced into Hawaii in the 1940s. With the favorable Hawaiian climate and abundant variety of

hosts, the fly population quickly exploded to become a serious pest of many fruits grown in the islands. In 1947-48, three braconid wasp parasites were introduced on parasitized fruit flies from the Orient. These three parasites, *Opium longicaudatus, O. vandenboschi,* and *O. oophilus,* established themselves in a successional sequence. By 1951 the latter parasite had gained full dominance, which it continues to maintain, and the fruit fly population seldom reaches economically important levels.

3. Grasshoppers have long been serious pests throughout the world. An early attempt at introduced biological control of grasshoppers was the introduction of the bacterium *Coccobacillus acridiorum* by d'Herelle in 1912 in an attempt to initiate an epizootic population. Although the disease organism did provide some control of the migratory locust in Mexico, the attempt was generally considered to be unsuccessful. More recent introductions of disease organisms, with better understanding of their biologies, have been more successful.

## EXAMPLES OF AUGMENTED BIOLOGICAL CONTROL OF INSECTS

1. Homeowners often go to their local garden center and purchase lady beetles or mantid egg cases for release around their shrubs or gardens. Both of these are naturally occurring predators, and both will be of benefit as long as they remain well fed. Unfortunately, if food becomes scarce, they fail to recognize property boundaries and will move elsewhere for a meal.

2. *Trichogramma* sp. are naturally occurring wasps that parasitize the eggs of many pest species, including the bollworm, *Heliothis zea,* in cotton and soybeans. Attempts have been made to rear and release these wasps to augment natural populations. Success has been relatively limited due to the extreme sensitivity of these wasps to pesticides and the great quantities of pesticides used on these crops. The parasites do, however, continue to provide some measure of natural biological control.

3. Nuclear polyhedrosis viruses of the cabbage looper and the beet armyworm occur naturally. These two insects are pests of numerous crops, including cotton and soybeans. Populations of both pests are periodically reduced by epidemics caused by these viruses. Unfortunately, under natural conditions, these epidemics frequently occur late in the season after extensive pest feeding. It has been discovered that these viruses can be collected from the field, reared in the laboratory, and released in the field earlier in the season to minimize damage by these pests. Commercial use of the naturally occurring *Bacillus thuringiensis* for control of hornworms, budworms, and other pests is also well documented.

## BIOLOGICAL CONTROL IN YOUR 4-H PROJECT

1. Discuss the advantages and disadvantages of biological control as a pest-control strategy.

2. Identify some people who use biological control in their jobs, for example, a farmer, nurseryman, county agent.

3. Make a list of careers in which biological control might be used. (Your county agent, librarian, or science teacher may be able to help.)

4. Identify a situation where biological control might be used. Carefully plan a biological control project that can be accomplished by you as a 4-H'er. Complete the project. Be sure to keep good records of your project plan, what you actually do, the cost of the project, and the benefits (including financial savings, if any).

## CONCLUSION

As you conclude the 4-H Biological Control Project, we hope that through it you have learned:

- That biological control is a preferred method of pest control;
- What advantages and disadvantages are associated with biological control;
- That natural biological control is taking place constantly around us; and
- What the career opportunities are in this field.