Fact Sheet

Canadian Forestry Service

Environment Canada
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BIOLOGICAL CONTROL OF INSECT PESTS

Fig. 1 — Dying spruce-fir forest following several years of severe defoliation by the spruce budworm

Most insects that feed on forest trees can breed rapidly, causing widespread damage to Canada's forests. Fortunately, few become major pests because they are usually held in check by natural means such as weather, or attack by other living organisms. Such organisms are known as biological control agents.

Biological control agents play an important role in the natural regulation of pests. Without them, many insects that feed on forest trees would occur in such numbers as to inflict serious damage. With these agents, the numbers of most potential pests can be kept so low that the effect on a tree's health is minimal.

Predators and parasites

The most important biological control agents are of two types — known as predators and parasites. Their names denote the way in which they attack the pest insect, or host. The distinction is sometimes difficult to make.

Predators are organisms that capture and devour the insect pest. They include insect-eating birds, some small mammals such as shrews, and some spiders and mites. There are also insects that prey on other insects — for example, the praying mantis and the larvae of ladybird beetles.

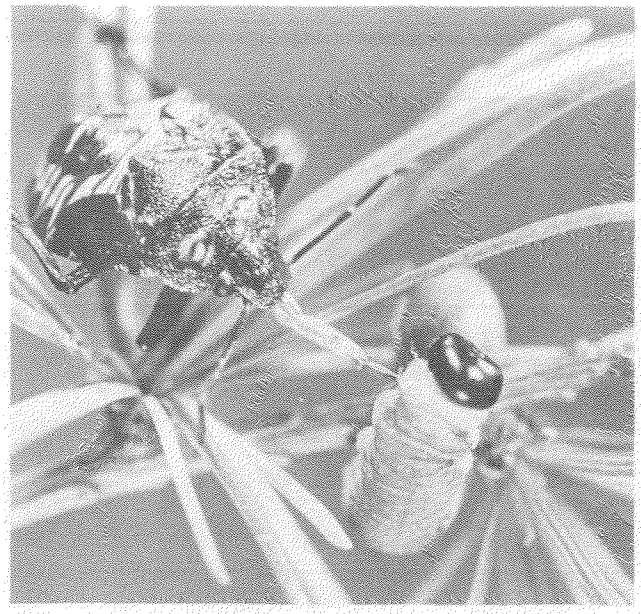

Fig. 2 — Pentatomid predator feeding on a sawfly larva

Parasites are organisms that usually live within the host, drawing their nourishment from it without giving anything useful in return. Generally, the host dies. Some parasites, however, only weaken the host insect, slowing down its development and thereby reducing the pest population.

Parasites are further divided into two main types:

1. Parasitic insects (parasitoids)
These often lay their eggs on or within the host, where they hatch and the larvae develop by consuming the host. When the adult parasitoid emerges, the cycle begins again. Parasitoids are frequently host-specific — that is, they only lay their eggs on or in specific pest insects. Some parasitoids are able to find even hosts that occur in very small numbers, and so keep populations of pest insects down to levels at which they can do little damage to the forest. Some species of tiny wasps and flies are examples of parasitoids.

2. Parasitic microorganisms (pathogens)
Four groups of pathogens are important in forestry: bacteria, viruses, fungi and protozoa. Any of these

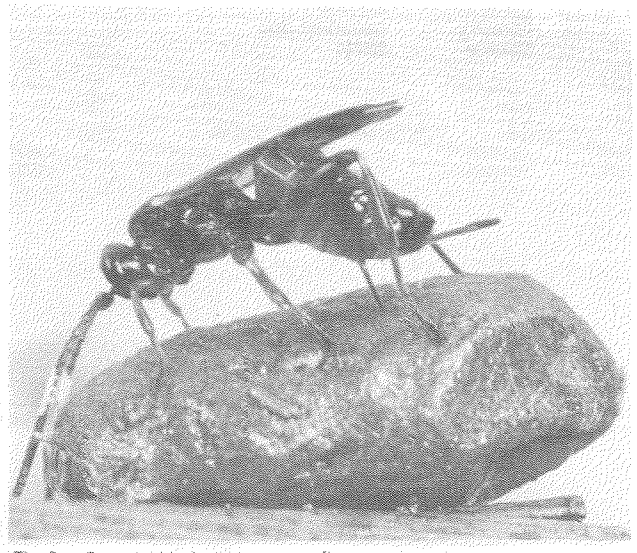

Fig. 3 — Parasitoid laying eggs on sawfly cocoon

may enter the host by contaminating its food, entering through its outer covering, or contaminating the eggs of the female host.

Bacteria, viruses and fungi usually cause diseases fatal to the host, while protozoa more often live at the host's expense, weakening but not killing it. Disease symptoms can betray the type of infection. A white, cottony growth on the outside of a dead or dying insect indicates a fungal infection; dead larvae with a dark and flaccid appearance denote virus infection; and a shortened, shrivelled larva with an abnormally large head shows infection by bacteria.

Some pathogens develop quickly, causing an outbreak of disease that spreads through and drastically reduces populations of the host insect. Others, although also lethal, spread less quickly.

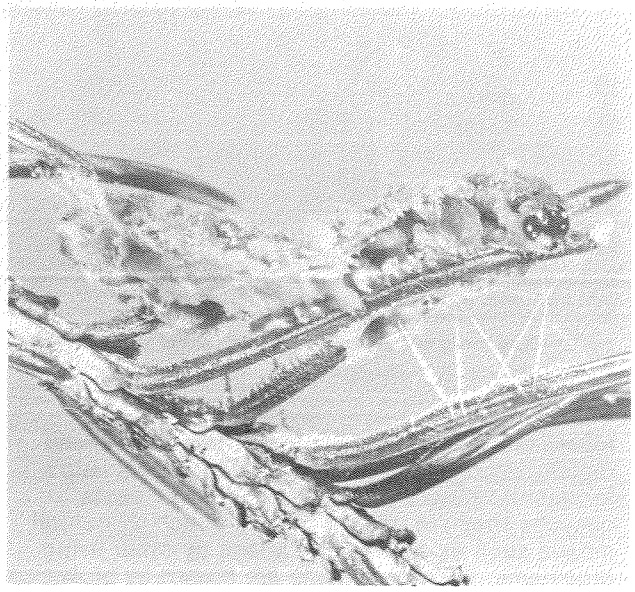

Fig. 4 — Spruce budworm larva killed by a fungal pathogen

How is biological control used?

Biological control agents can be employed against forest insect pests by:

- adjusting the environment to help predators: for example, providing good nesting sites for insect-eating birds
- adjusting the environment to help parasitoids; for example, planting vegetation that will support alternate hosts for parasitoids, or will provide adult parasitoids with a food source
- breeding and releasing parasitoids and predators
- producing and applying pathogens
- introducing foreign parasitoids to feed on accidentally-introduced pests

While these methods may all work in particular situations, the effective use of any biological control agents is not a simple matter. One must first understand how the pest develops and spreads, and the precise way in which the control agent works.

Also, and especially with pathogens, it is important to ensure that their introduction will not be a danger to the environment, or to public health and safety. When used under such conditions, biological control agents have good potential for use in forestry, and the Canadian Forestry Service is investigating ways of using them, through research and development programs at its research centres and institutes across Canada.

Some success stories

During the 1930s, the European spruce sawfly *(Gilpinia hercyniae)* threatened the entire spruce population of eastern Canada — a problem similar in magnitude to today's spruce budworm outbreak. In the Gaspé Peninsula, where the infection was first detected, half of the marketable spruce was destroyed before the outbreak was eventually controlled by the introduction of a virus and several parasitoids. Because of the continuing control exerted by these parasites, the European spruce sawfly is no longer a problem in Canada. The program cost $300 000.

Another European pest, the winter moth *(Operophtera brumata)* appeared about 1930 in the Maritime provinces, where it attacked red oak, red maple and white elm. Two parasitoids were introduced in the late 1950s, and by the mid-1960s the winter moth had become one of the less common defoliators of hardwoods in the Maritimes. Before regulation of this pest, losses through its destruction of red oak alone exceeded $7 million; unchecked, losses would have reached $38 million in the dollar values of that time. The program cost $500 000.

There has also been some success with insect pathogens. The bacterium *Bacillus thuringiensis*, developed for use after years of research, has been commercially available for some time. It is notably effective against the larvae of many butterflies and moths that attack both trees and agricultural crops.

This pathogen does not spread naturally through the host population. Thus, it provides protection mainly in the year of application only, and must be reapplied to later generations of pests, like conventional chemical insecticides.

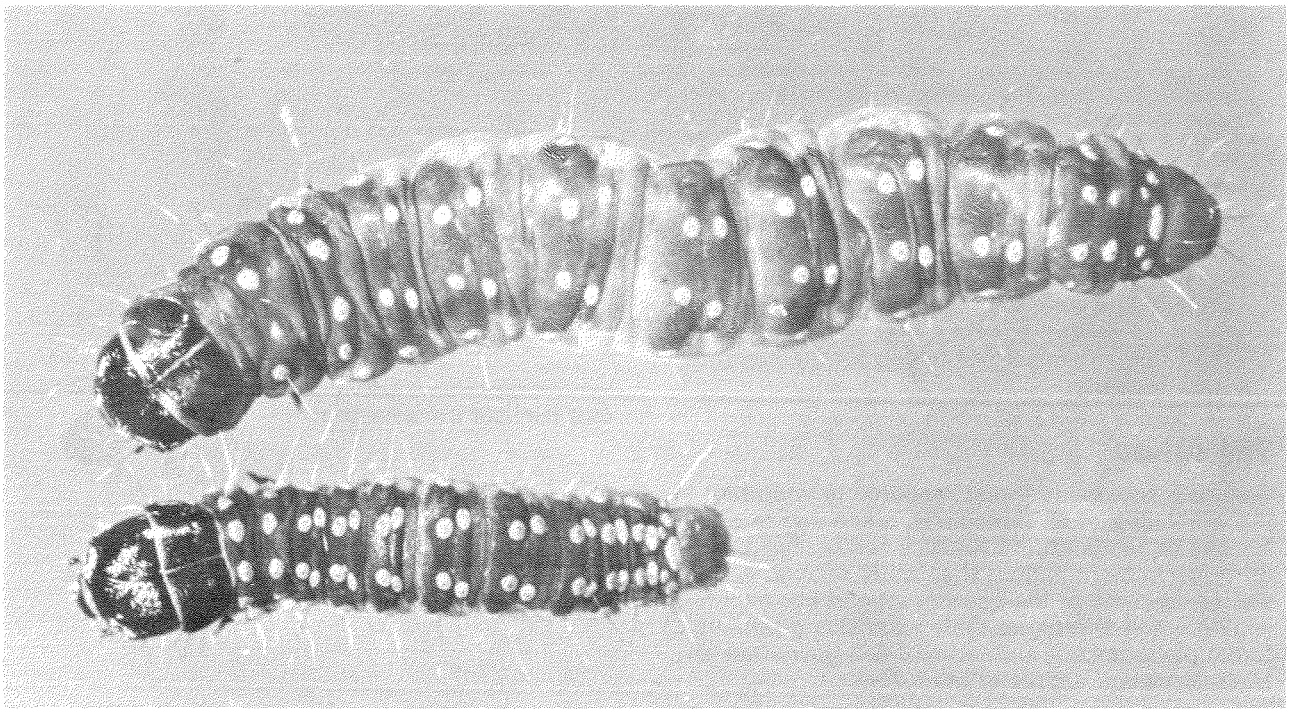

Fig. 5 — *The top spruce budworm larva has developed normally; the bottom larva of the same age is infected with Bacillus thuringiensis*

Future possibilities

The Canadian Forestry Service is currently studying a wide range of insect pathogens against forest pests. A virus has been found that is extremely effective against the redheaded pine sawfly *(Neodiprion lecontei)*, a serious pest of red and Scots pine plantations. This virus spreads rapidly from spot introductions and gives fast and complete protection to entire pine plantations.

Similar types of virus are effective against the Douglas fir tussock moth *(Orgyia pseudotsugata)* and Swaine jack pine sawfly *(Neodiprion swainei)*. While studies on pathogenic fungi are not so far advanced, these also show promise for use against such pests as the hemlock looper *(Lambdina fiscellaria fiscellaria)* and the spruce budworm *(Choristoneura fumiferana)*.

Pros and cons of biological control

Pro —

1. Biological control has the potential to regulate insects that cause economic damage to Canadian forests. Realization of this potential should reduce dependence on chemical insecticides, at present our only effective defence against many forest pests.
2. Whereas chemical insecticides kill a variety of insects, biological control agents tend to be host-specific, so their effects on beneficial and harmless species, as well as on other wildlife, will likely be less.
3. Some biological control agents are self-perpetuating — that is, once introduced, they maintain themselves, and hold their hosts in continual check.

Con —

1. The effects of biological control agents are slower to appear than those of chemical insecticides.
2. More research is needed before many of them will be ready for practical application in the field.
3. Since, at present, most biological control agents can only be produced in living hosts, the rate of production is low, and the cost high. Costs, coupled with their host-specific tendencies, make biological control agents a less attractive proposition than chemical pesticides for the manufacturing industry.

The future

Canada's renewable forest resource is important to the well-being of all Canadians, since one in every 10 jobs depends on the forestry sector. But this resource is more limited than most people realize, and some parts of the country are already experiencing wood shortages. Only extensive programs of forest management and renewal will guarantee an adequate wood supply in the future.

Such programs must include the development and application of improved ways of protecting the forest from insect damage. At present, chemical insecticides offer the most reliable protection and will continue to be used, with proper caution, where required. However, research and development in a wide range of biological controls will, it is hoped, make them available for use in the field, thereby reducing reliance on chemical insecticides. The Canadian Forestry Service is dedicated to this long-term goal and plans to devote a substantial part of its program in forest protection research to the development and use of biological control agents.

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For further information

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