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INSECT PARASITES CONTROL THREE INTRODUCED SAWFLIES

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INTRODUCTION

Insect parasites (or parasitoids) encompass a group of natural enemies which, in their immature stages, live on or inside another insect and eventually kill their host. Biological control refers to the use of such natural enemies to reduce pest numbers. Classical biological control involves the introduction of exotic natural enemies to control exotic or introduced pests. The objective of classical biological control is to establish a viable population of a natural enemy—a population that will persist in an area and then spread naturally to attack the host insect throughout its range.

This technical note highlights three cases of successful classical biological control. The cases illustrate that there is no standard approach for use on all pests. Rather, specific biological control measures are based on an understanding of the biology and ecology of each pest and its natural enemies.

EUROPEAN SPRUCE SAWFLY CONTROLLED WITHOUT CHEMICAL PESTICIDES

In the autumn of 1930, foresters traveling in the interior of Quebec's Gaspé Peninsula reported serious defoliation in spruce stands. The following year an aerial survey indicated that some 5 000 km^2 of forest in the region were defoliated—the European spruce sawfly (*Gilpinia hercyniae* [Hartig]) had arrived in North America (Fig. 1).

The European spruce sawfly had been known in Europe for over 100 years, but it had caused little or no damage. In the Gaspé, however, it killed an estimated 41 million m^3 of spruce in less than 15 years. In one district, the white spruce (*Picea glauca* [Moench] Voss) cover type was reduced by 111 m^3 per hectare. Surviving trees suffered growth losses and, eventually, windfall. Within 3 years of its discovery, the sawfly outbreak had spread to most of Quebec, New Brunswick, and adjacent regions in the United States. By 1938 the insect had been detected in Nova Scotia and Prince Edward Island, and west into Ontario as far as Lake Superior.

Besides its damage to forests, the sawfly is historically important for its role in one of Canada's most successful programs of forest insect biological control. Between 1933 and 1951 the forest industry and government agencies cooperated in the release of over 890 million parasites. The Dominion Parasite Laboratory at Belleville, Ontario, was established to propagate millions of parasites for the annual releases, and to do research on the use of such parasites and predators for biological control. After 1942 the sawfly outbreak began a rapid decline. Shortly following the last release, the European spruce sawfly was reduced to an "unimportant" insect in terms of its economic impact (Neilson et al. 1971).

Figure 1. European spruce sawfly.

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Most of the parasites released in Canada were obtained from Europe. *Dahlbominus fuscipennis* (Zett.), a parasite of sawfly cocoons, was released in the greatest abundance. It established very quickly in areas of high European spruce sawfly infestation in Canada. Following introduction, samples showed that parasites attacked as many as 60 percent of the sawfly cocoons.

By 1940 other natural factors, among them poor weather, insect predators, and small mammals, contributed to reductions in sawfly numbers. A viral disease, believed to have been accidentally introduced with either the parasite or the sawfly, rapidly spread over a wide area and claimed a significant number of sawflies. Annual releases of hundreds of millions of insects may have helped to distribute the virus.

During the 18-year program 27 introduced natural enemy species were released, and nine of these established with variable effects on the host. Over 90 percent of the released insects were *D. fuscipennis*. This species was critical in reducing the sawfly population from the outbreak level. Since then, two other parasites, *Drino bohemica* and *Extenterus vellicatus*, have been more important in maintaining low-level sawfly populations.

By 1951 the sawfly outbreak was under control. Like many native insects, the European spruce sawfly now survives at low levels, but occasionally attains higher, although not economically significant, populations where conditions are favorable or when natural control factors have been reduced by the use of broad spectrum chemical insecticides.

At a cost of approximately $300,000 (1940 dollars), the 21-year biological control program against the European spruce sawfly eliminated the need for any further control measures. In contrast, the spruce budworm, *Choristoneura fumiferana* (Clemens), has to date eluded such biological control attempts and continues to pose a perennial problem in eastern Canada. For the period 1950 to 1980, the cost of budworm spray programs has been estimated at $200 million (Hulme 1988).

MOUNTAIN ASH SAWFLY: BIOLOGICAL CONTROL OF AN URBAN DEFOLIATOR

Mountain ash (*Sorbus* spp.) are appealing shade trees, and valued in urban landscapes for their attractive foliage, showy flowers, and bright orange–red fruit. However, introduced urban landscape species are susceptible to numerous pest problems. One major defoliator of mountain ash is *Pristiphora geniculata* (Hartig), the mountain ash sawfly, and a native of Europe. Although it rarely kills trees, damage caused by this sawfly has been severe enough to reduce the popularity of mountain ash in urban forestation. The sawfly also infests native mountain ash in forested habitats (Fig. 2).

The mountain ash sawfly was imported to North America from Europe, probably as cocoons in nursery stock. Since its first detection in 1926, the sawfly has spread throughout the range of its host from the northeastern United States to Canada.

The biological control of mountain ash sawfly in North America led scientists in Europe to a parasitic wasp called *Olesicampe geniculatae*. However, the sawfly was so rare in Europe that scientists with the Canadian Forest Service had to produce 10 000 sawfly cocoons in Canada for shipment overseas to create artificial infestations in Austria. There, the wasp attacked the sawfly larvae while they were feeding and remained in the larvae until they dropped from the trees to pupate. More than 1 000 parasites, returned in sawfly cocoons to Canada, became the seeds of a rearing program.

In 1976 and 1977, parasites were released in mountain ash plantations near Beaumont, Quebec (Quednau 1990). To encourage establishment, both sawflies and wasps were confined to infested trees in screened tents so as to maintain high host density and protect the introduced parasitoids from animal predation.

In August 1977 the emergence of parasite females provided evidence of successful establishment. Parasitism in the vicinity of release cages was 92 percent. In a neighboring nursery sector, 65 percent of the sample of young sawflies was parasitized. In the second summer following release the wasps were present 300 to 500 m from the point of origin. Within 4 years, parasitism was 90 percent or greater in all five plantation sampling sectors. By 1985, the mountain ash sawfly was all but eliminated in Beaumont. By 1988, 12 years after the experimental release, *O. geniculatae* had dispersed naturally and was recovered as far east as Truro, Nova Scotia, and as far west as Peterborough, Ontario. These represented distances of nearly 500 km from the point of release (Fig. 3).

Success of the classical biological control of mountain ash sawfly is attributed to a number of factors, including a suitable release site, a great number of released parasites, host specificity of the wasp, a virtual absence of competing parasite species, and minimal impact by hyperparasites (parasitic insects that attack other parasites and reduce their effectiveness against pests).

In another test of the parasite's effectiveness, independent releases of the parasite were made in St. John's, Newfoundland, between 1981 and 1986 by the Canadian Forest Service.

Figure 2. Mountain ash sawfly.

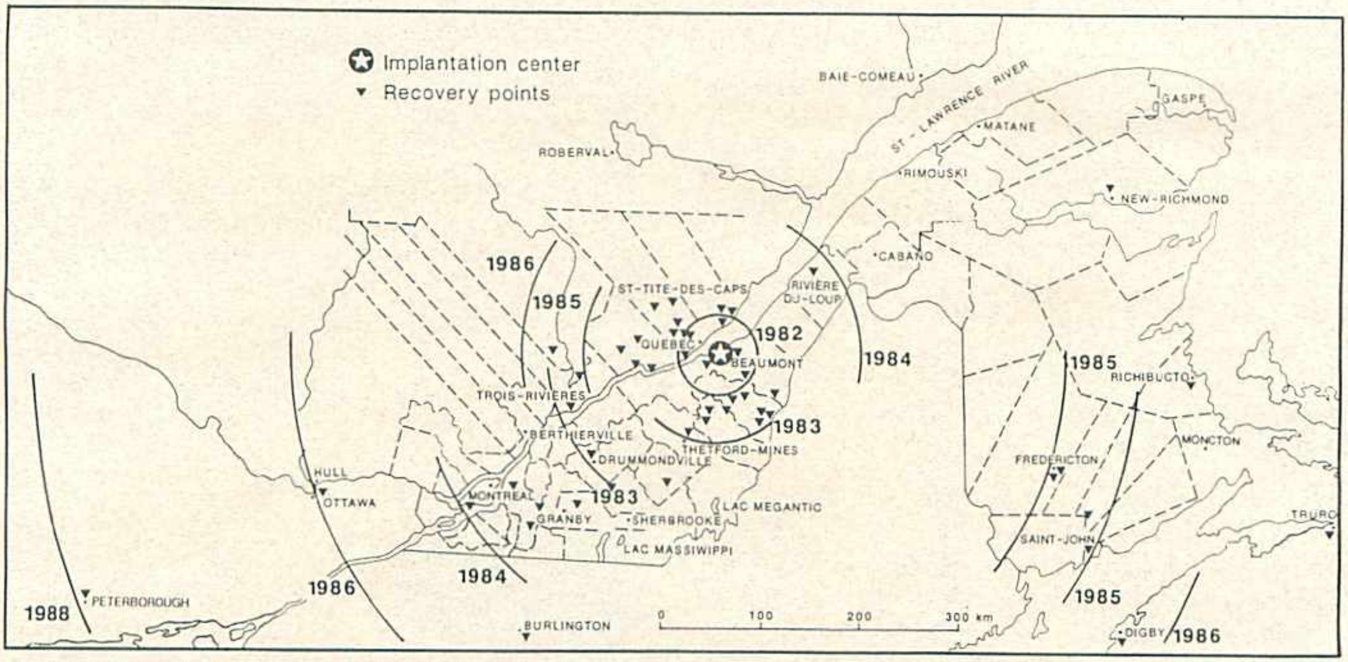

Figure 3. Natural dispersal of O. geniculatae *from the Beaumont, Quebec, release site.*

O. geniculatae rapidly established in the area and sawfly populations dropped to insignificant levels by 1990. Monitoring indicated that the parasite had further spread to the west and south coasts, and scientists expect effective and persistent suppression to follow (West et al. 1994).

SUCCESS AGAINST LARCH SAWFLY IMPROVES BIOCONTROL STRATEGIES

Since 1882, the larch sawfly, *Pristiphora erichsonii* (Hartig), has caused moderate to severe defoliation in every province and territory of Canada (Figs. 4, 5), and was a major factor in diminishing the commercial status of larch (*Larix laricina* [Du Roi] K. Koch). The insect also feeds on exotic European, Japanese, and Siberian larches.

The larch sawfly's sudden appearance and relatively few natural enemies caused forest entomologists to suspect that the pest was of European origin. Entomologists responded in 1910 by importing the parasitoid *Mesoleius tenthredinis* Morl., which was effective against larch sawfly in England. Following releases in Manitoba, parasitism by *M. tenthredinis* gradually increased to nearly 90 percent by 1927, and there was good evidence of control over large areas. However, during a 1940 outbreak in Manitoba, a strain of larch sawfly emerged that was essentially immune to the parasite. This resistant strain has since become dominant in most of Canada, while the susceptible strain is confined to parts of southern British Columbia and Newfoundland. To counter this development, scientists have successfully introduced a second strain of *M. tenthredinis* to which the larch sawfly is not immune.

In the early 1960s another European parasitoid, *Olesicampe benefactor* Hinz., was released and established near Pine Falls, Manitoba. Five years after its release this insect was parasitizing 90 percent of the sawfly population and continued to do so until 1972, when the local sawfly outbreak began its collapse. Meanwhile the parasitoid spread from Manitoba into northern Minnesota and northwestern Ontario. The beneficial effect of the parasitoid has since been reduced by an effective hyperparasite. Nevertheless, larch sawfly populations are generally under control, and *O. benefactor* could continue to be used if released in large enough quantities. Such inundative releases could be effective for control in plantations when defoliation is first detected. A facility capable of mass producing parasitoids on demand would be required, but technology exists to accomplish this.

Figure 4. Larch sawfly.

Figure 5. Defoliation caused by the larch sawfly.

CONCLUSION

Because they operate within natural systems, classical biological control strategies have many facets, and no two approaches are exactly the same. European spruce sawfly control was impressive in its extent and permanence. It also showed the value of considering several different kinds of natural enemies for achieving control. Control of mountain ash sawfly was founded upon careful experimental work, such as the collection of parasites in Europe and the measured release of parasites in caged trees. Larch sawfly demonstrated the dynamic nature of host–parasite relationships, and the need for continued monitoring to ensure ongoing pest management.

Biological control requires considerable up-front investment in experimentation, collection, rearing, and release technology; all of which must be based upon a fundamental understanding of the ecology of specific pests. The payoff in successful programs, however, is high. Initial investments should be considered in comparison with the perennial costs of aerial spraying programs, growth reduction, and tree mortality.

Because biological control is an ecological method of pest control, it can be a key component in the design of integrated pest management programs. An ideal program would provide pest managers with a number of control measures. These could include augmentation or introduction of natural enemies over extensive areas for reducing the severity of pest outbreaks; intensive measures, such as chemical or *B.t.* spraying for protecting foliage in highly valued stands; and silvicultural treatments to minimize the hazards of infestations.

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