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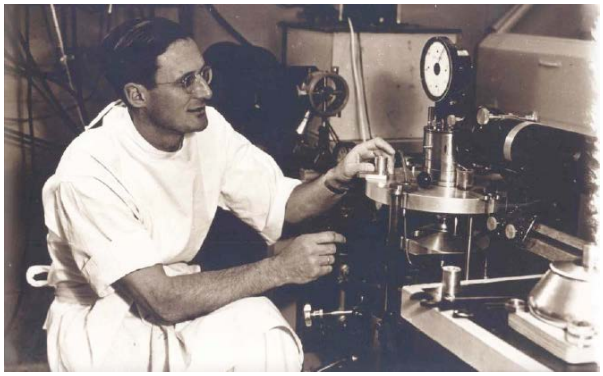
Canadian Forest Service – Great Lakes Forestry Centre

# Retrospective on virus research at the Great Lakes Forestry Centre

## INTRODUCTION

The Great Lakes Forestry Centre (GLFC) in Sault Ste. Marie is one of five Natural Resources Canada, Canadian Forest Service (NRCan, CFS) research centres across Canada. At these centres, scientists conduct innovative research on many forestry issues and have gained a worldwide reputation for scientific excellence. At GLFC, research is conducted in the areas of pest management, fire, climate change and forest ecosystems, but the research on pest management has a particularly long and distinguished history here. Research on biological control agents, including viruses, bacteria and fungi for control of forest pests originated at laboratories in Sault Ste. Marie in the 1950s.



**G. Bergold at the Laboratory of Insect Pathology (circa 1950)**

Scientists developed the first virus for use in forestry at these laboratories in Sault Ste. Marie and research on viruses continues today. NRCan, CFS also examines the environmental, ethical and legal aspects of virus registration and use.

Viruses are particularly attractive as pest control products as they are highly specific to target insects. All tests conducted in many parts of the world have ascertained the safety of insect baculoviruses to non-target organisms and the environment. The use of these biocontrol agents helps protect valuable forest resources, thus mitigating economic losses to the forest industry and contributing to the sustainability of Canada's forests.

### The origins of GLFC

A forest insect laboratory was established in Sault Ste. Marie in 1944-45 to conduct surveys and entomological research, largely in response to a serious spruce budworm outbreak that was affecting much of the spruce–fir forests of eastern Canada. Biologist J.J. deGryse, then chief of Forest Insect Investigations, had the idea to establish a research institute with the goal of studying possible biological control methods, as an alternative to the chemical agents being used at that time. This visionary thinking was inspired by the 1944 discovery in eastern Canada that an insect virus was responsible for the collapse of a major outbreak of the European spruce sawfly, a pest as damaging as the spruce budworm. It was hoped that pathogens such as this could be developed into suitable pest control products for use in forestry. In 1950, a Laboratory of Insect Pathology opened and was staffed with scientists from around the world who were pioneers in this field. The first director was Dr. MacBain Cameron. Under his direction, scientists conducted fundamental research on the isolation, identification, structure, growth, mode of action and biochemistry of insect viruses required for their exploitation as control agents. Since then, the laboratory has undergone a number of physical moves and name changes, including the Insect Pathology Research Institute and the Forest Pest Management Institute, but has been part of the Great Lakes Forestry Centre since the late 1990s.

### The early scientists

Ted Bird, a Canadian, was recruited in 1950 and was one of the scientists who identified a virus as the causal factor in the collapse of a sawfly outbreak. He was then able to obtain virus from Europe and use it successfully against European spruce sawfly in the field, causing the population to collapse within two years. This was the first time a virus had been used in forestry to control an insect pest.

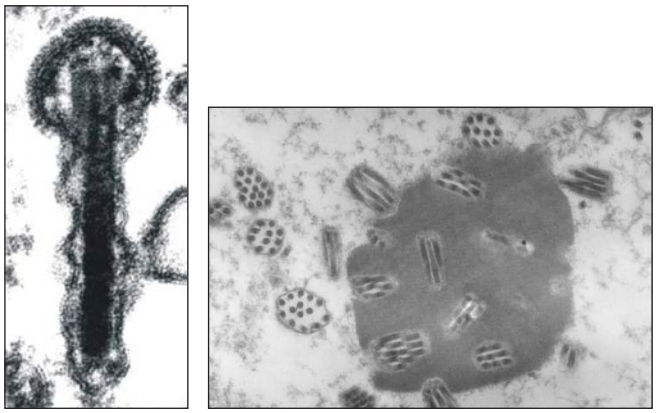
Gernot Bergold, regarded as the best insect virologist in the world at the time, was also recruited in 1950. However, he was from Tübingen University in Germany, an amazing feat considering Canada had recently been at war with Germany. During his time at the laboratory, he learned a great deal about the properties of insect viruses, including their structure and morphology, as well as the nature of virus multiplication.

In 1952, Gerard Wyatt came from Cambridge University, UK. His observations on base pairing in DNA that he had isolated from insect viruses provided strong evidence to support the double helix structure for DNA proposed by Watson and Crick. Their landmark paper published in Nature in 1953, for which they won the Nobel Prize in medicine, cited Wyatt's work to support their theory.

Peter Faulkner, also from the UK, joined the laboratory in 1954 and made many important discoveries about viruses. He determined that viruses require specific proteins to be able to work. He also discovered that when viruses replicate they take one of two forms: a budded virus, which can infect other insect tissues, or an occlusion-derived virus, which allows for transmission of the virus from one insect to another, leading to effective control of outbreaks.

### Commercialization of the first virus product

In 1983, John Cunningham, from Oxford University, UK, was successful in getting the first virus product registered in Canada as a biological control agent. The product, Lecontvirus, is highly effective against redheaded pine sawfly and is both safe and economical. All of the background work required for its development was conducted at the laboratory. Many steps were involved in addition to the laboratory work, such as field testing, large scale production, application technology and commercialization, including obtaining a patent and registration with the Pest Management Regulatory Agency. Other successful virus products were developed to control Douglas-fir tussock moth, gypsy moth and balsam fir sawfly.



**A budded virus (left) and an occlusion-derived virus (right)**

### Other highlights

Understanding the interaction between the virus and the insect is an important part of the development of effective strategies for the use of viruses in pest control. Scientists were able to determine that in the case of redheaded pine sawfly for example, a single infested insect could cause an entire colony to collapse, because the virus had the ability to replicate in the midgut of the insect, leading to its rapid and effective transmission.

Viruses require living cells to grow and multiply. Work in the laboratory was aided by the development of an insect rearing facility. GLFC currently houses one of the best facilities in the world. Another important development was the establishment of insect cell lines, which greatly enhanced research abilities, allowing studies to be carried out without the entire organism and at a high level of precision.

Basil Arif, currently scientist emeritus, started as a molecular virologist in 1972 and became a world leader in the molecular biology and genomics of insect baculoviruses and entompoxviruses. Through advanced DNA analysis techniques, specific genes can be isolated, characterized and inserted into viruses to enhance their effectiveness. Arif and his team developed a genetically modified spruce budworm virus that has a faster mode of action and reduces the infected larvae's ability to feed. The virus contains a gene that disrupts the critical developmental phase of larval molting and renders infected insects inactive, resulting in less insect damage to the trees.

In recent years, biotechnology has made possible the sequencing and identification of the complete suite of genes from an organism. The sequencing of the DNA of hymenopteran baculoviruses for example, has been a useful tool in understanding the evolution of viruses affecting Lepidoptera (butterflies and moths). Studying the evolutionary pathway of these two orders of insects has helped scientists determine how viruses managed to adapt genes from plants as an evolutionary strategy and lead to a better understanding of their mode of action.

## CONCLUSION

Scientists at GLFC continue leading edge research in the field of insect biocontrol. It is important to recognize the foresight and outstanding efforts of pioneers in their field, who paved the way.

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