BATTLE OF THE BARK

AS THE PINE BEETLE EPIDEMIC PENETRATES ALBERTA, JÖRG BOHLMANN IS UNLOCKING THE CONIFER TREE'S SURVIVAL SECRETS IN AN EFFORT TO UNDERMINE THESE PERSISTENT PESTS

Majestic and proud, the conifer tree stands as one of the world's tallest, largest and oldest living things. Stretching hundreds of years, its extended life span is testament to its resilient nature and its curious ability to deter its enemies using molecular defenses embedded within its bark. There, the workings of a highly sophisticated chemical-defense process take shape, in the form of chemical mixtures known as terpenoids (or the hydrocarbon and resin acid compounds normally found in the essential oils of plants), which have proven enormously effective in both repelling and physically deterring its adversaries. While few organisms have managed to penetrate these natural defenses, an industrious and persistent pest has slowly but surely evolved the necessary tactics to disarm these previously impenetrable giants and at the same time, is multiplying en masse in formerly inhospitable areas that have suddenly become balmier due to global warming.

"When you apply physical damage to a conifer, you'll notice it starts bleeding sticky, gooey resin that is a mixture of terpenoid chemicals. This is what the conifer tree produces that allows it to be actively protected against pests," says Dr. Jörg Bohlmann, UBC Vancouver Associate Professor of Forestry and Botany. "The pine beetle epidemic in BC that has devastated some 10 million hectares of forest trees is an example of scientists recognizing we have a problem with insects that have overcome the conifer's chemistry."

For Bohlmann, the encroaching pine beetle epidemic has been more than a worrisome headline in local newspapers: It has been one of the driving forces behind his research. He is currently a project leader for the Genome Canada/Genome BC-sponsored Treenomix project, a forestry genomics research program that aims to identify a conifer's chemistry, the biochemical machinery responsible for making this chemistry and deciphering the genes that are encoding this biochemical process.

While research so far has successfully uncovered many of the conifer tree's molecular secrets, Bohlmann notes that our current inability to respond to the pine beetle epidemic has largely been influenced by the limited understanding of the genomic processes that underlie the relationship between these insects, their associated fungal pathogens and the conifer. It is this relationship that Bohlmann hopes to make the most impact on through an integrated collaboration with microbiologists and entomologists: "Since we have developed an understanding of the conifer's biochemical processes to some degree, we're now looking at the insect and what kinds of mechanisms does it have to overcome the tree's highly sophisticated defenses."

According to Bohlmann, the pine beetle has learned a few tricks from its ancestors who have been waging war against a conifer's chemistry for millions of years. One of these tricks has involved detoxifying an already weakened conifer's chemistry by chemically altering it, then releasing it as an active pheromone communication system where the pine beetle uses a chemical signal indicating its host tree is vulnerable enough for more pine beetles to lay the eggs necessary to undermine the life-sustaining elements of its bark.

Bohlmann explains: "There are always a few pioneers that make the first lodge on the tree and if they overcome the initial phase of the tree's defenses, they start producing chemicals that are very similar to the host's terpenoids. These chemicals then call in hundreds or thousands of pine beetles at the same time. But that's part of the natural dynamic so it's nothing to get panicked about. We have a problem when the pine beetles come to an epidemic stage where they can't be controlled."

Also during the process of attack, the pine beetle inoculates the tree and brings it under attack with a fungus to further weaken its natural-defense system. A symptom of this process involves a bluish-gray stain, known as "denim pine," that indicates the fungus is active in interrupting the conifer's vital water and nutrient transport systems.

"It's a very neat symbiosis: They both need the tree but neither the fungus nor the pine beetle can consume the tree alone," Bohlmann says. "Together, they rapidly interrupt the tree's water and nutrient transport systems, overcome the tree's defenses and destroy the tree's actively growing stem cell tissues."

The alarming speed at which these insects have decimated one of the province's most-valuable resources has heightened the need to develop science-based solutions to curtail the devastating effects of these voracious pests. Currently, the pine beetle has crossed the Rockies and settled into Alberta, drawing concern from scientists that it will eventually penetrate the Canadian Shield. Because pesticides are costly and can greatly harm ecosystems and waiting for several cold winters is unreliable, a proactive and environmentally friendly solution is key.

Bohlmann is hesitant to predict whether a major breakthrough, capable of stopping the pine beetle dead in its tracks, is imminent. In BC, the pine beetle epidemic has grown to a level that is too large to single-handedly overcome. Nevertheless, he is optimistic about how the integrated genomics research program funded by Genome BC and Genome Alberta can potentially become of enormous economic, social and environmental value for the long-term sustainability of Canada's forests.

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"Similar to the biomedical field, it will take a long period of active research to come up with successful treatment but part of what I can promise is to work towards better diagnostic and prognostic tools that will enable us to better predict insect pest outbreaks," he says. "Dealing with this pine beetle epidemic will better prepare us for future infestations. As the pine beetle moves east, it is naïve to assume all we need to be concerned with right now is the dead trees left from this epidemic. There are a lot of spruce trees and Douglas firs out there and they're all equal host trees for other bark beetle species."

Dr. Jörg Bohlmann works at UBC's Michael Smith Laboratories and receives funding from the Natural Sciences and Engineering Research Council (NSERC), Genome BC, Genome Canada, the Canada Foundation for Innovation (CFI) and the Human Frontier Science Program (HFSP).

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A ponderosa pine's defense mechanism against infection by a mountain pine beetle