After more than 100 years apart, webworms devastate New Zealand parsnips

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After more than 100 years in New Zealand without their webworm enemies, newly infested parsnip plants are highly susceptible to the destruction caused by the webworm caterpillars. Credit: Photo by Art Zangerl

What could be lower than the lowly parsnip, a root once prized for its portable starchiness but which was long ago displaced by the more palatable potato? Perhaps only the parsnip webworm gets less respect. An age-old enemy of the parsnip, the webworm is one of very few insects able to overcome the plant's chemical defenses. The tenacious parsnip webworm has followed the weedy version of the parsnip in its transit from its ancestral home in Eurasia to Europe, North America and – most recently – New Zealand.

The long association of the parsnip (Pastinaca sativa) and parsnip

webworm (Depressaria pastinacella) offers a unique window on the complex interaction of plant and insect enemies, according to a study appearing this week in the *Proceedings of the National Academy of Sciences*. And the recent appearance of parsnip webworms in New Zealand, more than 100 years after the parsnip first arrived there, offers the best view yet of how these species influence one another.

The research team, led by University of Illinois entomology professor and department head May Berenbaum, made two key findings. First, the researchers found, the New Zealand parsnips had significantly lower levels of certain chemical defenses than parsnips growing in Europe and North America, where webworms are a constant threat. Second, the New Zealand parsnip webworms were dramatically affecting the plant's ability to reproduce. The webworm caterpillars eat the parsnip flowers and burrow into their stalks.

"In certain populations affected by webworms, 75 percent of the plants were completely devoid of any reproductive parts," said Art Zangerl, a senior research scientist in the department of entomology and co-author on the paper. "The affected plants were contributing zero fitness, which is really dramatic. We don't often see that."

Fitness is a measure of a species' ability to successfully reproduce. Environmental factors that reduce the fitness of an organism – by, for example, destroying all of its offspring – can influence the course of its evolutionary trajectory. Survivors less susceptible to that environmental factor, or selective agent, enjoy a reproductive advantage, contributing more offspring, and more of their genetic attributes, to subsequent generations.

In New Zealand, the newly arrived parsnip webworms are a major selective agent, Zangerl said, wiping out a majority of the flowering parsnips.

The altered chemical defenses of New Zealand parsnips are probably allowing the webworms to feast on most of the plants in any given locale, Berenbaum said.

The parsnip's chemical defenses normally include a good dose of furanocoumarins, a class of organic compounds that can be toxic to insects that eat the plant. While the parsnip webworm has evolved to tolerate large doses of furanocoumarins in its diet (it can eat up to 5 percent of its body weight of these toxins) the chemicals do limit its capacity to inflict damage.

What isn't clear is whether the absence of parsnip webworms in New Zealand for more than 100 years allowed the parsnips to let down their guard, Berenbaum said.

"Parsnips have been in New Zealand since the 19th century," she said. Absent an aggressive enemy like the webworm, the parsnip had no reason to keep producing large amounts of furanocoumarins.

"It could be simply that the parsnips have had 100 years to relax," Berenbaum said.

Other factors may explain the lower levels of certain furanocoumarins, however, she said. It could be that the parsnips that were first brought to New Zealand had less of these chemicals to begin with. Or perhaps the soil or climate influenced their evolution.

The appearance of parsnip webworms in New Zealand offers an appealing research opportunity, Berenbaum said. The researchers will be able to measure any changes in plant chemistry that result from the webworm infestation.

"Here, we're looking at one variable, and it's the insect," she said. "The

soil is essentially the same as it was 10 years ago. The climate is more or less the same.

“The neighboring plants are the same. The only variable is the insect and we have shown that the insect is a selective agent.”

Berenbaum and Zangerl have spent several decades studying the co-evolution of the parsnip and its webworm.

In the late 1990s, they studied pre-1900 museum specimens of parsnips collected in the U.S. They found that the furanocoumarin compound sphondin – produced in high levels in parsnips growing in the U.S. today – occurred at low levels or not at all in the oldest museum specimens. Early colonists brought parsnips to the New World in the early 17th century, but the parsnip webworms did not arrive for another two centuries. The webworms have difficulty metabolizing sphondin.

This suggested that the plants ramped up production of sphondin in response to the webworm infestation, the researchers concluded.

These findings have implications for those hoping to manage invasive weeds by importing the insects that attack them in their native land, Berenbaum said. While such strategies may appear to be effective initially, the plants may be able to adjust to the insect threats over time by upping their chemical defenses. Only time, and more data collected in New Zealand, will determine if this occurs, and if it does, how quickly the plants can respond, she said.

Source: University of Illinois at Urbana-Champaign

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