Virus inhibits immune response of caterpillars and plants

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A larval parasitoid emerging from its caterpillar host. Credit: Gary Felton, Penn State

It is well known that certain wasps suppress the immune systems of their caterpillar hosts so they can successfully raise their young within those hosts. Now researchers at Penn State show that, in addition to suppressing caterpillar immune systems, wasps also suppress the defense mechanisms of the plants on which the caterpillars feed, which ensures that the caterpillars will continue to provide a suitable environment for the wasps' offspring.

According to Gary Felton, professor and head of entomology, a type of virus, called a polydnavirus, resides within the ovaries of the female wasps and, when injected into caterpillar hosts, is responsible for suppressing both the caterpillar immune response and the plant defense mechanism.

"We found that not only do polydnaviruses suppress the immune systems of the caterpillars, but they also attenuate the defense responses of the caterpillars' host plant," said Felton. "The polydnavirus suppresses glucose oxidase in the saliva of caterpillars, which normally elicits plant defenses. Suppressing plant defenses in this way benefits the wasp and the virus by improving the wasp's development and survival within the caterpillar."

The team—which included Ching-Wen Tan, doctoral student in entomology—placed parasitized and non-parasitized caterpillars onto tomato plants. After allowing the caterpillars to feed on the plants for 10 hours, the researchers harvested the remaining leaves and examined them for enzyme and gene expression activity associated with a defense response.

"Using molecular and biochemical techniques, we found that parasitized caterpillars induced significantly lower enzyme activity and defense-gene expression among the tomato plants than the non-parasitized caterpillars," said Tan. "We also determined that the caterpillar's saliva, which was reduced in glucose oxidase by the polydnavirus, was responsible for inducing these lower defense responses in the plants."

The results appear online in the *Proceedings of the National Academy of*

Sciences.

According to Felton, the team's results support the findings of another study by Feng Zhu of Wageningen University in The Netherlands and colleagues that appeared in the same issue of *PNAS*.

"That study also shows that the polydnavirus of a parasitoid-caterpillar system—a different system from ours—has a similar ability to influence host plant immunity," said Felton. "In nature, a significant percentage of caterpillars are parasitized by wasps. In addition, tens of thousands of wasp species harbor polydnaviruses. As a result, there is strong potential for our results and the results of the Feng Zhu team to be very common among many plant-herbivore interactions."

Tan adds that the results of the two studies suggest that the interaction between plants and their natural enemies is much more complex than previously thought.

"Our study demonstrates the important role that microorganisms play in plant-insect interactions," she said. "The ability of polydnaviruses, which possess less than a couple of hundred genes, to so dramatically affect wasps, caterpillars and plants is remarkable."

The Penn State team plans to examine whether other parasitic wasps and viruses that can parasitize a much broader range of caterpillar species also can suppress plant defenses in a similar capacity.

More information: Ching-Wen Tan el al., "Symbiotic polydnavirus of a parasite manipulates caterpillar and plant immunity," *PNAS* (2018). www.pnas.org/cgi/doi/10.1073/pnas.1717934115