The hungry caterpillar: Beware your enemy's enemy's enemy

November 27 2012

Lysibia nana parasitizing cocoons of Cotesia glomerata. Credit: Nina Fatouros

When herbivores such as caterpillars feed, plants may "call for help" by emitting volatiles, which can indirectly help defend the plants. The volatiles recruit parasitoids that infect, consume and kill the herbivores, to the benefit of the plant. However, such induced plant odours can also be detected by other organisms. A new study published November 27 in the open access journal *PLOS Biology* shows how secondary parasitoids ('hyperparasitoids') can take advantage of these plant signals to identify parasitoid-infected caterpillars, and duly infect the primary parasitoid, to

the detriment of the original plant.

Plant volatiles have long been considered to mediate this mutualistic relationship between plants and herbivores' natural enemies such as parasitoids. When a caterpillar feeds, the parasitoids are able to use the emitted volatiles to locate the otherwise inconspicuous caterpillar, releasing the plant from its attacker. This principle has made its way into sustainable agriculture by using natural enemies such as parasitoids to control herbivorous pests on agricultural crops. However, the largest group of enemies of parasitoids, hyperparasitoids, have so far been left out of studies in this area. This is because very little is known about the cues that hyperparasitoids use to locate their parasitoid hosts.

The new study, by a team of Dutch researchers led by Erik Poelman, shows that hyperparasitoids exploit the different plant odours that are released when a plant is fed upon by a parasitoid-infected caterpillar.

"In controlled laboratory assays as well as under field conditions, hyperparasitoids were offered plant odours coming from two types of plant: ones damaged by healthy caterpillars, and ones damaged by parasitoid-infected caterpillars. We found that they preferentially detected odours of plants damaged by infected caterpillars," explained Dr Poelman. "We were excited by these results as they indicate that hyperparasitoids rely on a network of interactions among plant, herbivore and parasitoids to locate their host".

To show how this complex network of interactions can reliably provide hyperparasitoids with information on the presence of their parasitoid host, the researchers collected saliva of the caterpillars, as they noticed the colour of saliva in healthy, non-host caterpillars was different to that of caterpillars hosting a parasitoid. Factors in caterpillar saliva play an important role in provoking the release of odours from plants, and a change in saliva composition may then alter the cocktail of odours

emitted by the plant.

Indeed, Dr Poelman's team found that plant odours induced by the saliva of parasitized caterpillars was more attractive to hyperparasitoids than plant odours induced by the saliva of healthy caterpillars. Consequently, plant odours may actually reduce the benefit of attracting parasitoids to a plant.

"Our results demonstrate that the effects of herbivore-induced plant volatiles should be placed in a community-wide perspective that includes species at the fourth trophic level, to improve our understanding of the ecological functions of volatile release by plants," said Dr Poelman. In addition to the ecological aspects of their work, the authors also stress that their findings are important for developing Integrated Pest Management strategies, in which crops are manipulated to control insect pests by using parasitoids.

Although parasitoids are effective biological control agents, this study suggests that using plant odours to optimize biological control of pests may have side effects that could actually reduce the benefit of pest control, said Dr Poelman.

More information: Poelman EH, Bruinsma M, Zhu F, Weldegergis BT, Boursault AE, et al. (2012) Hyperparasitoids Use Herbivore-Induced Plant Volatiles to Locate Their Parasitoid Host. PLoS Biol 10(11): e1001435. doi:10.1371/journal.pbio.1001435

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https://phys.org/news/2012-11-hungry-caterpillar-beware-enemy.html

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