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Science for Environment Policy

Can new biopesticide protect crops without harming honeybees?

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Contact:
a.m.r.gatehouse@ncl.ac.uk

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A potential new biopesticide, made of spider venom and snowdrop proteins, kills agricultural pests but shows minimal toxicity to honeybees, new research suggests. Learning and memory of honeybees exposed to the biopesticide were not affected, even at doses higher than they would normally encounter in the environment.

Insect pollination is vital for food production; however, there are concerns that some neonicotinoid pesticides, designed to be safe for mammals, could harm bees and other pollinating insects. In fact, the use of three of them has recently been restricted by the European Commission.

For this study, researchers developed a new biopesticide, a biological toxin designed to protect crops while at the same time not harming honeybees. The researchers combined toxins from the venom of the Australian funnel web spider (*Hadronyche versuta*) with a protein from the snowdrop plant (*Galanthus nivalis*) to create the insecticide.

On its own, the spider venom is non-toxic to any insect that ingests it, as it is unable to reach the nervous system. However, when combined with a carrier protein from the snowdrop, the toxin is able to cross the gut wall, where it targets the insect's central nervous system, disrupting calcium channels and causing paralysis. Insect species differ in the protein structures that make up these channels, therefore the spider venom can potentially disrupt calcium channels in some insects (e.g. pests) but not others (e.g. honeybees).

The researchers carried out a series of tests to determine if their biopesticide was toxic to honeybees. First, they showed that applying it to the body of honeybees did not affect their survival, indicating that the poison cannot penetrate their outer covering. In contrast, honeybees painted with a neonicotinoid did show reduced survival.

The survival of honeybees fed on a sugar solution containing biopesticide solution was reduced by 22%, compared to those fed on sugar alone. However, they received an unrealistically high dose – 100 µg per bee – that they are unlikely to encounter in the wild.

Those fed on the neonicotinoid solution had the lowest chance of survival: the estimated dose needed to kill half the honeybees was around 8.95 µg per bee. Although the researchers did not test the exact biopesticide dose needed to kill half the honeybees, the results reveal that this dose would be much higher, greater than 100 µg per bee. Honeybee larvae fed the biopesticide were not affected as they were able to break it down in their gut.

To assess the effects of long-term exposure at realistic doses the researchers fed honeybees 21.7 µg of biopesticide a day over seven days. This had no effect on survival. The survival of honeybees fed with an environmentally realistic dose of neonicotinoid (0.727×10^{-3} µg, or 0.727 ng, a day), however, was significantly reduced.

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Finally, as a worst case scenario, the researchers injected honeybees with 20 µg of the biopesticide. Although these honeybees had significantly lower survival than those injected with a harmless solution, their overall mortality was relatively low: less than 17% of the honeybees died.

This biopesticide is able to target the calcium channels in the brains of crop pests. In honeybees, these channels are associated with memory and learning, and there is concern that pesticides using this mechanism could affect essential foraging behaviour. To investigate this, the researchers first examined whether the biopesticide could reach honeybees' brains. After feeding the honeybees on contaminated solution for an hour they did find traces of it in the dissected brains.

To assess whether this presence in the brain affected memory, the researchers then presented honeybees with certain smells and then gave them a reward of food. The honeybees then learned to associate these smells with food and would extend their proboscises when they encountered the smell again. Those fed with biopesticide did not respond any differently to short or long-term smell tests than those that had not been exposed.

In terms of toxicity to pests, the researchers have shown in laboratory studies that the biopesticide is toxic to aphid, beetle and moth and butterfly larvae as well as adult flies. Furthermore, glasshouse trials have shown that the efficacy of the biopesticide against the Colorado Potato beetle (*Leptinotarsa decemlineata*) was comparable to that of a commercial Bt (*Bacillus thuringiensis*) biopesticide.

Although further research is needed to compare the efficiacy of the biopesticde with conventional pesticides, these results suggest that this novel substance could prove to be a promising alternative, say the researchers.

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