



The Effects of Fungicides on Bumble Bee Colonies

Embedded Question 1: Before you start the video, consider the following statement: People are concerned that bee populations throughout the world are declining.

Write down a few sentences that summarize what you know about which factors may be contributing to the decline of bee populations.

[CLAY BOLT:] We spray lots of chemicals on plants — fertilizers, pesticides, fungicides. Could some of these chemicals have harmful effects on pollinators like bees?

There are almost 4,000 species of native bees in North America, but some of these species are declining. As a conservation photographer working on bees, I wanted to learn whether fungicides are one of the reasons our native bees are in trouble. So I visited entomologist Shawn Steffan at the University of Wisconsin.

Embedded Question 2: The narrator is interested in investigating the impact of fungicides on bees. Which of the following best describes a fungicide?

- a. A type of pesticide that uses toxins extracted from fungi to kill pests.
- b. A type of pesticide that kills fungi and bacteria.
- c. A type of pesticide that makes plants resistant to fungal pathogens.
- d. A type of pesticide that kills fungi or inhibits their growth.

[SHAWN STEFFAN:] So, our work is primarily focused on isolating the mechanism by which fungicides may be harming native bee species.

[BOLT:] I didn't see how a chemical designed to kill fungus would affect bees. But Shawn explained that some microscopic fungi, like yeasts, have an unexpected connection with bees.

[STEFFAN:] So, in nature, microbes are everywhere. When bees go out and get pollen from a flower, they bring it back to the nest. So you bring back this protein-rich, wet, sticky, sweet soup. What's to keep it from spoiling in the course of two, three, four days? It appears that fungi help to preserve these pollen provisions.

[BOLT:] Inside the nest, the growing bumble bee larvae feed on this pollen mixture. Shawn wants to figure out what kinds of fungi and other microbes these provisions contain.

Embedded Question 3: Shawn wants to determine which species of bacteria and fungi live with bees. In a few sentences, describe a method you might use to identify the microbes.

[BOLT:] So he begins by dissecting a bumble bee nest in the lab.

[STEFFAN:] We open up these large larval cells. And we get little bits of uneaten pollen. That pollen has fermented. We take it out and then culture it on a plate.

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[BOLT:] Culturing microbes from the bees' pollen provisions — in other words, growing them in the lab — allows Shawn to isolate the microbes and identify them by their appearance and genetics. He's finding that yeasts are a major component of bumble bees' diets.

[STEFFAN:] These larval bees, this is the only food they get. And it appears that some bee species, by the time they finish eating their pollen provision, that pollen provision is more yeast than pollen.

[BOLT:] So is it possible that fungicides in the environment harm the yeast and other fungi that the developing bees depend on?

[STEFFAN:] There are all these microbes in the pollen, that, um...a lot of those are fungi. And if you have fungicide residue in that pollen, it stands to reason that the fungi would suffer.

[BOLT:] And if the fungi suffer, the bee larvae might suffer too.

Embedded Question 4: Shawn has a hypothesis that fungicides harm bee development. Using what you now know, describe an experiment to test Shawn's hypothesis. Be sure your response includes what data should be collected and how you would collect it.

[BOLT:] That's the hypothesis that Shawn wanted to test. He placed 10 bumble bee colonies, all about the same size, into outdoor cages containing flowers. There was one colony per cage, and in half the cages, the flowers were treated with a fungicide.

[STEFFAN:] The bumble bee colonies could only forage at the flowers that we provided.

Embedded Question 5: Shawn plotted the data in a bar graph with two bars: one representing the number of bees per colony in the control cages and the other representing the number of bees per colony in the cages exposed to the fungicide.

If the results support the hypothesis that fungicides harm bee development, what would you expect this bar graph to show?

[STEFFAN:] At the end of the trial — it lasted a month — the control bees, they averaged about 43 individuals per colony. The colonies that were exposed to fungicide residues on flowers, they averaged about 12. We're talking about a profound effect.

Embedded Question 6: Are the results consistent with what you expected? (Yes/No)

Embedded Question 7: What do you conclude from this experiment? Write your conclusion in a few sentences.

[STEFFAN:] This is basically what appears to be the first hard evidence that a fungicide — not applied to adults, but just on the flowers — caused major colony declines in a single bumble bee species, *Bombus impatiens*.

There's lots of data that show fungicides sprayed directly on adult bees...they're harmless. Those bees are okay.

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Embedded Question 8: Shawn explains that many studies have shown that directly spraying bees with fungicides doesn't harm them. Are those results consistent with what Shawn has discovered? Explain your answer in a few sentences.

Embedded Question 9: Shawn has made progress in understanding how fungicides may impact bee colonies, but there is still work to be done. Can you suggest additional research that you think would help us better understand how fungicides affect bees?

[STEFFAN:] What we're saying is, well, the pathway by which the fungicide hurts the bees, it doesn't appear to hurt the adult. It hurts the larva. Again, this is just one fungicide and it's just one bumble bee species.

[BOLT:] With thousands of native bee species in North America, and many different fungicides used on our crops and ornamental plants, there's still plenty of work to do to understand the effects of fungicides on wild pollinators. But Shawn's experiments so far suggest that because of the intimate relationship between bees and fungi, we need to pay close attention to how we use fungicides.

Embedded Question 10: How could farmers use the knowledge gained in this study to reduce possible harmful effects of fungicides on bees?

[STEFFAN:] Fungicides are sprayed globally, legally, according to their label, on flowering crops. Some fungicides may be truly harmless, but it's looking like some are not. We're not saying that fungicides should need to be banned in any sense. But there are things that can be done. You can spray before bloom. You can spray after bloom.

And so our goal is to figure out which ones are not so good, why they're not so good — basically figure out what it is about them that makes them harmful to bees. And hopefully that will inform policy.

Embedded Question 11: Do people have a responsibility to protect bees? Write down a few sentences to capture your thoughts.