Antibiotic used on food crops affects bumblebee behavior, lab study finds

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"I decided to become a bee biologist because I wanted to understand how the natural environment can influence agriculture and vice versa," says Laura Avila, above. Her work spans experiments in both the lab and field. Credit: Emory University

An antibiotic sprayed on orchard crops to combat bacterial diseases slows the cognition of bumblebees and reduces their foraging efficiency, a laboratory study finds. *Proceedings of the Royal Society B* published the findings by scientists at Emory University and the University of Washington.

The research focused on streptomycin, an antibiotic used increasingly in U.S. agriculture during the past decade.

"No one has examined the potential impacts on pollinators of broadcast spraying of antibiotics in agriculture, despite their widespread use," says Laura Avila, co-lead author of the paper and a post-doctoral fellow in Emory's Department of Biology.

The current study was based on laboratory experiments using an upper-limit dietary exposure of streptomycin to bumblebees. It is not known whether wild bumblebees are affected by agricultural spraying of streptomycin, or whether they are exposed to the tested concentration in the field.

"This paper is a first step towards understanding whether the use of streptomycin on food crops may be taking a toll on pollinators that benefit agriculture," says Berry Brosi, senior author of the paper. Brosi began the work as a faculty member in Emory's Department of Environmental Sciences and is currently with the University of Washington.

Funded by a U.S. Department of Agricultural grant, the researchers will now conduct field studies where streptomycin is sprayed on fruit orchards. If a detrimental impact is found on bumblebees, the researchers hope to provide evidence to support recommendations for

methods and policies that may better serve farmers.

"Production of our food, farmer livelihoods and the health of pollinators are all tied together," Brosi says. "It's critically important to find ways to maintain agricultural production while also conserving the ecosystem services—including pollination—that a biodiverse ecosystem provides."

Based on established evidence, the researchers hypothesize that the negative impact of streptomycin on bumblebees seen in the lab experiments may be due to the disruption of the insects' microbiome.

"We know that antibiotics can deplete beneficial microbes, along with pathogens," Avila says. "That's true whether the consumers of the antibiotics are people, other animals or insects."

Avila is a member of the lab of Nicole Gerardo, Emory professor of biology and an entomologist who studies the co-evolution of insect-microbe systems.

During the past decade, the spraying of antibiotics on U.S. crops has increased exponentially as farmers battle a rise in plant bacterial infections. "Fire blight" can turn the blossoms and shoots of apple and pear trees black, making them appear scorched by fire, and can also kill entire trees. "Citrus greening," also known as "yellow dragon disease," turns citrus fruits green, bitter and unusable and has devasted millions of acres of crops throughout the United States and abroad.

"I've seen the struggle of making a living by producing crops, how expensive and difficult it can be to control diseases and pests," says Avila, who grew up in a coffee-producing region of Costa Rica.

Largely untouched forests bordered her family farm. "The diversity all around us fascinated me," Avila says. "I decided to become a bee

biologist because I wanted to understand how the natural environment can influence agricultural production and vice versa."

Seventy-five percent of the world's food crops depend on pollination by at least one of more than 100,000 species of pollinators, including 20,000 species of bees, as well as other insects and vertebrates like birds and bats. And yet, many of the insect pollinator species, particularly bees, face risks of extinction.

Previous studies have shown that the antibiotic tetracycline, used to treat pathogens in managed honeybee hives, can alter the gut microbiome of the insects and indirectly increase susceptibility to pathogens and mortality. Exposure to high oxytetracycline concentrations has also been found to have a similar effect on the bumblebee gut microbiome, decreasing their immunity to pathogens. And exposure to high doses of tetracycline have been found to affect honeybee learning, while oxytetracycline slows the onset of foraging in managed colonies.

For the current paper, the researchers conducted lab experiments with managed bumblebees, Bombus impatiens, to test the effects of an upper-limit dietary exposure to streptomycin. Half of the bees were fed on plain sucrose, or sugar water, to simulate nectar. The remaining bees were fed on sucrose dosed with streptomycin.

After two days on this diet, the bees were presented different-colored cardboard strips—one yellow and the other blue. One color was saturated with plain water and the other was saturated with sucrose. In a series of training trials, each bee was presented a single, colored strip until it touched it with its antennae or proboscis.

The researchers measured the number of trials it took for a bee to show a preference for the color strips saturated with sucrose. The bees fed streptomycin often required roughly three times as many trials to make

the association, relative to the other bees. The antibiotic-treated bees were also more likely to display avoidance behavior towards either of the stimuli.

Those bees that passed a training threshold were given a short-term memory test five minutes later. Each bee was presented with both of cardboard strips simultaneously and allowed to select one. The rate at which the bees dosed with streptomycin selected the sucrose reward was around 55 percent, while the untreated bees selected the sucrose at a rate of nearly 87 percent.

To assess foraging ability, trials were conducted in a foraging chamber containing an experimental array of artificial flowers that dispensed sucrose or plain water. The flowers were either blue or yellow but were identical in size and shape. Each bee was outfitted with a tiny, ultra-lightweight radio frequency identifier "backpack" to monitor its movements among the artificial flowers, which were each equipped with a short-range antenna and tracking system.

The computer-analyzed results showed that the antibiotic-exposed bees visited far fewer sucrose-rewarding flowers relative to the control bees.

In the spring, Avila and Brosi will launch field studies to determine if broadcast spraying of streptomycin affects bumblebees in pear orchards.

"I was surprised at how strong an effect we found of streptomycin on bumblebees in the laboratory experiments," Brosi says. "That makes it imperative to learn if we see similar effects in an agricultural setting."

The timing of antibiotic application, the amount applied and possible alternatives to the use of an antibiotic may be potential mitigation methods should the field research identify harmful impacts on bumblebees of agricultural spraying of streptomycin, the researchers

note.

More information: Laura Avila et al, Upper-limit agricultural dietary exposure to streptomycin in the laboratory reduces learning and foraging in bumblebees, *Proceedings of the Royal Society B: Biological Sciences* (2022). DOI: 10.1098/rspb.2021.2514

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