Podcast Interview: May Berenbaum

PNAS: I’m your host Prashant Nair, and welcome again to Science Sessions. The alarming decline in honey bees across the United States is by now a familiar refrain in the news media. Researchers have pinpointed a list of manmade and natural threats to honey bee health, and agricultural insecticides figure prominently on this list. May Berenbaum, an entomologist at the University of Illinois at Urbana-Champaign, draws our attention to one group of agrochemicals called triazole fungicides. Triazole fungicides are widely applied to an array of food crops to protect against pathogens, but they’ve been known to block the action of honey bee enzymes called cytochrome P450 monooxygenases. These enzymes detoxify agricultural insecticides. In a recent PNAS article, Berenbaum, her associate Wenfu Mao, and others report that by acting on the P450 enzymes triazole fungicides might also hamper honey bees’ ability to detoxify natural chemicals found in their food. That in turn might stymie the bees’ ability to derive energy from food. One such natural chemical is a compound called quercetin, and it’s found in small amounts in the diet of newborn honeybee larvae. Berenbaum and her colleagues tested whether exposing honeybee larvae to quercetin and the triazole fungicide myclobutanil would deal honey bees a double whammy. Human diets are essentially unpredictable. So we have a variety of cytochrome P450 monoxygenase enzymes to deal with the diversity of chemical compounds found in our shifting diets. Honey bees, on the other hand, have a small inventory of these enzymes, less than half the number found in many other insects.

Berenbaum: Honeybees, because their colonies have to be active all year long, basically, they have to be able to forage from and process nectars and pollens from a whole diversity of flower types. Which means they encounter a whole diversity of phytochemicals as well, and it was particularly intriguing because the honey bee genome project revealed that they do have a reduced inventory of cytochrome P450 monooxygenases. These are the workhorse enzymes of Phase 1 detoxification. Phase 1 detoxification alters the structure of the toxins such that they can’t interact with whatever the target site is. So I was intrigued by how with such a reduced inventory they manage to get along with such a diversity of phytochemicals. So how do they cope?

PNAS: It turns out honey bees’ P450 enzymes have evolved to be versatile. They can detoxify both agricultural chemicals as well as toxins found in nectar and pollen. That versatility, however, might have a downside.

Berenbaum: The possibility occurred to us that maybe fungicides could render honeybees incapable of processing their own food. And that’s how we got started on this path, to see what fungicides would do to metabolism of some of the more abundant and prominent and biologically important phytochemicals in their host plants.
PNAS: So Berenbaum’s team fed newborn honeybee larvae diets containing quercetin.

Berenbaum: All bees in the first 3 days of their life as grubs or larvae are fed glandular secretions called jelly. And after 3 days, the worker-destined female grubs get fed not just worker jelly, which is a little different in composition from royal jelly, but it’s mixed with honey and pollen. So at day 4, they’re getting honey and pollen. But nobody gets it in the first three days, and we thought if we’re going to see an impact, it’s probably going to be in the life stages not bombarded with phytochemicals. So that’s why Wenfu figured, we’ll feed quercetin to larvae for the first 3 days of life, and then we’ll see what quercetin is physiologically capable of doing.

PNAS: What they found was indeed what they had suspected. The expression levels of genes encoding P450 enzymes shot up in larvae that were fed quercetin-containing diets. Feeding both quercetin and myclobutanil to adult worker bees lowered the expression of genes involved in energy generation. What’s more, workers bees exposed to both quercetin and myclobutanil had less ATP in their thorax than bees exposed to quercetin alone. That’s significant because ATP, the major biological energy currency, fuels muscles in the thorax that power flight. So, viewed as a whole, these findings mean that triazole fungicides like myclobutanil might have synergistic negative effects on honey bee health when they interact with chemical compounds derived from food. That’s not unlike the unfavorable food-drug interactions that can occur in people. I asked Berenbaum whether these findings carry policy implications for the use of agricultural fungicides.

Berenbaum: There’s a long road between a scientific study that’s published in a journal and policy. So I think this paper could raise awareness, but, in and of itself, I don’t think it’s a call to immediately change policy. But I hope it is something of a call for people to be more aware of potential adverse impacts of fungicides, which have been kind of overlooked in discussions of pesticide impacts on honey bees.

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