Science Careers From the journal Science

Pollinating His Own Science

By Vijaysree Venkatraman
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Spread all over eastern Massachusetts, his clientele includes five-star hotels in downtown Boston and innkeepers on the Cape.

CREDIT: Izzy Berdan

Noah Wilson-Rich began studying the health of honeybees as a graduate student at Tufts University in 2005. Growing up in Connecticut, he was not a nature-loving kid; he recalls being scared of "creepy-crawlies."

An undergraduate course in sociobiology, and a subsequent lab project, changed that. Eusocial insects—bees, ants, termites, and wasps— that live in colonies and share their colonies' upkeep began to fascinate him. He knew that communal living, while essential to the insects' survival, also makes them vulnerable to infections.

Then, when Wilson-Rich was a year into his graduate program, a mysterious ailment hit beehives across the United States. "Honey bees were disappearing in

shockingly large numbers. Not dying—they were just gone from the hives," he says. The phenomenon has been labeled colony collapse disorder (CCD).

Seven years later, no single, underlying cause has been identified to explain the large-scale die-off of bees. A growing list of pathogens, parasites, and pesticides are prime suspects. "CCD, in fact, appears to be many syndromes rolled into one. Every time a victory is declared, another disease agent pops up and there are new battles to fight," says Jay Evans of the U.S. Department of Agriculture's (USDA's) Bee Research Laboratory in Beltsville, Maryland.

Honeybees don't just provide honey: They pollinate food crops. So the spread of the disease has very important practical implications. Realizing this, Wilson-Rich threw himself into lab work.

Academics and apiarists

Even a graduate student working on a pressing, real-world problem needs diversions. That fall, Wilson-Rich went to the Topsfield agricultural fair, an annual event in Essex County, Massachusetts. Naturally, he was drawn to the Bee House and its observational hives. Local honey was on sale, and apiarists were on hand to talk about what they do. The young entomologist—whose knowledge about insects had so far come largely from textbooks—put his name on the sign-up sheet for a beekeeping course. Before long, he was a certified beekeeper.

Back at Tufts, in the lab of Philip Starks, Wilson-Rich was focused not directly on finding the cause of CCD, but on understanding how honeybee immunity works. A starting point was to develop methods to test bees' immune function. Because the honeybee genome had just been sequenced, many investigators were using microarrays to look at gene-expression patterns in normal and infected bees. "However, if we look only at gene activation, it is possible to miss post-transcriptional or post-translational modifications," Wilson-Rich says. So he decided to test for the presence of specific compounds in the blood of bees.

To induce an immune response, he used a nylon filament as a needle. An ice cube served as the anesthetic. When the honeybee's body is infected, its blood darkens with the same compound that darkens human skin. In bees, melanin production is triggered by the enzyme phenoloxidase (PO) via the formation of quinones that are toxic to pathogens. How dark the blood turns is a measure of the insect's ability to mount an effective immune response, a relationship that has been documented in other invertebrates.

In the hive, bees have age-specific roles. Young adult “nurses” tend to the brood; older “foragers” procure food. Wilson-Rich's data indicated that as bees age, the amount of protein in their blood goes down but the amount of PO goes up. Foragers exhibit greater PO activity, a potent defense that could be conferring herd immunity to the hive. With CCD, nurses prematurely turn into foragers without sufficient immunity; disease resistance of the colony drops and

disastrous consequences follow. With his thesis adviser and an undergraduate student, he published his findings as first author in the *Journal of Insect Physiology* in 2008.

A nontraditional path

Like any good graduate student, Wilson-Rich attended academic conferences. He also went to meetings of beekeepers associations in New England. He noticed a disconnect. "At conferences, scientists were talking about CCD and ways to make bees healthy, while beekeepers were wondering why their bees were dying and what they could do to prevent that," he says. "It was frustrating to see so little communication between these two groups." He decided to become a link between scientists and beekeepers.

Counterintuitively, research showed that urban honeybees survive winters better than their country cousins do. They also yield more honey. Promoting beekeeping—in Boston—became Wilson-Rich's new mission. He would coax Bostonians to install hives in backyards and on rooftops and decks. His own early aversion to insects helped him reassure clients who shared his fears. He figured out that he could install and maintain beehives and then help hive-owners harvest the honey. It had the makings of a modest business.

An alternative funding model

Wilson-Rich's transition from academic scientist to private sector honeybee health researcher/entrepreneur happened in steps. In 2009, when he was at Tufts, he entered the Dow Chemical Company's Sustainability Innovation Student Challenge. While he was infecting bees in the lab, it occurred to him that he could, perhaps, inoculate them with something fortifying so that they would not fall prey to CCD. For bees in a hive, he decided that an oral vaccine would be a viable alternative. He won a $10,000 award for his idea and filed a patent for his method to immunize honeybees. Buoyed by this success, he worked hard in the lab and continued to write papers.

By 2010, he thought he had enough publications to graduate—but his research adviser didn't share this view. His defense date kept getting pushed back. A postdoc offer that he'd lined up was rescinded, he says. That same year, he entered Massachusetts Institute of Technology's famous $100K entrepreneurship contest and won $2000 for his elevator pitch. At the end of the year, he defended his dissertation on "Genetic, individual, and group facilitation of disease resistance in honey bees (*Apis mellifera*) and two species of paper wasps (*Polistes dominulus* and *P. fuscatus*)."

Best Bees Company LLC was born on 1 January 2010. "It was based on a no-investor, no-inventory model," he explains. He buys a new hive only after he sells the previous one. Today, he's the chief scientific officer of the company he founded; he uses 100% the profits to research honeybee health. "This funding

model has been going strong for over 3 years now, and in our 4th year we hope to be up to 200 hives sold and managed," he says. Spread all over eastern Massachusetts, his clientele includes five-star hotels in downtown Boston and innkeepers on Cape Cod.

In some ways, his career resembles that of an academic faculty member—but with important differences. He earns his bread and butter by means of a full-time teaching contract in biology at Simmons College. His research program is not in a university biology building but at the Best Bees' lab, which is located in a warehouse space in Boston's South End. The company has seven "employees," but no one takes a salary. The chief operating officer runs his own software business; the rest are student interns who work there to earn college credit. Space is set aside for lab equipment—machines to run polymerase chain reactions, gel electrophoresis, and so on—but now desks occupy that space. Assays are sent out to commercial labs or done in the labs of the college interns who work with Wilson-Rich.

Right now, their revenue is generated by beehive sales and service, but they're seeking other revenue streams. "We continue to apply for research grants through traditional funding sources like NSF [the National Science Foundation], NIH [the National Institutes of Health], USDA, and others," he says, but so far none of those grants have come through. He is hopeful that someday the products from the company's applied research projects could generate income for research—even salaries. Bee-business-generated funding remains modest.

Science in the lab and the field

This summer, Best Bees will field-test an antifungal vaccine, made from yeast sugar, along with a probiotic supplement for bees. They hope the vaccine will act against the fungal spore *Nosema*, a growing threat to hives in the United States and one of the parasites linked to CCD. Rick Reault, the president of the Middlesex County Beekeepers Association in Massachusetts, says that he wants the vaccine to work because local apiarists prefer to keep their practice organic. Plus, there are limited foraging areas for bees due to habitat loss—and the supplement could help bees' overall health. "Both products have already passed the palatability test—a great thing for any oral medicine," Wilson-Rich says.

Evans, of the USDA bee lab, says that if Wilson-Rich takes good notes and maintains controls, it will be interesting to see the data that come out of this experiment. Wilson-Rich says he is committed to the level of rigor that he learned in the lab of his Ph.D. adviser. Best Bees already has manuscripts in preparation, using original data and with author lists that include undergraduate student-interns.

Wilson-Rich, who loves being on stage, also accepts speaking engagements to spread the message of beekeeping. "I used to be a theater kid," he says. "My first role was as a tree in a play." Since his TEDx talk last year, he has received

more outreach invitations. This winter, he was in Kenya as part of the Bees Without Borders program, which trains people from impoverished communities in the income-generating skill of beekeeping. He continues to sell and manage hives to keep his company's operations growing. And, for what it's worth, he was named one of the 50 Sexiest Scientists Alive by the online magazine *Business Insider*, at number 8. He is working on a book called *The Bee, A Natural History*, to be published by Ivy Press in the United Kingdom.

Like the proverbial subject of his studies, he stays busy.

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