2013 06 23 -- Chensheng Lu -- ( Lunatic ) Harvard Scientist Joined Forces To Rescue An Embattled Insect

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# The bee keepers

## How a Harvard scientist, a sixth-generation bee whisperer, and a retired entrepreneur joined forces to rescue an embattled insect and save the American food supply.

By Scott Helman

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**CHENSHENG LU** hardly cuts the profile of a provocateur. He dresses business casual and wears silver-rimmed glasses. He lives in Wellesley. He gardens. He has two children, one in high school, another in college. He occupies a tidy office in the Landmark Center, as an associate professor in the Harvard School of Public Health's Department of Environmental Health. And yet the mention of Lu's name in certain quarters elicits palpable discomfort: *Oh, him.*

Lu, who is 49 and goes by Alex, grew up a city kid in Taipei, the youngest of three siblings. He rode his bike to the baseball field, sometimes to the comic-book store. He knew little about agriculture, little about nature. Then he came to the United States for graduate school, first to Rutgers University and then to the University of Washington, where he got his PhD in environmental health. In the Pacific Northwest, Lu found his calling: tracking pesticide exposure in food, homes, and workplaces. The prevalence of these chemicals, he grew convinced, was a critical and understudied aspect of public health.

For nearly all this time, Ken Warchol was in Northbridge, teaching social studies to middle school and high school students, playing a 19th-century industrialist in historical reenactments, and coaching track and cross-country. On the side, Warchol, who is 63, tended to his lifelong passion of beekeeping, operating his own hives, helping other bee enthusiasts around Worcester County, and examining apiaries as a state inspector. "My whole life," he says, "I've been with bees."

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A sixth-generation beekeeper, Warchol traces the family tradition to Poland in the 1840s. His father brought the practice and tools with him to the United States after World War II. Several years later, Warchol, as a young boy, got his first hive from his father, who made him a wager: Whoever had more honey at collection time won dinner at the Bungalow, a restaurant down the road. Warchol can still remember the particulars of his victory. He had 84 pounds of honey to his dad's 76, and he got steak at the Bungalow. Only recently, as his mother was dying, did she spill the secret. His father had given him the strongest hive so he could win.

Dick Callahan grew up nearby in Worcester and earned a PhD in entomology from the University of Massachusetts, inspired by Rachel Carson's 1962 book *Silent Spring*, which chronicled the damage wrought by pesticides and sparked the modern environmental movement. After four years in the Air Force, he embarked on a career as a scientist and entrepreneur, running environmental surveys in the ocean, cofounding and taking public a pharmaceutical firm, and then helping others start their own companies. "I'm a real capitalist," the retired 72-year-old says.

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**Alex Lu, Dick Callahan, and Ken Warchol open a hive in Northbridge, where they are studying the effects of pesticide exposure on honeybees.**

About 15 years ago, Callahan was wandering around a Worcester flower show at what is now the DCU Center. He came upon a beekeeping exhibit and thought, *I've always been interested in that.* Soon after, he enrolled in a school run by the Worcester County Beekeepers Association. One of the instructors was Ken Warchol. They became friends and worked together on a government study of an eradication program for Asian long-horned beetles. Callahan went on to start several beehives of his own at his home in Holden and on a nearby farm.

The tale of how Lu, Warchol, and Callahan began collaborating is one chapter of a much larger story, a story of billions of vanishing honeybees and what their plight means for our dinner tables and health. It's a story of science and mystery, of politics and big business, of California almonds and Maine blueberries, of threatened livelihoods and jeopardized crops. It's a story about the high stakes and strong passions of environmental research. It's a story about chemicals, and what we know and don't know about their imprint.

This part of the story begins simply enough. In the fall of 2009, Lu and his son drove out to Keown Orchards in Sutton to watch Warchol give a presentation to beekeepers on preparing hives for the winter. Afterward, he introduced himself to Warchol as a Harvard scientist, asking Warchol to consider partnering with him on a research project.

Warchol's first reaction was, *the Harvard University?* "I got a 1,300 on my college boards," Warchol recalls telling him in an early conversation. "I wasn't even close to getting into Harvard." Lu reassured the beekeeper. He wasn't looking for a student. What he needed was a teacher.

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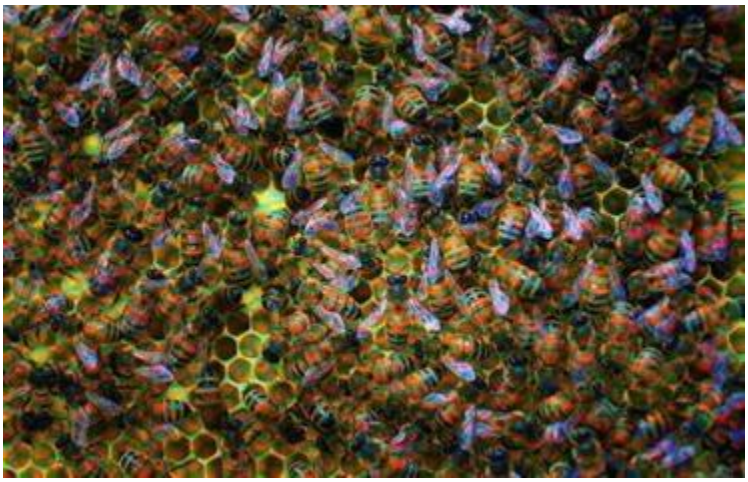
**IN LATE 2006,** beekeepers across the United States began reporting an ominous discovery: their honeybees were disappearing at unprecedented rates. Beekeepers, many of whom tended thousands of hives, were accustomed to losing 10 percent to 20 percent of their colonies each year. Normally, in diseased hives, piles of dead bees pooled at the bottom. This was different.

David Hackenberg, a commercial beekeeper in Lewisburg, Pennsylvania, sounded the alarm on *60 Minutes* in 2007, explaining that he had lost a staggering two-thirds of his bees. Other beekeepers fared worse, losing up to 90 percent of their hives. Researchers termed the phenomenon "colony collapse disorder." In affected apiaries, bees were inexplicably abandoning their colonies, often leaving behind food and young. The bees weren't just lying there dead. They were gone. "It was like a ghost town," Hackenberg told *60 Minutes.*

The phenomenon became an epidemic, wrecking colonies of small independent beekeepers and large commercial operations alike. Beekeepers who responded to an annual US Department of Agriculture-funded survey reported losing, on average, more than a third of their hives every year from 2006 to 2013, though not all losses have been attributed to colony collapse. Beekeepers in the Northeast have been among those hardest hit.

As the toll mounted, beekeepers, scientists, federal regulators, the media, and environmentalists groped for answers, blaming, at various points, climate change, poor nutrition, fungus, cell-tower radiation, mites, viruses, and even a purported scheme hatched by Russian spooks. The latest consensus among regulators and some scientists is that a combination of factors, including parasites, pesticide use, and increasingly homogenized American agriculture, is what's decimating the honeybee population. A US government report published in May concluded that "a complex set of stressors and pathogens is associated with CCD, and researchers are increasingly using multi-factorial approaches to studying causes of colony losses."



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**Lu, Warchol, and Callahan's bees.**

The urgency of solving the puzzle is undeniable. Honeybees are critical to the food supply. About one-third of what we put in our mouths benefits directly or indirectly from honeybee pollination, according to the USDA. Without bees, harvests dwindle and food prices rise.

Every year, commercial beekeepers truck hundreds of thousands of hives from state to state to pollinate a multitude of crops, from tree nuts in California to cranberries in Massachusetts. Many make a good part of their living through pollination contracts with growers. In recent years, the US honeybee supply has diminished to the point where growers have had to import pollinators.

In his previous research, Alex Lu had focused on human exposure to pesticides, making his name with a study in the Seattle area, first published in 2005, showing that switching children to a largely organic diet could quickly and dramatically reduce the amounts of pesticide residues in their bodies. He knew no more about honeybees than the average consumer.

What he did know, however, was pesticides — their complexity, their ubiquity, and their potency. Seeing David Hackenberg's story on *60 Minutes* aroused his suspicions. Like Hackenberg himself, Lu had a hunch that pesticides, above all, were to blame for the vanishing bees. He wasn't the first to see a connection, but he was determined to prove one.

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**THERE'S A CERTAIN GENIUS** to pesticides known as systemics. Unlike traditional pest-killing chemicals, which are usually sprayed on crops, lawns, and trees, systemic pesticides render a plant toxic to bugs from the inside out. Seeds are treated with pesticide before they're sowed (or sometimes the soil is pre-treated). When the plant grows, the poison essentially grows with it, spreading to all parts of the tissue and killing any snacking corn borers, rootworms, aphids, or stink bugs.

The big systemic pesticides these days are called neonicotinoids, which are derived from nicotine and target insects' nervous systems. They have exploded in popularity over the past decade, thanks to a perception that they are both safer and more effective than the pesticides they replaced. The vast majority of corn planted in the United States today is pre-treated with neonicotinoids, the seeds colored like candy. So are other major crops such as soybeans and canola.

The wind, not bees, pollinates corn, but bees can collect corn pollen. And neonicotinoid-laced pollen blows onto nearby flowers and crops, exposing honeybees to the poison. Neonicotinoids are also used on plants that bees do pollinate, including cucumbers and watermelons. Unlike older pesticides, neonicotinoids can linger in the soil for months or even years.

The more Lu learned about colony collapse, the more convinced he became that the epidemic's timing was no coincidence, coming as neonicotinoid use surged in American agriculture. With a $25,000 grant from Harvard, he began designing an experiment to test his hypothesis, aiming to replicate the honeybee disappearances that beekeepers were experiencing. It was clear neonicotinoids were acutely toxic to bees, just as they were to crop-eating insects, but what about at lower levels, over a prolonged period of time?

Lu, Warchol, and Callahan sketched out a plan. In the spring of 2010, they would set up 20 hives at four locations, two in Uxbridge and two in Northbridge. They would feed all the hives high fructose corn syrup, mimicking a common commercial beekeeping practice. (Beekeepers typically supplement their colonies' food supply with syrup or sugar.) In four of the five hives at each site, the syrup would contain imidacloprid, a commonly used neonicotinoid. The fifth hive, the control in the experiment, would be fed syrup not dosed with pesticide.

They began with a population of roughly 220,000 bees that grew into 1.4 million or so. On July 1, 2010, they started the pesticide regimen, beginning with very low doses, to make sure they didn't kill the bees right away. They upped the amounts after four weeks to levels that Lu says were on the conservative end of what bees encounter in the real

world — through syrup made from corn treated with neonicotinoids or nectar and pollen collected from contaminated flowers and crops. The four pesticide-laced hives at every site were given different concentrations of imidacloprid.

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**Part of the hive in Northbridge.**

Winter came, and they saw nothing. The hives seemed fine. “We were starting to get discouraged,” Warchol says. “Dick and I were talking, saying, ‘Wow, there’s really nothing going on.’ ” Lu had the same reaction. “At that time,” he says, “I thought my hypothesis was wrong.”

Then everything started to change. Around the beginning of 2011, a beekeeper whose yard they were using as a testing site reported seeing a mass of bees suddenly fleeing one of the hives. It was suicide — to endure the winter, honeybees typically cluster together inside their hive for warmth, surviving on food that a beekeeper has provided to sustain them. Some of the bees had dropped dead on the surrounding snow. The rest had disappeared.

Over the next several weeks, Lu, Warchol, and Callahan lost 15 of the 16 hives they had fed imidacloprid. It resembled colony collapse disorder, with abandoned hives bearing plenty of food. “It was an exciting moment in a sense, even though the bees were dying,” Warchol says. For Lu, it all clicked. “It’s not Mother Nature,” he says. “It’s us.” They lost one of their control hives to disease, but it looked very different from the hives the bees had fled, with dead bees littering the colony.

When Lu, Warchol, and Callahan sought to publish their results, they encountered resistance. Some journals wouldn’t take the manuscript. Peer reviewers raised objections. They finally published in 2012 in an Italian journal called the *Bulletin of*

*Insectology.* They also wrote a letter alerting the US Environmental Protection Agency to their work, just as two European research teams announced similar findings.

Critics challenged their science, the design of their experiment, and their conclusions. One California beekeeper was especially strident, going to great lengths to try to discredit their study. A leading bee researcher called it "an embarrassment."

Others, like May Berenbaum, head of the Department of Entomology at the University of Illinois at Urbana-Champaign, offer more measured criticism. Berenbaum questions Lu's sample size, saying sweeping conclusions are impossible from 20 hives. She also cites a separate study that found no evidence of neonicotinoids in commercially available high fructose corn syrup, which she says undermines the premise of bees being exposed to pesticides through the food provided by beekeepers. (Lu dismisses these objections, saying 20 hives was plenty, statistically speaking, and that no historical record exists on neonicotinoid levels in corn syrup.)

A self-described "tree-hugger," Berenbaum is highly critical of systemic pesticides. She just hasn't seen enough evidence to support banning them. If and when it reaches that point, she says, "I'd be the first one in line" pushing to restrict their use. "It's a seductively easy fix," she says, noting that many other chemical residues have been found in dead bees. "But like many seductively easy fixes, it is, I think, not likely to fix everything, or maybe even fix enough."

For Lu, the push-back to their study — and the fact that no one, to his knowledge, sought to replicate it — emboldened him to go back into the field. "He's a very passionate guy," Callahan says. "There's no question about it."

So Lu, Warchol, and Callahan established new testing hives at three sites in 2012. They varied their methods somewhat, in part by testing bees' exposure to both imidacloprid and another neonicotinoid called clothianidin. The results, they say, only reinforced their conclusion that pesticides are likely a major culprit behind colony collapse.

As last winter approached, the number of bees in all their test hives steadily dropped, which is normal for that time of year. But while the control hives started to rebound in January, the pesticide-treated hives did not. Lu is now finalizing the study in hopes of publishing the results in a journal soon. One factor he is investigating is whether neonicotinoids do more harm to honeybees in colder temperatures.

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**YOU COULD SPEND A LIFETIME** reading studies and counter-studies on pesticides and their effects on plant, insect, and animal life. Suffice it to say that debate rages over the chemicals we rely on and their true costs and benefits. But Europe, where honeybees have also suffered, has seen enough to act.

In May, despite opposition from the United Kingdom and some other member countries, the European Commission adopted a ban on the use of three neonicotinoids on crops that attract bees and other pollinators. The ban, based on a risk assessment by

European scientists, takes effect December 1 and will be reevaluated after two years at the latest. (A few European Union countries had already imposed their own such restrictions, and there's some evidence bee health has improved.) It's a step Lu and other critics of neonicotinoids say the United States should be taking. "The EU's ban is a slap in our face," he says.

Europe and the United States, though, have different approaches to environmental regulation. Where Europe is willing to take products off the shelf until they can be proved safe, the United States often allows industry to sell products until they've been proved harmful, a process that can take years.

SUZANNE KREITER/GLOBE STAFF

**Bees in Northbridge.**

The EPA, in particular, has come under heavy criticism for allowing pesticide manufacturers to start selling new products after limited safety testing and then leaving it up to the companies themselves to provide further data down the road. "It's a formula that is designed to fail, and it's doing just that," says Steve Ellis, a longtime commercial beekeeper in Barrett, Minnesota, who says he lost 65 percent of his hives in the 2012-2013 winter. "And the bee industry is failing because of it." Ellis belongs to a group of beekeepers and environmental organizations that filed a lawsuit against the EPA in March alleging the agency has been negligent in pesticide regulation.

Chas Mraz, a third-generation beekeeper in Middlebury, Vermont, also thinks systemic pesticides might be to blame for bee losses, which he has experienced himself, but he's pessimistic anything will be done about it. "It's just like nobody gives a damn about the beekeepers or a lot of other small enterprises in this country," he says.

The USDA and the EPA have been working jointly on honeybee health, trying to balance the importance of pest control to agriculture with the risks to pollinators. Kim Kaplan, a spokeswoman for the USDA's Agricultural Research Service, says pesticides are critical to food production and that crop yields would be substantially lower without them. "We have a lot of people to feed," she says. "So who goes without?"

The government, Kaplan says, can't hastily take neonicotinoids off the shelf unless the science is clear, an argument echoed by EPA officials. Kaplan insists the government is looking hard at pesticides, including the scenario that chronic exposure is a catalyst that makes bees more susceptible to other problems.

What does the government make of Lu's work on pesticides and honeybees? When I ask Kaplan about it, one of the first things she says is "Have you read some of the critiques of his studies?" In 2012, after he released the results of his first study, Lu says, he was disinvited from a meeting of the EPA's Scientific Advisory Panel. It was the kind of gathering he had participated in many times, and his research was certainly germane — much of the meeting, the agenda suggests, dwelled on bees' exposure to pesticides. But Lu says he was told his work was too controversial. (The EPA denies that Lu was disinvited, saying there were simply more candidates than available slots at the meeting.)

The pesticide industry, meanwhile, downplays any risks posed by neonicotinoids, seeking to shift attention to other potential causes of dwindling bee colonies. Industry representatives make their case in detailed responses to news articles, through millions of dollars of lobbying in Washington, D.C., at government conferences, and on social media. Bayer, one of the biggest manufacturers, maintains a golden-hued Web page and Twitter account under the name Bayer Bee Care, where it promotes alternative explanations for why honeybees are disappearing.

Ray McAllister, senior director for regulatory policy for CropLife America, a pesticide industry association with more than 90 member companies, says his organization is committed to improving honeybee health. Like other industry representatives, he questions the pesticide levels Lu used in his study, saying they were significantly higher than those bees would find in the natural environment. "It's just difficult to draw any meaningful conclusions from the study," he says.

But what of the European ban? McAllister calls the decision politically motivated and the product of faulty science. What if, I ask him, honeybees in Europe bounce back after the two-year hiatus? "I will be very surprised," he says.

Lu has come to expect this kind of response, seeing parallels to how Big Tobacco tried for years to deflect growing evidence of the health risks posed by smoking. The more pesticide companies can muddy the picture of what's happening to honeybees, Lu says, the better their business does. "This is just like a gold mine."

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SUZANNE KREITER/GLOBE STAFF

**MORE THAN ANYTHING, HE REMEMBERS THE QUIET.** It was the spring of 2011. Lu had driven out to Worcester County to see one of the apiary sites. Other hives were buzzing. But not the ones exposed to pesticide. "Those four hives were dead silent," he says. The take-away, to him, was clear: "This," he thought, "is the replication of Silent Spring." It was, as Rachel Carson had written about the absence of birds decades before, a "spring without voices."

Lu has studied pesticide exposure in Seattle-area children, in migrant farm workers in Washington state, and in Boston Housing Authority tenants. He and his family try to buy organic food. They also grow fruits and vegetables themselves in eight raised beds. He describes honeybees as "a wonderful gift that God gave to us." But he is hardly the radical anti-pesticide activist his critics may assume.

He calls pesticides "a tool that we cannot afford to lose," given their importance to food production. He believes there's a responsible way to use pesticides, but that we're nowhere near that. "I think it can be done," he says.

Callahan thinks farmers should approach pesticides the way sensible people approach antibiotics: "You take it when you need it. You want to take it carefully. You want to know what you're doing. And you sure as hell would like to know the side effects."

I heard a few people raise the idea of the honeybee as canary. Bees aside, what do we know about the consequences of our own chronic exposure to chemicals like neonicotinoids? "Very little," Lu says. He sees promise in an emerging research field called metabolomics, which seeks to connect the dots between the body's short-term responses and reactions to things like chemical exposures and the subsequent development of disease.

Even if Lu turns out to be right about neonicotinoids, still outstanding is the question of what chronic exposure actually does to bees physiologically. Does it impair their navigational and orientation capabilities, as some research suggests, prompting them to fly away? Does it indeed make them more susceptible to cold temperatures? Does the buildup of pesticide residues enhance bees' vulnerability to mites and pathogens? All of the above?

In a sense, Lu and the scientists, regulators, and companies skeptical of his work don't seem all that far apart. It may well be that several accomplices share responsibility for colony collapse. It's just that Lu is ready to pick neonicotinoids out of the lineup, and not everyone is.

If there's any upside to this crisis, it's widespread sympathy for honeybees, sparking new interest in beekeeping in urban areas such as Boston and New York, in the suburbs, and beyond. Some 320 beginners signed up for the Worcester County Beekeepers Association's Bee School in March, which Warchol says is the largest such class ever seen anywhere in Massachusetts. Chas Mraz says the same thing's happening in Vermont.

For veterans like Warchol, the allure of beekeeping has never worn off — of tending to a flourishing hive, of harvesting its honey, of bearing witness to the intricate age-old ecosystem, with all the individuals working for the good of the whole. "I still love it," Warchol says over a handsome breakfast at an Uxbridge diner. "I go out there on a sunny afternoon. It's such a glorifying feeling to see this little micro-world — how they work together — and you learn so much from it. They all know their jobs. They do it well. They just know what to do to make a successful beehive."

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