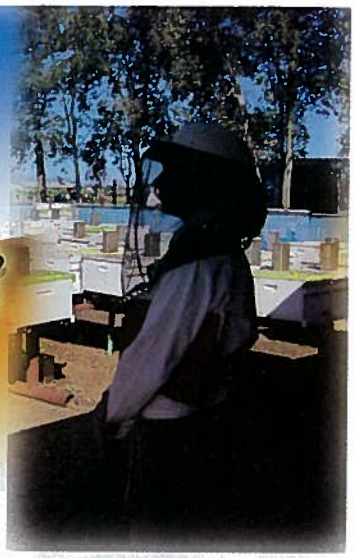
Marla Spivak
Getting Bees Back on Their Own Six Feet

Part 1 of 2 parts

by M.E.A. McNEIL

Marla Spivak is something more than a bee researcher and professor at the University of Minnesota, but there is no good word that sums her up. If there were, it would apply to people who can pick up a stereogram and see its hidden 3-D picture in the field of abstract images — those who can look at the big picture and pick out ideas that make sense of it, like an athlete who sees a path to the goal through a maze of moving bodies.



Dr. Marla Spivak is as at home in the bee yard as she is in the lab. She is developing the connection between research and beekeepers.

Case in point: a dirty Jeep windshield. Spivak was riding along a Northern California back road, on her rounds to visit queen breeders. She was deciphering the glass covered with Pollock-like patterns of bright yellow bee droppings–dots, stripes and plops. The driver, Dennis vanEnglesdorp, the astute Pennsylvania State Apiarist, joined the game: The little ones, they decided, were from new foragers taking orientation flights, the long ones, cleansing flights from bees that have been cooped up, and the splats were Nosema, a fungal pathogen that causes diarrhea–a problem that they had come to test for. Spivak had brought along VanEnglesdorp for his practical advice in solving the big puzzle beyond the windshield: how to turn back the decline of the honey bee.

Most experts have come to agree that the cause is what Jeff Pettis of the USDA Beltsville bee lab calls "a cumulative effect." The story of Zac Browning, an Idaho commercial beekeeper is typical: Over the last five years, he has increased medications and feed for his bees and still lost a third of his colonies at almond pollination this year. He calls it "a perpetual cycle of diminishing returns." His loss is around the national average, which Pettis calls "unsustainable."

With some researchers charged with the task of finding out what is wrong, Spivak has devoted her career to promoting what's right. She calls her task "getting bees back on their own six feet".

Why bees? In the "stuck places in life," Spivak said, "bees and beekeepers have somehow been there for me. I owe them." For one, when she'd fallen gravely ill while traveling in Peru, the doctor who cured her was a beekeeper, and she took care of his bees while recuperating.

Her fascination with bees had begun in college in Arizona, when she was so deeply drawn into a book about bees that she stayed up all night; she never came out. She interned with New Mexico beekeeper Jerry Cole and, after finishing her BA in biology at California State University at Humbolt, she volunteered at the Tucson USDA bee lab, supporting herself by driving an ice cream truck. "That was an enlightened lab. There was so much good research energy there, it was great–Steve Taber and Martha

Dr. Marla Spivak (center) with her right hand man, Gary Reuter, and graduate student Katie Lee with mating nucs for the Minnesota Hygienic bees. The stock was developed at the University of Minnesota as a prototype for beekeepers, who can now select for the behavior from their own lines. (Photo courtesy of Marla Spivak)

Age-painted bees removing freeze-killed brood from an observation hive for experiments on hygienic behavior done around 2004. (Photo courtesy Marla Spivak)

Harvesting mated Minnesota Hygienic queens from Minnesota beekeeper Darrel Rufer's nucs in Texas in 2004. (Photo courtesy Marla Spivak)

Gilliam; H. D. Spangler was there, too.

"Taber taught people how to think. He was my mentor that way. Every step of the way he would challenge your thinking. How long does it take eggs to hatch? You'd say three days, and he'd say, how do you know that? And he made you go back and question everything you knew, test it on your own. He was a really creative thinker."

She'd eschewed graduate school as "so far removed from reality," but during six months in Venezuela as the beekeeper setting up grad students' experiments for Chip Taylor's African bee research, she was drawn to study Africanized honey bees (AHB). The reputed "killer bee", she could see, "had a lot of good characteristics. They were a smart bee. There was a lot of behavioral variation among Africanized colonies, and therefore probably a lot of room for selection."[1] She spent two years in Costa Rica studying AHB and received her PhD from the University of Kansas under Taylor in 1989.[2]

During her post-doctoral research at the Center for Insect Science at the University of Arizona, she saw a pattern in the decline of the bee that would guide her work until the present: "Despite our tendency to try to control nature, it is not healthy for the bees to be fully domesticated, for them to be totally reliant on us. Since the introduction of Varroa mites, we have made our European-derived bees chemically dependent on our medications for their survival, and this is not a wise strategy. Bees really need to develop their own defenses against diseases and parasites."[3] What she calls a co-evolutionary arms race with pathogens serves as a selective process, allowing for the emergence of traits to combat infection.

Taber and Gilliam, at the USDA lab in Tucson, had picked up on old work on hygienic behavior of bees: Park and Pendell saw the trait in the 30's. In 1942, Woodrow and Holst reported observing bees uncapping and ridding the hive of larvae with American foulbrood in the latent, non-infectious state–with the spore-carrying adult bees not infected. Rothenbuhler picked up the research in the 50's, coining the term "hygienic behavior". He knew that it did not sort out cleanly as a Mendelian trait, but not how it is controlled by a number of genes in a complex way. It was not until the 80's that Taber reexamined the behavior, and he and Martha Gilliam found that it produced resistance to chalkbrood as well as foulbrood.

"I decided to ask, said Spivak, "Is hygienic behavior a mechanism against Varroa and why hasn't anybody selected lines for it? Is there a problem with this trait? We've known about it since 1930; what's going on here? Is it because it's just easier to treat with antibiotics or does this trait compromise honey production or make the bees neurotic or what? So I decided to breed these lines just to look at the behavior."

She took her quest to the University of Minnesota, where she became an assistant professor in 1993. In a group of honey producers interviewing her for the job, American Beekeeping Federation president David Ellingson recalled that "She looked at the whole picture and she had this vision of something that would work." Asked about mites, "Marla said the resistance would build up. Boom! Just like that, it happened."

She came at the problem with scientists – chemists and ecologists, as well as a neurobiologist exploring the neuromechanisms that modulate bee behavior. She and Gary Reuter, her inventive technician, developed what is known as the Minnesota Hygienic line of bees – gentle, productive bees that detect and rid the nest of infected brood before pathogens can spread.[4]

Presenting the work, "I noticed everyone's glazed eyes when I was done," Spivak said. "Finally one gentleman stood up and very politely asked, 'How does a little thing like you lift those honey supers anyway?' I realized they didn't hear — and didn't understand — my words because they couldn't make the connection between me on the podium and me in the bee yard. I found it to be a genuine question, and funny, and I learned from it."

Liquid nitrogen testing for hygienic behavior in Darrel Rufer's colonies in 2005 at one of his apiaries in Minnesota, where he brings his colonies for the summer. Abdullah Ibrahim, left, and Kathy Jez are former grad students. The N2 freeze-kills the circle of brood, which is checked in 24 hours to see what proportion are removed by hygienic behavior. Rufer's open-mated colonies now test as well as the original instrumentally inseminated Minnesota Hygienic line.

Gary Reuter working with Minnesota beekeeper Jeff Hull on selection for hygienic behavior on his hives in Louisiana. The trait is now strong in Hull's bees.

Working with the beekeepers, Spivak and Reuter set up field trials in Minnesota and North Dakota to test the bees under commercial pressures. Ellingson, among the first to try the new line, found that he was able to reduce the miticides he used. In addition to support from the The National Science Foundation, USDA Sustainable Agriculture Research and Education, and the National Honey Board, backing for the work came from the beekeepers themselves – honey producers from Minnesota and Wisconsin, beekeepers' associations of North Dakota, South Dakota, Iowa and California.

The stock had an olfactory ability to identify American foulbrood, chalkbrood and Varroa, which it removed. In 2001, a cross was made with the VSH (Varroa Sensitive Hygiene) line created by John Harbo and Jeffrey Harris at the USDA Baton Rouge lab. That further reduced mite loads and increased the degree of hygienic behavior.

Spivak's goal was never to produce the über-bee: "I didn't want to promote a monoculture." The idea was to demonstrate the trait with the goal that "beekeepers can select from their tried and true lines." She was asking others to take the pattern, not the product.

Handing over this project was the next step in the vision. Its one thing to create an instrumentally inseminated line and quite another to put it out to the vagaries of open mating. But three Minnesota queen producers now breed naturally mated colonies that, Spivak is delighted to tell, test as well for the hygienic trait as the instrumentally inseminated queens from the University breeding project.[5] It is a notable accomplishment, given that half the genetics of any given beekeepers' open-mated colonies come from the bees of other apiaries. Because the hygienic trait is recessive, it takes an environment of drones bred for the behavior to create such a phenomenon. Sweet success.

Spivak teaches several courses at the University, including basic beekeeping, which has been taught there since 1922. She took over from the respected Basil Furgala and still follows his practices, which she has found to be "so sound; a great way to keep bees." Disease management in the course, though, has changed; preventative practices trump prophylactic treatment. Some of her classes are open to the public, including bee management, queen rearing, and a web class, "Healthy Bees".[6]

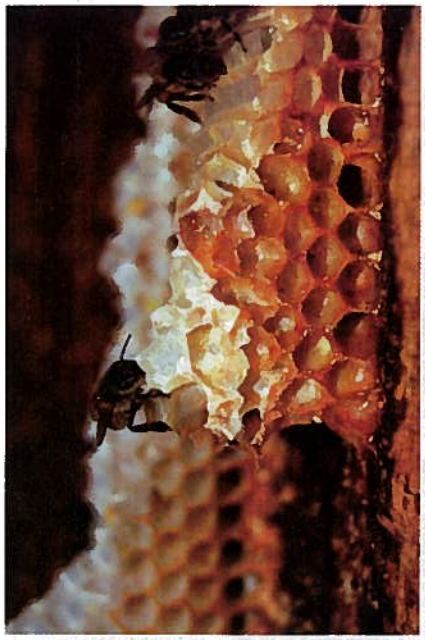
Attention from the University for her work has benefited her goals. She wears the honorific title Distinguished McKnight Professor lightly, but she relished the invitation to teach a credit course of her choosing. She created Entomology 4021: Honey Bees and Insect Societies, which focuses on cooperative behaviors of social insects. It was a prescient choice to delve into the evolution of individual and social behaviors, given her larger goal of keeping honey bees healthy. At a scientific meeting, she attended a talk on European ants that reduce bacteria in the ant mound by bringing in resin globules. "I thought, oh, of course. I was sure that was what the bees were doing with propolis," she said – an example of social immunity.

Many species of bees have long been observed collecting and using resins as propolis. The few honey bee resin foragers pack resin on their corbiculae like pollen. It is unloaded by other bees with effort, mixed with wax and used by "cement bees" for sealing cracks, creating smooth surfaces to attach comb, entombing predators. Feral colonies line their nest interior with a "propolis envelope". A large body of research for human medicine has established that propolis has antimicrobial properties. But how it affects the microbes in the hive or the immune systems of the bees had not been explored.

"My graduate student, Mike Simone-Finstrom and I had to gear up to understand how to study that kind of thing in honey bees. I asked for help from Jay Evans at the Beltsville bee lab, the expert in the U.S. on the bee immune system," said Spivak.

What they found is that in the presence of propolis, the bees' immune system is quieter – because, it appears, the propolis takes over the job of killing general microbes in the nest. To determine this, Simone-Finstrom was able to measure the amount of gene transcript producing antimicrobial proteins in the bees. He found a significantly lowered expression of two honey bee immune-related genes and lowered bacterial loads in the propolis-treated colonies. They cite this as the first direct evidence that the bees' nest environment affects immune-gene expression.[7]

An intriguing phone call from a technician at a med school HIV lab inspired a new exploration of propolis. Spivak's caller had treated a cold with propolis, as she had learned to do growing up in Russia. She re-



Spivak's lab investigated the beneficial use of propolis by bees. In feral colonies, bees secure comb to the hive wall with propolis. As seen here, the attached cells will sometimes also have a thin coating of propolis. (Photo: Michael Simone-Finstrom)

A resin forager returns to the nest to a "cementing site", where workers will laboriously unload it and mix it with wax to be used as propolis. Spivak and her colleagues have shown that the antimicrobial properties of propolis quiet the immune systems of the bees. Here, propolis can be seen at the tops of two frames. (Photo: Michael Simone-Finstrom)

Jerry Cohen is a plant biologist at the University of Minnesota who is working on a collaborative project with Marla Spivak to find the active antimicrobial components in propolis. (Photo courtesy of Jerry Cohen)

ported that she'd then experimented with it in a Petri dish against HIV, which it successfully killed. "I wondered how to pursue it," said Spivak. "I don't do human research. And then it dawned on me — it was one of those moments — that we shouldn't do the work on humans, we should test propolis on bee diseases."

Her idea was to fractionate (break up into smaller chemical components) the propolis, identify and then test the components against various bee diseases. Once the active ingredients were known, they could be tested for humans. She enlisted two of her colleagues from the first propolis study, Jerry Cohen and Gary Gardner, chemists and plant biologists, and they came up with the methods to do the analysis using propolis from a variety of sources.[8] They can, for example, culture American foulbrood, put a component of propolis in the solution and measure the optical density: It is dense when it is full of bacteria and clears as they are killed. They are able to run these samples rapidly.

But viruses can't be cultured, Spivak explained; they have to be studied in the bees. So the team reared infected larvae in an incubator and fed them royal jelly with different concentrations of propolis.

Cohen thinks the fractions contained in propolis may number ten times the 300-500 in the current data. Graduate student Mike Wilson hopes to isolate antimicrobial properties, keeping in mind that in humans there is growing resistance to antibiotics, most of which come from fungal sources.

"Within several years we'll have identified fractions that are active against bee pathogens for sure," said Spivak. "Of course, a long-term hope is that after testing propolis components on bee diseases and viruses, we can find components that would be helpful to treat human viruses, particularly an inexpensive treatment for HIV for developing nations." And "beekeepers may be able to diversify their income by harvesting and selling propolis."

To get to that point, Spivak wanted to better understand this tiny minority of resin gatherers who bring such benefit to the colony. Graduate students Simone-Finstrom and Joel Gardner have determined that these specialists are more sensitive to tactile stimuli such as gaps and rough surfaces. They sense sucrose at greater dilutions than pollen foragers. How the researchers discovered these characteristics, described in their paper, is as interesting as the facts they gleaned.[9]

Each new understanding prompts more questions. Experiments are underway to find out: If propolis has an effect on Varroa; if propolis changes the bees' immune systems when disease is present; what prompts resin foraging (do bees self-medicate?).

At the same time, Spivak is pondering a larger question: How can these ways that the bees help themselves benefit a wider population? She surprised herself with the simplicity of her answer. In Northern California, where most of the queen bees are bred in the continental U.S., a technical team could be established – like farm advisors for beekeepers, a liaison between producers and researchers. As she rolled through the countryside that afternoon contemplating the evidence on the windshield, Spivak was on her way to making the idea a reality.

Part 2 of this article describes the establishment of this new advisory team as well as Spivak's projects to place bees in land reclamation areas and establish a new bee lab at the University of Minnesota.

Footnotes

1 Her measured interview on the television show MonsterQuest last June provided balance to the goal of the program to induce fear.

2 See Michael D. Breed, David J. C. Fletcher, Marla Spivak *The "African" Honey Bee,* Westview Studies in Insect Biology, 1991. 435 pp.

3 Spivak, Marla, "Bee Health: Putting Control in Last Place", The *American Bee Journal*, November, 2008.

4 Spivak, Marla and Gary Reuter, "New Direction for the Minnesota Hygienic Line of Bees", The *American Bee Journal*, December 2008, 1085.
Spivak, Marla, Gary Reuter, Katie Lee, Betsy Ranum, "The Future of the MN Hygienic Stock of Bees is in Good Hands!" The *American Bee Journal*, October 2009, 965-967.

5 Darrel Rufer (612) 325-1203; Mark Sundberg (218) 721-5942 mdsund2000@yahoo.com; Jeff Hull (218) 205-6426.

6 University of Minnesota public bee classes: www.extension.umn.edu/honeybees/components/publiccourses.htm
Beekeeping in Northern Climates; Successful Queen Rearing; Bee Management, a 3-week, hands-on course that includes management of honey bees and native bees, including bumblebees and blue orchard bees. A web-based course called "Healthy Bees" teaches sustainable methods of controlling diseases and pests of honey bees.

7 Simone, Michael, Jay D. Evans, and Marla Spivak, "Resin collection and social immunity in honey bees", *Evolution* 63-11: 3016–3022.

8 The collaborative project included PhD students Jessica Burtness and Mike Wilson, University of Minnesota Department of Horticultural Science.

9 Simone-Finstrom, Michael, Joel Gardner, and Marla Spivak, "Tactile learning in resin foraging honeybees", *Behavioral Ecology and Sociobiology*, April 2010

Marla Spivak
Getting Bees Back on Their Own Six Feet

Part 2 of 2 parts

by M.E.A. McNEIL

A hands-on researcher is finding ways for bees to defend themselves.

Dr. Marla Spivak is as at home in the bee yard as she is in the lab. She is developing the connection between research and beekeepers.

The idea came to Marla Spivak as she looked at a map of the United States, sitting in her office at the University of Minnesota, where she is a professor of apiculture. If the picture of her were a cartoon, a light bulb would appear above her head.

She is prone to having these sparks of perception. The first one came some 20 years ago, when she realized that our well-meaning medication of honey bees would come to naught, and that bees "need to develop their own defenses against diseases and parasites." She revived some old research and, together with Gary Reuter, developed the Minnesota Hygienic line – bees with the olfactory ability to identify and remove brood infected American foulbrood, chalkbrood and Varroa. Then, she gave over the process of developing hygienic bees to all comers.

Another insight into bees' self-defense came from hearing a research talk about propolis-gathering ants that have low microbial activity in their nests. Her lab subsequently discovered that the honey bee immune system is quieted in the presence of a layer of propolis enveloping the inside of a bee hive. A further realization – that there could be more specific application to bee and even human health — resulted in an ongoing study to fractionate propolis in order to discover its active components.

Three Minnesota beekeepers now have open-mated lines that test as well for hygienic behavior as the original instrumentally inseminated MN Hygienic stock. And the propolis studies have influenced respect for the precious substance, which was long regarded as a nuisance. Still, the overall decline of the honey bee, according to Jeff Pettis, head of the USDA Beltsville bee lab, is "unsustainable."

For three years Spivak had been pondering the question: What more can be done for bees to help themselves, "onto their own six feet"? The map she was contemplating in her office was marked with the locations of the queen producers in the U.S. Quite a few were in the South, but the map showed that the vast majority of American queens, with the exception of Hawaii, come from Northern California. The larger producers there, she knew, sell 20,000 to 50,000 queens a year – some up to 70,000. The smaller ones in the area produce around 10,000, all in a three-month period. It's the continental center for queen rearing, the source for much of the genetics across the country. Of course, she thought, the answer was right there, simple and clear. What if those queen producers became the agents of change?

Many of the California queen breeders are located around the northeast edge of the Sacramento Valley at around 39°N at the foot of the Cascade and Sierra Nevada ranges. They are that far north because most are long-time family operations originally situated there for trade with Canada – started by Homer Park, Oliver Hill, Harry Laidlaw and others. The Koehnens have been there over 100 years. Northern California beekeepers shipped thousands of packages each spring to replenish Canadian apiaries that were routinely killed off every winter. When the Varroa mite was found in the U.S., the border was abruptly closed by the Canadian government – to no avail it turned out, but it left the breeders with huge stocks and drove many bankrupt. The new focus became queen rearing for the domestic market. "Although they are further north than is ideal for early queen production, it may be a blessing," said Spivak, "Because no queens can be sold within 100 miles of any AHB (African honey bee)

Spivak in the bee yard with Bob Koehnen, whose family has bred bees in Northern California for over 100 years. Photo: Alison VanAlten

Buzz Landon checks a 24 hour hygienic test at his apiary in an almond orchard. Spivak looks on as he finds that his bees have cleaned out nearly 100% of the dead brood.

sighting."

Her idea was, in concept, a good one, but people are more difficult to manage than insects. Spivak is quick to make the point that these people don't need to be told how to keep bees. "These guys know what they're doing. I think these bee breeders do an amazing job of selecting and raising good quality queens. They are really concerned about their bees' health. If you spend some time with them, you see how they handle their bees; they are being extremely delicate and careful. So my idea isn't to change what they are doing, I just want to enhance what they are doing. I want to help them help their bees defend themselves against diseases and mites. And I want to help them decrease chemical use so they can sell queens across the nation—change the genetics across the nation in a way that would be beneficial."

She knew what hadn't worked. Beekeepers come to conferences, and they "sit and listen to the lectures by university people — dense talk, dense data. They don't learn that way. They go out in the hallways and ask others, what's working for you?" Even if there were more state apiary inspectors in California, their job would be to prevent the spread of diseases. And there is only one university extension apiarist west of the Rocky Mountains, the respected Eric Mussen, who does not have enough hours in a day. What if a team on the ground provided a liaison between producers and researchers – like farm advisors for beekeepers? Such people are common in agriculture: The pest control advisor or the crop consultant.

In 2008 Spivak, together with her technician Gary Reuter, grad student Katie Lee, and colleague Alison vanAlten,[1] went on the road in Northern California, visiting 19 queen breeding operations who agreed to see what she was about. Wherever they were welcomed, she explained her idea and tested colonies for hygienic behavior and pathogens. Building trust was a slow process. In 2009, Lee — along with Betsy Ranum and weekly rotating help from Spivak, vanAlten or Reuter — again spent the month of March visiting each bee breeder open to the idea.

In the spring of 2010, Spivak was on the road near Chico, California, having just analyzed hygienic tests for a breeder. "Their numbers were not so great this year" she said, "But that's no judgment. They wanted all of their colonies to be hygienic. They wanted it, and that's enough. They have to want it and they do. That was great. We can easily make that happen."

What she is saying is that all news in this project is good news, whatever the results. It provides a base of information for decision making. For example, Spivak tests for the fungus *Nosema ceranae* (which has replaced *Nosema apis*). Thus far, the uses of the data have ranged from comparisons between treated and untreated colonies or those that have and haven't gone for almond pollination, elimination of costly treatments shown to be ineffective, and elimination of treatment where spore counts were low – allowing for the emergence of resistance and an indicator of good breeding stock.

A change in Nosema sampling was made when Dennis vanEnglesdorp, the Pennsylvania State Apiarist, toured some bee yards with her to discuss the project this year. Spivak explained the thinking: "The young bees can pick up spores, either from the comb or through trophallaxis. It takes about 12 days for those cells to start invading the stomach lining of the bee. You can't see the infection until the bees are about 12-16 days old; that's what some laboratory experiments show. Inside bees are 1-14 days old, and most of the foragers are outside. If you sample foragers, you are sampling in favor of finding it. If you sample nest bees, you are biasing in favor of not finding it…So we decided to take some inside-outside samples."

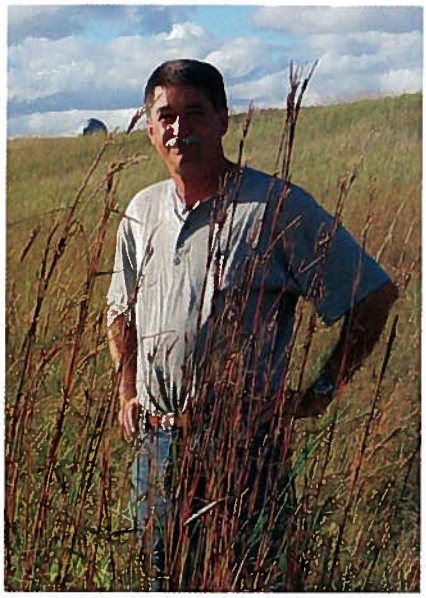
In apiary after apiary, Spivak gathered bees with a bee vac made by the innovative Reuter.[2] In a nearby shed, honey house or barn her Brazilian student Renata Borba counted out piles of 120 test bees, crushed them and shook each group into 1 ml water. (She now skips the laborious step of removing the abdomens at the suggestion of vanEnglesdorp.) Seated on an upturned bucket or a super, Spivak peered through the microscope that she brought from her lab, looking for Nosema spores in the prepared samples. For every colony she counted spore by spore against a hemacytometer, a grid used for counting blood cells; then she prepared a report for each beekeeper.

The next stop of the day was at Can-Am Apiary, named for the once thriving cross-border commerce in bees. Leonard and Linda Pankratz greeted Spivak warmly and wasted no time getting into the testing since

Renata Borba, a University of Minnesota entomology student, and Gary Reuter, Spivak's assistant, prepare a drone trap at Pendell Apiaries in Northern California.

Spivak's student and assistant, Renata Borba and Gary Reuter, follow a drone trap at Pendell Apiaries in Northern California for a study of drone viability conducted by Dave Tarpy at North Carolina State University.

Borba, left, and Spivak pour liquid nitrogen onto circles of brood, setting up 24 hour hygienic testing at an apiary of Dan Suhre, who looks on.



Spivak is working with Ned Euliss, above, a wildlife biologist, on his idea to study colonies of bees placed near bee forage provided by the new farm bill. Euliss is with the U.S. Geologic Service Northern Prairie Wildlife Research Center in North Dakota.

they still had to bank queens. Then Leonard Pankratz, a long experienced beekeeper, showed Spivak something he had never seen before – robust, healthy larvae and adults adjacent to dwindling pupae. He wondered if there could be a connection to the spraying of the fungicide Pristine on a nearby orchard. There in the bee yard, Spivak dialed Jamie Ellis at the University of Florida and then Reed Johnson at the University of Nebraska and explained the problem to the researchers. Both agreed to add the chemical to the list of those they are testing on brood and promised to get back to her.

She was on the road again, watching the clock, aiming to meet Buzz Landon at his apiary in an almond orchard.[3] She and Borba wanted to check the results of their 24 hour tests on time — circles of brood frozen with liquid nitrogen. They would see how well the bees have cleaned out the cells, an indication of hygienic behavior. A non-hygienic colony can take as long as six days.

Landon, a young, gentle-spirited guy, has 500 hives in almonds and reports a 10% loss for the last year – a third of the national average. He keeps his bees in the Chico area almonds February thru mid-March then breeds queens and makes nucs in his local yards. The tests looked good – very good: some circles were 100% clean of dead brood, and others were well on the way. Spivak remarked that his comb looks new. "The comb is like the liver," she explained to Borba, "It absorbs everything."

Spivak recommends replacing comb within the brood nest every three to five years, even though it is costly to both the beekeeper and the bees. She points out that old comb harbors spores from American foulbrood, chalkbrood, and Nosema which can remain viable for years. It also absorbs pesticides, which accumulate to the detriment of the bees.

Landon explained that chemical companies have field days with tents and refreshments to sell treatments, but there is no objective information for beekeepers and queen producers. "As it is now, someone phones and says so-and-so is doing something or other, and we all start doing it." So why not, he asked, have a field day for this project?

(L) Frank and Sheri Pendell pause in the midst of a work day at Pendell Apiaries. In the background, Gary Reuter and Renata Borba of the tech team project work at the mating nucs. (R) Leonard Pankratz of Can-Am Apiaries selects nucs for testing by Marla Spivak.

Spivak uses a bee vac, invented by her assistant Gary Reuter, to gather a sample of bees for Nosema testing. Renata Borba waits to bag the bees, while Leonard Pankratz works ahead in his apiary.

Testing for Nosema by (from left, clockwise) Renata Borba, Marla Spivak, Esmeralda Garcia and Georgina Garcia. The Garcias, grafters at the apiary of Pat Heitkam, are counting out bees to be put into dilution by Borba and read for spores by Spivak.

Spivak is gathering such ideas as plans for the team take shape. Another suggestion is experimental apiaries to test treatments the beekeepers are interested in, for example, the walnut oil that one has asked about. "What form the team ends up in, I can't say," she remarked. "I'm going to have to let go of my baby because how the project evolves is going to be bigger and better than I can anticipate — and that's good," she said.

And so it went, as Spivak traveled the back roads – listening, testing, observing, answering, counting bee samples and leaving the beekeepers with results to make decisions on their own.

Spivak makes reports on testing in the field for each beekeeper to evaluate and use in determining practices.

Reuter and Borba made the next trip to Northern California, staying a night up a remote valley in the camaraderie of Frank and Sheri Pendell in Stonyford.[4] The Pendells count the isolation of their apiaries as an advantage for breeding bees. The task at hand, to which the researchers devoted the better part of a day, was to find the Pendell drone congregation areas and send samples to David Tarpy at North Carolina State University. He is studying the reproductive quality of commercial bees; in this case, he will test the viability of the semen in the drones as well as genetic diversity. The work is funded by a grant from the USDA National Research Initiative.

Last year, Spivak brought a master of drone sleuthing, Chip Taylor of the University of Kansas, to California to show Tarpy and beekeepers how to do the trapping. Armed with that tutelage, Reuter and Borba each took a weather balloon attached to a long net trap baited with queen pheromone and run out with a fishing rod and reel. They parted and began trolling the open landscape. Drone flights started reluctantly that day, with workers pushing males out the door in the early afternoon. It was an hour before Borba's voice crackled in the walkie-talkie: "I have one." One drone does not a DCA make, but it was more than Reuter's lure had attracted. So they walked together, their eyes skyward on the trap, for two more long, hot hours, fishing the sky. They followed a few drones until Frank Pendell joined them; he had a sense for it, and they soon came into what felt like a booming concert of buzzing, with comets of bees rushing overhead. Borba systematically sampled different areas of the congregation, urging the drones, one by one, into small shipping cages. Back at the apiary, Sheri Pendell carefully packaged the cages with attendants for an overnight cross-country journey. The UPS truck was making its long way up the valley as the team passed it, rolling down to their next task.

In November, 2010, Katie Lee will move to Chico to continue the work, which has been funded for six months by the National Honey Board and the Almond Board. She will work out of an office at the University of California County Extension in Oroville.

Lee has developed a standard method to sample colonies for Varroa.[5] Spivak explains: "Beekeepers were just saying I have mites, I'd better treat. Or they were just blanket treating by the calendar. We wanted to come up with a standard way for beekeepers to estimate the number of mites easily, very quickly and with precision, so if beekeepers speak of mite levels they are all using the same currency. She sampled mite levels in almost a thousand colonies in commercial apiaries and worked with some really good statisticians in the entomology department. She came up with recommendations that will give good precision: Take 300 bees. (We have a gizmo that measures 300 bees that Gary Reuter invented.) Using powdered sugar, shake the mites off the 300 bees. If you find 10 mites in 300 bees, divide that number by 3 to tell how many per 100 — 3.3. Multiply by 2 to compensate for the number of mites that are inside the sealed brood cells and in the pupae. She did a lot of research for that simple conversion factor, that multiplication by two — the result of a lot of sampling and statistics. So that is 6.6,

Renata Borba, Spivak's student, cages trapped drones for shipment to Dave Tarpy's project on viability.

Ray Olivarez begins a frozen brood test for the hive of one of his most prized breeder queens, "Montana". He is one of the large-scale queen breeders working with Marla Spivak on a program to institute the equivalent of farm advisors for beekeepers.

and that would say that you have 6.6 mites per 100 bees, which is probably at a treatment level for commercial colonies in California."

The long-term goal of that research is to reduce the amount of pesticide use in honey bee colonies for the control of Varroa. Guidelines will be provided for beekeepers to make educated treatment decisions based on the sampling plan.

A growing number of apiaries have opened to the bee advisors, from large producers like Ray Olivarez in Orland to Dan Suhre, whose sons Eric and Adam each keep apiaries independently in cooperation with him in Glenn. Bee breeder Pat Heitkum said of the project, "It could be industry-changing. I don't think anyone has had entry into all the bee breeders before. They have all opened up to her. I think that's unprecedented."

Katie Lee will be the first formal bee tech – the title is yet to be decided. Lee, who Spivak describes as "friendly, super-organized and motivated," will have boots on the ground this fall.

Not every good idea that Spivak works on comes from her, but she knows one when she sees it. The new farm bill specifies that fallow land set aside in the Conservation Reserve Program (CRP), often seeded to attract game fowl, must be seeded with legumes for pollinators as well. Ned "Chip" Euliss of the U.S. Geological Survey studies climate and land use and their effects on wildlife. His project will place honey bees next to CRP land, measure their health and follow them on their migration into California. Spivak has received a grant from the USDA to work on the idea together with Euliss and Pettis. They will look at the protein and lipid content in the bees, as wells as their immune system function to determine how the landscape affects their well being and diversity. They will also measure the abundance and diversity of native bees, a subject close to Spivak's heart.[6]

"It's an important grant. The results can change policy for pollinators and land use. It's really exciting," said Spivak.

Another project has the potential of having wide effect for beekeepers throughout the nation. Spivak is working with Vera Krischik, a colleague in entomology at the University of Minnesota. Together with their graduate students, they will examine the effects of two chemicals, the neonicotinoids imidacloprid and thiomatoxin, on honey bees and bumble bees. The EPA is interested in the outcomes in order to determine their regulatory language for the chemicals.

The bee lab at the University of Minnesota that is housing this pivotal work serves a five state region– the top honey-producing area in the U.S. But the facilities are outdated and inadequate and are physically separated across the St. Paul campus. Spivak's vision is for a new research lab with an educational component for the public. "This would be unique in the nation, if not the world, to have a research facility and a public space in that facility," she said. The lab would contain ongoing research as well as exhibits and demonstrations. Funding, which would include positions for an apiculturist, curator and a grad student, is sought from private and public sources.[7]

News of the recent decline of the bees was so disheartening that Marla Spivak thought of her public lecture as the "bee bummer talk", but no more. Her inspirations have helped to turn that downward spiral: many lines of bees with hygienic behavior now proliferate; the queen breeder advisory project is launched; propolis studies have provided valuable understanding of natural bee defenses. Together with the forage project and the neonicotinoid investigation, all promise to have wide-ranging effect. Spivak says of her penchant for these strokes of insight, "I don't take credit for it. The only part I take credit for is that I'm trying to stay open."

1 Leader of the Ontario Bee Breeders Tech Transfer Team

2 Plans for the bee vac are at: www.extension.umn.edu/honeybees/components/freebees.htm, "Bee Sampling Vacuum Attachment"

3 Buzz's Bees, P.O. Box 274, Richvale, CA 95974, (530) 882-4302, buzzsbees@pulsarco.com

4 Pendell Apiaries, P.O. Box 40, Stonyford, CA 95979, (530)963-3062

5 Lee KV, Moon RD, Burkness EC, Hutchison WD, Spivak M. 2010. Practical sampling plans for *Varroa destructor* (Acari: Varroidae) in *Apis mellifera* (Hymenoptera: Apidae) colonies and apiaries. *Journal of Economic Entomology.* In press

6 Evans, Elaine, Eric Mader, Marla Spivak, M. Managing Alternative Pollinators: A Handbook for Beekeepers, Growers, and Conservationists, 2010

7 See www.BeeLab.umn.edu