PLIGHT OF THE BUMBLEBEE

by Adam Federman

Bombus franklini, a North American bumblebee, was last seen on August 9, 2006. Professor Emeritus Robbin Thorp, an entomologist at UC Davis, was doing survey work on Mt. Ashland in Oregon when he saw a single worker on a flower, Sulphur eriogonum, near the Pacific Crest Trail. He had last seen the bee in 2003, roughly in the same area, where it had once been very common. "August Ninth," Thorp says, "I've got that indelibly emblazoned in my mind."

Thorp had been keeping tabs on the species since the late 1960s. In 1998, the US Forest Service, the Fish and Wildlife Service, and the Bureau of Land Management supported an intensive monitoring project to determine whether the bee should be listed as an endangered species, in part because of its narrow endemism. The total range of B. franklini is only 190 miles north to south, from southern Oregon to northern California, and 70 miles east to west between the Coast and Sierra-Cascade Ranges.

ARE COMMERCIAL GREENHOUSES TO BLAME FOR THE DISAPPEARANCE OF NATIVE POLLINATORS?

When Thorp began to monitor the bee, populations were robust and he even estimated their range to be slightly further to the north and southwest than previously believed. The study was, in part, an attempt to find out why franklini's range is so restricted and other western bumblebees, such as its close relative Bombus occidentalis, are not. Thorp was investigating that question when something else occurred: populations of both bees began to decline precipitously. "All of a sudden the bees disappeared out from under me," he says.

Bees, and particularly the European honeybee, Apis mellifera, have come to symbolize a deepening ecological crisis in North America. Colony Collapse Disorder, first reported in 2006, has been described as "an insect version of AIDS," ravaging honeybee colonies throughout North America. It has become a cause celebre of sorts, embraced by Häagen-Dazs, which features the bee on some of its pints of ice cream and asks consumers to imagine a world without pears, raspberries, and strawberries. The US has become so dependent on honeybees for agricultural purposes that in 2005, for the first time in 85 years, the US allowed for the importation of honeybees to meet pollination demands. Although millions of dollars have been invested in an effort to pinpoint the cause, the honeybee lobby and some environmental organizations say it's not enough, and argue that if dairy cows were disappearing, the response would be slightly more engaged.

The decline of bumblebees has received far less attention, though in the public imagination their plight has often been conflated with that of the honeybee. Not only do bumblebees pollinate about 15 percent of our food crops (valued at $3 billion), they also occupy a critical role as native pollinators. Plant pollinator interactions can be incredibly specific and thus the loss of even one species carries with it potentially severe ecological consequences. As E. O. Wilson writes, "If the last pollinator species adapted to a plant is erased ... the plant will soon follow." There are close to 50 bumblebee species in the United States and Canada, which have evolved with various plants and flowers over the course of millions of years. Yet our knowledge of those species is incredibly weak.

In recent years, there has been much loose talk about the overall decline of pollinators, and the causes are manifold: habitat loss, pesticides, the spread of disease, and, without fail, global warming. The tendency to make sweeping claims

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about the demise of all pollinators has led to a lack of specificity when it comes to why particular species have declined, or in the case of B. franklini, disappeared. One of the only news stories to highlight the plight of bumblebees, published in the Washington Post last August, noted that "the causes of bumblebee decline are not scientifically defined and might be a combination of factors."

A crucial factor, according to Thorp and other scientists, was the rise of the commercial bumblebee rearing industry in the early 1990s, largely for greenhouse tomato pollination. Captive bees, they say, played a key role in spreading disease, which has led to the decline of several North American species, all of which belong to the same subgenus. If their theory proves to be correct, the rapid growth of the greenhouse tomato industry over the last two decades may have inadvertently wiped out a number of important native pollinators.

Around the same time that Thorp noticed a decline in B. franklini, John Ascher, a research scientist in the division of invertebrate zoology at the American Museum of Natural History, was having trouble finding samples of Bombus occidentalis, a common western bumblebee, for his personal collection in California. When Ascher went to graduate school in Ithaca, New York, he was able to find samples of Bombus affinis, B. terricola, and B. ashtoni without difficulty. (BB. affinis, terricola, franklini, and occidentalis belong to the same subgenus. B. ashtoni is a social parasite that specializes on members of this group). But in 2001, the bees began to disappear. B. terricola became rare, Ascher says, and BB. affinis and ashtoni non-existent. The declines that Ascher, Thorp, and others observed were not site specific. A recent study carried out by Sheila Colla and Laurence Packer at York University in Toronto compared surveys of B. affinis — the species most closely related to B. franklini — from 1971-73 and 2004-06 both in Ontario and throughout its native range (18 sites in Canada and 35 in the US). From 2004 to 2006, they found only one individual of B. affinis, foraging on a woodland sunflower in Ontario's Pinery Provincial Park. None were found in the US.

"It would be like if you went out one day and there were no cardinals, or there were no mockingbirds anymore," Ascher says. "It's that obvious to bee people."

In 1997, just months before he began his monitoring project, Thorp attended a symposium of the Entomological Society of America during which he learned that an outbreak of Nosema bombi — a fungus that lives in the bees' intestinal track — had wiped out commercial populations of B. occidentalis in North America. Breeders couldn't get rid of the disease and were suffering a shortage of colonies. In an e-mail to a bombus list-serv in 1998, Adrian Van Doorn, then head of the pollination department at Koppert Biological Systems, a commercial breeder, noted that they had been rearing B. occidentalis for several ▶

years with few problems, but that in 1997 the rearing stock had "become infected with N. bombi." There was no treatment for the disease, and the breeders were unable to eradicate it. A competing company, Biobest, suffered similar losses, and both companies would eventually phase out production of B. occidentalis altogether. Today they produce only one bee for distribution in all of North America: Bombus impatiens, an eastern bumblebee whose range extends from Maine to southern Florida. After observing sharp declines of B. franklini and B. occidentalis, Thorp began to wonder if there was a possible connection to the disease outbreak that had swept through the commercial facilities.

Thorp knew that the USDA Animal Plant Health Inspection Service (APHIS) had allowed Biobest to ship queens of both B. occidentalis and impatiens to Belgium, where they were reared in facilities that likely housed the European bee Bombus terrestris, the preferred species of commercial breeders. The colonies were then shipped back to North America and distributed for use in greenhouse and possibly open field pollination in the US. This went on from 1992 to 1994 until APHIS, under pressure from scientists, conservation groups, and even some industry representatives, terminated the practice.

Thorp argues that while the bees were in European facilities that housed B. terrestris, they acquired an exotic strain of N. bombi. When the colonies were shipped back to the US and distributed, the commercial bees, which can easily escape from greenhouses if they aren't equipped with insect screens (and few were at the time), were able to infect related wild populations. The disease spread from there, carried by impatiens on the east coast and B. occidentalis on the west.

"Basically, these two species in the West were declining while other bee species were thriving very well in the same areas," Thorp says. "It was not obvious habitat alteration or pesticides or global warming or other things that could potentially, and have on record, gotten rid of local bumblebee populations in various areas and are threats to bumblebees. This seemed to be very unique and very specific. And then it turned out that people in the East began noticing that two other very closely related species, which were at one time quite common, had also disappeared."


James Buckley

Bombus terrestris may be spreading previously unknown parasites.

The evidence to support Thorp's hypothesis is circumstantial. A sudden and dramatic decline of several species belonging to the same subgenus points to the introduction of an exotic disease. The timing coincides with the outbreak of N. bombi within commercial rearing facilities, and there is an established point of entry via the importation of colonies from European rearing facilities during the early years of the industry. The big question is whether a European strain of N. bombi ever entered the country and whether scientists will ever be able to figure that out.

Both Koppert and Biobest strongly dispute Thorp's hypothesis and argue that the pathogen entered their facilities from wild bees collected for the purpose of replenishing genetic stock. In the early 1990s, Koppert helped to establish a joint venture, Bees West Inc., which had a rearing facility near Watsonville, California. Tom Kueneman, the founder of Bees West and someone who opposed the trans-Atlantic shipment of bumblebees, says the company used only three collection sites within about 50 miles of Watsonville; all of the collection sites used by Bees West were at least 150 to 200 miles from the nearest greenhouse using commercial bees at the time. Kueneman adds that Koppert and Bees West had close to 99 percent of the market share west of the Rockies and that Biobest had a very small presence there. "It's really a non-story if you want to look at scientific facts," he says.

Kueneman and Rene Ruiter, Koppert's general manager, argue that the heavy El Niño years and high humidity of the early 1990s led to a higher prevalence of N. bombi among native populations of B. occidentalis. When those bees were collected and housed at high density, the disease spread quickly and wiped out the commercial stock.

"Back in the '90s, we collected B. occidentalis in California ... and it had a lot of nosema," Ruiter says. "That was the reason why we discontinued B. occidentalis. The bee itself contained nosema and we were unable to stamp it out."

But at the time, there were few regulations governing what was then a young industry, and no one was keeping a close eye on where the bees were being shipped once they entered the US, if they were housed in facilities with insect screens, and if colonies were

properly disposed of after use.

Indeed, the commercial bumblebee industry has grown so rapidly in the last two decades that it is hard to remember what life was like before cherry and grape tomatoes were available in supermarkets year round. Although certain species were exported from England to New Zealand in the 1870s and 1880s for red clover pollination, and attempts to rear bumblebees were made in the early 1900s, their use on a commercial scale is relatively new.

Dr. R. De Jonghe first used B. terrestris for tomato pollination in the mid 1980s and launched Biobest in 1987. "Within a few years in the Low Countries," writes Hayo H. W. Velthuis in a brief history of the domestication of the bumblebee, "there was hardly a tomato grower left that still used pollination through artificial vibration." (Artificial vibration refers to the costly practice of hand pollinating tomatoes, the industry norm before the use of bumblebees.) Koppert soon followed suit and began to rear bees for crop pollination on a commercial scale.

Since then, the greenhouse tomato industry has continued to expand — it represents roughly 17 percent of US fresh tomato supply — and with it the use of commercially reared bumblebees. "You can't grow them on that scale without the bees," says Martin Weijters, head grower at Houweling Nurseries, a large greenhouse facility in California. Mexico has far outpaced the US and Canada in greenhouse tomato production in recent years, and the use of bumblebees for blueberry and cranberry pollination has become increasingly popular.

In the early 90s few had heard of the commercial bumblebee industry and it remains unclear precisely how many colonies were imported from Europe and where they were sent. At the time, there were greenhouse facilities in British Columbia, Oregon, Washington, and California. Biobest's general manager, Richard Ward, who was not with the company at the time, says they probably imported no more than a few thousand colonies and that most if not all were B. impatiens. Ruiter says that since Koppert never sent queens to Europe, it would have been virtually impossible for an exotic strain of Nosema bombi to enter their rearing facilities.

The commercial bumblebee industry is relatively young. As greenhouse production has expanded so has the need for pollinators.

Thorp argues, however, that the fact that Koppert never sent queens to Europe misses the point. They could have collected bees carrying a nonnative strain of N. bombi when they were replenishing their breeding stock. "If the disease organisms had gotten out into the field, they could easily have picked it up in their collections for replenishing their genetic stock," he says.

Although there is a trail of evidence establishing the shipment of queens to Europe and colonies back to North America, there is little documentation of the path the bees took once they returned. In a 2004 article, Robert V. Flanders, former USDA senior entomologist, said that the imported bees were distributed "throughout the United States with courtesy permits issued by APHIS."

According to Flanders, the bees were to be received by the Pennsylvania Department of Agriculture — the company distributing the bees, Beneficial Resources Inc., now defunct, was based in Pennsylvania — where they would be checked for parasites and pathogens. They were also to be accompanied by a zoosanitary certificate from the host country ensuring that the production facilities had been inspected and that the bees were free of pathogens.

Karl Valley, chief of the division of entomology at the Pennsylvania Department of Agriculture at the time (and currently chief of the division of plant protection), says that the inspection involved removing a single bee from each package, placing it in alcohol, and examining the exterior portions of the body for mites. They did not look for pathogens or other diseases specific to bumblebees. He doesn't recall how many shipments they received, where the bees were sent after they were examined, or if records from that period still exist.

Additional specimens were also sent to the Bee Laboratory in Beltsville, MD. According to a permit issued in 1992 and obtained by Dr. Thorp through a Freedom Of Information Act request, some of the bees were quarantined at the Maryland facility. "When cleared," the document states, "Dr. Shumanuki [sic] will release the bees to you and notify this office."

Dr. Hachiro Shimanuki was the research leader at the Beltsville Lab at the time and now lives in Florida. He recalls having examined only one sample of bumblebees from Europe over a three-year period and says that the company provided the sample.

"We certainly couldn't tell you whether it was a one percent sample or a one-thousandth of a percent sample," he told me. "It was just something that they sent to us as being typical of the kind of shipment they would like to make."

"There was really no request to look for any particular disease," Shimanuki adds. "As I recall, I think all it was was: Would the importation endanger our honeybees? That was really the question I guess that we tried to resolve in some way. That was our concern. But other than that, we didn't know what to look for."

There's another note on the permit ▶

record. It states that Dr. De Jonghe, a veterinarian and founder of Biobest, is the largest producer of bumblebees in the world and that the bees are "certified to be free of pathogens."

Leamington, Ontario (the "Tomato Capital of Canada") until recently had the highest concentration of commercial greenhouses in all of North America. (That honor now goes to Mexico, where Koppert has had a rearing facility since 2004 and produces B. impatiens, a bee that is not native to Mexico or the West Coast, for crop pollination.) The number of bumblebees needed for greenhouse pollination can reach into the tens of thousands. Houweling Nurseries in southern California, with 124 acres under glass, introduces roughly 20 hives with between 50 and 70 bees twice a week. That comes close to 30,000 bees a year.

Although Houweling installed insect screens on all of its vent windows in 2000 (to keep other insects out, not to prevent bees from escaping), they are not required by law and, without them, worker bees can easily escape, forage for pollen in the wild, and then return to the greenhouse. (According to Kueneman, during the early years of the industry, less than half of all greenhouses were using insect screens.) Hives sent to the West Coast, far outside the native range of B. impatiens, must be equipped with queen excluders — a very narrow rectangular opening large enough only for workers to get out. When the growers are through with the hives, they are required by law to destroy them either by drowning the bees or freezing them overnight.

Michael Otterstatter has studied the interaction between wild bees and pathogens for more than two decades and, five years ago, with a team of scientists from the University of Toronto, decided to look at whether commercial bees had higher rates of disease and if those diseases were spilling into wild populations. Otterstatter conducted a straightforward study that compared the prevalence of four pathogens among bees foraging in close proximity to commercial greenhouses with bees foraging in areas where there were no greenhouses. They sampled from six sites in southwestern Ontario, including Leamington, and found that bees near commercial greenhouses had a much higher rate of disease than those collected elsewhere. In fact, the presence of Crithidia bombi, a gut pathogen that lives within the intestinal track of bumblebees (like Nosema bombi) and can spread between bees at flowers, was found only in bees foraging near greenhouses.

"It actually turns out to be present in almost 90 percent of the [commercial] colonies we looked at," Otterstatter says. "Nearly all of them. And the other place that you find this pathogen is in populations of bees right around greenhouses, within a few kilometers.... It really looked like a disease that you only find around greenhouses."

Otterstatter's research team also found that the prevalence of N. bombi was three times higher at the Leamington site than elsewhere and that the infections tended to be more intense. Otterstatter notes that every study of commercially reared bees conducted in North America, Europe, and elsewhere has revealed very high levels of parasitic organisms, many of which are rare or entirely absent from most wild populations.

A study found that bees collected near greenhouses had a much higher rate of disease than those found elsewhere.

Koppert's Ruiter points out that his company's bees were not used in Otterstatter's study and says that the unusually high rate of disease is not a reflection of the industry at large. "It's appalling that something like that happens," he says. "I'm embarrassed for my industry. On the other hand, when I called him about his study, he was forthright in admitting that he didn't use our material, which is a good sign for us that we are doing what we're supposed to be doing, which is keeping things disease free."

According to Ruiter, Koppert's bees are inspected every two weeks by the Michigan Department of Agriculture and annually by Michigan State University. Ward, of Biobest, says that their facility is inspected on a regular basis without warning and that every shipment of bees made to the US or Mexico must have a health certificate signed by the Canadian Food Inspection Agency (CFIA).

The rise of the commercial bumblebee industry reveals the limits of APHIS's regulatory authority. Prior to 1997, when Koppert's bees were infected with N. bombi, there was a gentleman's agreement that B. occidentalis would be used only in the western United States and B. impatiens in the east, roughly within their natural ranges. In 1994, when the importation of bees from Europe was discontinued, Secretary of Agriculture Mike Espy spelled out the agency's policy in a letter addressing concerns raised by Congressman Sam Farr (D-CA). "Risk assessments conducted by APHIS officials indicate that this type of movement could result in the introduction of bumblebee pests and diseases into new areas, such as eastern species of parasitic nematodes into Western States," he wrote. Therefore APHIS would not be issuing permits for the movement of eastern species west of the 100th meridian and vice versa.

But now that B. occidentalis has been removed from the market, B. impatiens is shipped freely to western states. When I asked Wayne Wehling, senior entomologist at the USDA, if APHIS still agreed with its earlier risk

assessments he said, "Well, yes. That's the simple answer.

"Certainly we have been all over the board with that," he acknowledged. "And I think we've been all over the board largely because of the lack of clarity in the regulatory authority as to what our capacities really are."

Tony Wills

The bee battle echoes the controversy over salmon domestication.

Although the same concerns apply today, there are few restrictions (other than the use of queen excluders) on the interstate shipment of B. impatiens in the US. The largest greenhouse tomato-producing states — Arizona, Texas, and Colorado — are all states in which the bee is not native, and while the companies are happy to abide by the law, they do not share the concern about the shipment of bees outside of their native ranges.

For conservationists and many scientists, the movement of an eastern species to the West is reckless. If a queen did somehow escape and the bee became naturalized, it could compete with local species for floral resources, and close relatives of B. impatiens would be susceptible to nonnative diseases. "The diseases that are in B. impatiens could be virulent in things out here. We just don't know and I don't think we want to risk trying," Thorp says.

Globally, the issues and potential problems are perhaps even more pressing. B. terrestris has been introduced to Japan and Chile, where it is not native, and has become naturalized. Two parasites previously unknown in Japan, including N. bombi, have entered the country along with the commercial bumblebees. There are reports that B. terrestris has migrated from Chile into Argentina and that the bee may have been spotted in Uruguay as well. It is only in the last few years that the importation of B. terrestris into Mexico has been stopped. According to Wehling, the bee has already established itself in areas surrounding greenhouse production in the state of Michoacan, west of Mexico City.

In Canada, a laissez faire approach rules. The greenhouse industry in southwestern British Columbia relies heavily on commercial bumblebees and, although queen excluders must be present on all hives shipped west of the 100th meridian, most greenhouses do not have screens covering the vents, so worker bees would have no trouble escaping. Given the urgency of a memo from Agriculture Canada's Central Plant Health Laboratory to APHIS in 1993, this is even more surprising:

"We really must get together to discuss a plan of action," it reads. "It appears that attempts to limit the movement of Bombus is not working. Bombus impatiens is being moved into California. Perhaps there is a need to review the whole policy of Bombus importations into North America before all hell breaks loose."

The battle over the bees echoes other controversies that have erupted around domestication of previously wild species. One example cited frequently in the literature on bumblebees is the spread of sea lice among farmed salmon in the Pacific Northwest, which led to the decimation of wild populations. Many fishermen, conservationists, and activists warned early on that the proliferation of disease among farmed, nonnative, Atlantic salmon could spread to wild fish. They were largely ignored and told that no evidence had been found to prove such a hypothesis and that in fact the pathogens had migrated from wild salmon to farm stock.

Large fish die-offs were observed as early as 1989. In 2001, an outbreak of sea lice in Broughton, British Columbia led to one of the most dramatic declines of wild salmon ever seen. In a single generation, local pink salmon runs fell from 3.6 million spawners to 147,000.

Bumblebees, of course, are not salmon, but some of the same principles apply. "Feedlot farming attempts to break immutable laws of nature by overcrowding animals, lowering their genetic diversity and putting them where they do not belong," wrote Alexandra Morton in an essay on salmon farming published in 2004. The titles of many such essays and books are becoming all too familiar: Silent Spring of the Sea, Fruitless Fall, etc. In the case of bumblebees, there is a wealth of evidence pointing to the risks associated with the importation of nonnative species and of pathogen spillover. Yet, according to Otterstatter, Thorp, and others, the regulations in place are hardly adequate to ensure that risks are minimized. Discontinuing the shipment of bees beyond their native ranges and requiring all greenhouses to install insect screens would be a start, they say.

"Bumblebees are marvelous pollinators and I really wouldn't want to see the industry come to a halt," Thorp says. "But I would like to see a lot more protection of the potential environmental risk." ■

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