Notes from the Lab:

The Latest Bee Science Distilled

by Scott McArt

Nothing against honey bees, but is there anyone out there who doesn't like bumble bees? They're cute, fuzzy, often featured in children's storybooks, and they also happen to be the most important pollinator of Solanaceous plants such as tomatoes and peppers. Yes, all you salsa and hot sauce aficionados out there are bumble bee fans, whether you know it or not!

But bumble bees are also declining at an alarming rate. In fact, long-term data on bumble bee populations provide some of the best evidence in existence that pollinator declines are real. Much better evidence than for honey bees, actually. For example, 13 of the 18 species of bumble bees here in New York are known to be experiencing range contractions. These numbers are representative of similar trends throughout much of the world.

Why are bumble bees (and other pollinators) declining? There are many opinions on this topic, and I'm sure most readers of this article have their own. But what if we could ask the bees? What would they have to say? This is the topic for our eleventh "Notes from the Lab," where we highlight **"Conservation genomics of the declining North American bumblebee *Bombus terricola* reveals inbreeding and selection on immune genes,"** written by Clement Kent and colleagues and published in the journal ***Frontiers in Genetics*** **[9:316 (2018)].**

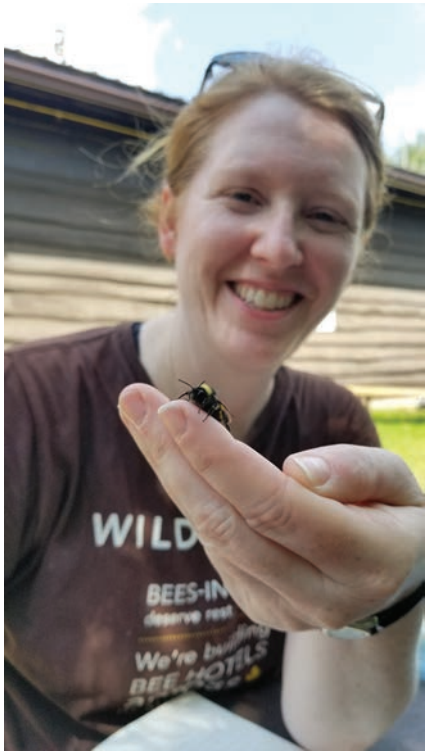
For their study, Kent and colleagues first searched throughout Ontario and Quebec for the yellow-banded bumble bee, *Bombus terricola*, at over 30 sampling locations. They collected several gynes, or potential queens, and brought them back to the lab. At the lab, the researchers extracted DNA from the bees, then sequenced the genomes using new sequencing technology.

As with any sequencing study, this is when the real work began. The authors spent lots of time putting the DNA puzzle together, specifically looking for a genomic signature of population size, inbreeding (which often occurs when populations are small and close relatives start mating with each other out of necessity), and any genes that had undergone recent and rapid selection (in other words, genes that may have been important for dealing with a recent stress).

So, are yellow-banded bumble bee populations still declining? Unfortunately, yes. Kent and colleagues found genomic evidence supporting a large (nearly 100-fold) decline in yellow-banded bumble bee populations over the past ~100 years. Furthermore, most of the bees analyzed showed signs of inbreeding.

Inbreeding is an especially bad problem for bees due to their haplodiploid genetic system (i.e., male drones typically have one set of chromosomes, while female workers and queens have two sets of chromosomes). When inbreeding occurs, some males are produced with two sets of chromosomes, which makes them sterile. This is due to homozygosity at the sex locus and single-locus complementary sex determi-

A yellow-banded bumble bee foraging



nation in bees (for more details, see Rusty Burlew's excellent and easy-to-follow explanation of how this works on p. 916 of the August issue of *ABJ*!). This outcome of inbreeding has been termed the "diploid male vortex" since it increases the extinction risk of a species whose populations start to dwindle. In fact, it may be an important mechanism for why many Hymenopteran pollinators are currently declining – once their populations decline to a threshold, inbreeding is more likely by sheer chance, and they fall into the "vortex." In their study, the authors found that up to 15% of yellow-banded bumble bee gynes were mating with infertile diploid males. That's bad news for all those offspring that don't get produced as a result, thus reducing the population in the next generation.

A bumble bee hard at work foraging

What did the genomes reveal about stresses on the bees that may be causing declines? Here's where Kent and colleagues' study really breaks ground. The authors show that over 25 genes responsible for immune function and anti-viral defense had undergone recent selection. In other words, yellow-banded bumble bees in Ontario and Quebec had recently undergone lots of stress from pathogens such as viruses.

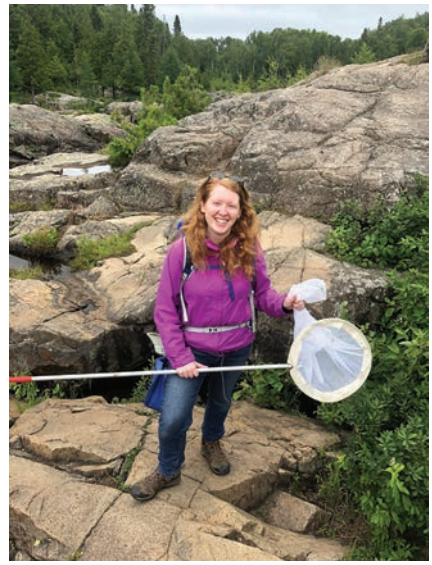
Interesting. Where did this pathogen stress come from? It's impossible to say exactly what caused the pathogen stress on yellow-banded bumble bees. But one possibility is that it came from those bumble bees that were pollinating your tomatoes and peppers. Those bumble bees are produced in giant warehouses and shipped around North America for pollination. And unfortunately, sometimes they get sick in the warehouses before they're shipped, then transmit their diseases to wild bees.

Another possibility is that beekeepers allowed their bees to get sick, which spilled over to wild bees such as the yellow-banded bumble bee. This phenomenon has been shown for deformed wing virus, which infects both honey bees and bumble bees.

Wait, my bees might be getting wild bumble bees sick? What can I do to prevent that? First and foremost, ensure that your colonies are healthy. We know that varroa transmits pathogens such as deformed wing virus. And we know that pathogens can be transmitted at flowers between different species of bees. So, if you control varroa and other diseases in your colonies, you're not only doing an excellent service to your bees, but also to your neighborhood of wild bees.

Second, tell your neighbors to use pesticides sparingly. For example, recent work from our lab found that yellow-banded bumble bees in the US were more likely to be infected with pathogens in landscapes that used more fungicides.

Finally, ensure that you have lots of nutritious flowers in your neighborhood! Similar to humans, bees have better functioning immune systems when they have access to a healthy and diverse diet. For us, that might include some spicy salsa. For bees, perhaps it's the pollen from those beautiful tomato and pepper flowers.



Collecting samples for analysis

Until next time, bee well and do good work,

Scott McArt

Interested in bumble bee conservation? Sending photos to bumblebeewatch.org (or the free phone app) helps researchers track bumble bees and has yielded important information about extant populations of rare species.

Reference:

Kent, C. F., A. Dey, H. Patel, N. Tsvetkov, T. Tiwari, V. J. MacPhail, Y. Gobeil, B. A. Harpur, J. Gurtowski, M. C. Schatz, S. R. Colla and A. Zayed. 2018. Conservation genomics of the declining North American bumblebee *Bombus terricola* reveals inbreeding and selection on immune genes. *Frontiers in Genetics* 9:316. **https://doi.org/10.3389/fgene.2018.00316**

All photos were taken by Victoria McPhail, a coauthor on the study.

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