THE UNDERGROUND LIFE OF BEES: What we know and would like to know

By Susan E. Elliott

It is not surprising that Crested Butte, the wildflower capital of Colorado, is neighbor to a pollination research hot-spot. Rich wildflower and pollinator communities go hand and hand, and for decades, the Rocky Mountain Biological Lab has facilitated innovative research in plant-pollinator interactions. In particular, the bumble bee assemblages around the RMBL have been the focus of studies exploring animal foraging theories, competitive interactions, and pollinator preferences for different floral traits. As a graduate student, I have tried to capitalize on and contribute to this rich history of pollination research by combining new and old methods of studying bees to address some of the still poorly understood questions in bumble bee ecology.

Why study bees?

Humans have been studying bees for millennia. The ancient Egyptians quickly learned to cultivate honey bee colonies to pollinate their crops. Today, the economic value of native pollinators in the United States is estimated at $67 billion. Additionally, over 90% of the estimated 240,000 species of flowering plants in the world could not reproduce sexually without animal pollinators. Pollination services to native and agricultural plants are supplied by a diversity of bee species. Nevertheless, in conventional agriculture, we primarily use honey bees for crop pollination. Honey bees, introduced across the globe from Eurasia 200-400 years ago, are used because they produce large colonies that are easily transported from crop to crop. However, honey bees are not always the best pollinators. For example, honey bees cannot buzz at the frequency required to effectively expel pollen from tomato and blueberry flowers. Thus, bumble bees, which can buzz at the correct frequency, are often used for pollinating tomatoes and blueberries. In high-altitude areas like Crested Butte, the winters are too long and cold for wild honey bee colonies to survive, so the native wildflower community relies entirely on native pollinators: bumble bees, solitary bees, hummingbirds, butterflies, and flies. Bumble bees are particularly easy to study while they are foraging on flowers because they generally ignore human observers. Thus, much of what we know about bumble bees is related to their interactions with the flowers they visit.

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While we know a great deal about what bees are doing on flowers, we know much less about what goes on when they're not visiting flowers. The bee diet consists entirely of the sugars and proteins they obtain from nectar and pollen. But besides foraging, bees must also spend time finding and maintaining nests, producing offspring, and avoiding predation. For most of the year, queen bumble bees hibernate underground. In the spring, queens emerge and search for new nests. Scientists typically only observe these nests by chance, when they notice bees entering and exiting through small holes in the ground.

To effectively manage and conserve native bumble bee populations, we need to better understand colony reproduction and colony densities. For example, how many bee colonies can a field of flowers support? Will the colonies produce ample offspring to provide pollinators for the following season? What proportion of the entire bee population will be impacted if a colony dies? Current threats to native pollinators (e.g., habitat loss, pesticides, competition with honey bees) add to the urgency of understanding the more cryptic phases of the bee life cycle.

Bumble bee colony reproduction: 3rd time's a charm

To investigate bumble bee colony reproduction, we use two methods to monitor captive colonies; we can lure queens to a nest box in the field or rear queens in the lab. In 2004, Humboldt State University undergraduate, Jeremie Marko, and I set out 20 nest boxes in the field to lure queen bees as they were emerged from hibernation. Bees colonized four of these boxes, and we watched these colonies grow throughout the season. We visited colonies at night when all the workers were at home, and using red headlamps, we counted the number of worker bees and the number of cocoons with prospective offspring. The colonies stayed quite small (up to a dozen workers), compared to colonies in areas with longer a flowering season where colonies can have up to a few hundred workers.

In 2005, I reared queens in the lab. As soon as the meadows around the RMBL were free of snow, I started searching for candidate queens. Queens searching for nests exhibit a characteristic behavior of flying low to the ground as they look for holes. I captured some of these queens, brought them into the lab, and put them in nest boxes. Then, Dartmouth College undergraduate, Matt Hamilton, and I fed the bees daily with a 50:50 sugar-water solution and honey bee collected pollen. As bumble bees are very particular about nesting conditions, 2005 was a year of learning how to please our queens. Unfortunately, most of them decided not to start colonies, so we returned them to their meadows to find their own nests.

This year, we combined methods, setting out field boxes along with bringing in queens to the lab. Winter RMBL resident, Billy Barr, provided snow-melt data, which allowed me to time putting out nest boxes and collecting queens for lab rearing to when the bees were emerging from hibernation and before they found their own nests. Our persistence paid off, and in this third year, we finally had enough colonies to conduct an experiment!

With these captive colonies, we asked the question: How important are floral resources to bumble bee reproduction? (i.e., Are flowers in our study meadows in short-supply or is there a surplus of flowers available for the bees?) We predicted that colonies in meadows with more flowers per bee should have higher reproduction. We placed our ten successful colonies into three meadows, which varied in flower densities. The preferred flower species of our focal bumble bee (*Bombus appositus*) is tall larkspur (*Delphinium barbeyi*), which varied in abundance across the three meadows. If ambient bee abundance was constant across meadows, we predicted that colonies in meadows with more flowers should produce more bee offspring. However, if natural bee densities were higher in meadows with more flowers, then the number of flowers available *per bee colony* might be constant across meadows. In this case, we would expect to see no variation in colony reproduction across meadows. To tease apart these two scenarios, we measured ambient bee forager abundance on flowers in addition to colony offspring production in the captive colonies. Finally, in each meadow, we fed one of the colonies with extra sugar-water. We predicted that if colony reproduction was limited by nectar resources, then fed colonies should produce more offspring than non-fed offspring.

Preliminary results from this experiment demonstrate, first of all, that bees are smart – where there were more flowers, we found more bees! So, bees distribute themselves out evenly such that flower availability per bee was similar across meadows. Subsequently, colony reproduction seems to be similar across meadows. In each meadow, our fed colonies are producing more queens and males for the next generation than non-fed colonies. These results suggest that bees respond to variation in floral resources and that their reproduction is limited by nectar supply. However, we still have minimal information about actual bumble bee population densities, which is where we are currently directing our research efforts.

Bumble bee nest density: radar work-in-progress

To investigate natural bumble bee nest densities, we are experimenting with passive radar technology to track bees to their nests. We use RECCO© radar transmitters like those used at ski resorts (including Mt. Crested Butte) to locate avalanche victims. If a skier unfortunately finds herself buried in snow, but has a RECCO© tag attached to her boot, she can be located by a rescue team equipped with radar detectors. The detector sends out a signal, which bounces off the tag and back to the radar operator, thus identifying the victim's location. We use these same RECCO© detectors with an extremely miniaturized version of the radar tag.

This summer we developed a tiny tag consisting of a computer diode with two ultra-fine wires attached. The tag weighs only 7 mg, less than 4% of the weight of a worker bee (approximately 200 mg). The wire is roughly the diameter of a human hair and about 1.5 inches long. We glue the tag to the hard hair-less surface of the bee's thorax. This project is still a work-in-progress, but we already know that the bees can fly with our tags attached and the tags can be detected four feet away. Our next step is to tag a large number of bees in a single meadow and then comb the ground with the radar detector to re-locate them. Our ultimate goal is to find the bees at their nests so we can locate all of the nests in an area to estimate natural colony densities. By combining our studies of colony reproduction and natural nest densities, we hope to paint a clearer picture of bumble bee populations in the meadows surrounding the RMBL.

My dissertation research at the RMBL thus far has strongly emphasized the importance of collaboration and multi-faceted approaches. I have been delighted to find that both the scientific community at the RMBL and residents of Crested Butte are more than happy to listen, learn, and contribute to our efforts to understand plant-pollinator relationships. Working together is the key to understanding complex natural systems. Together, the widespread economic contributions of pollination by bees, coupled with their apparent global declines, amplify the importance of understanding their population dynamics and interactions with native plants.