Notes from the Lab:

The Latest Bee Science Distilled

by Scott McArt

Too many honey bees can interfere with native wildflower reproduction

One of the more controversial topics among beekeepers, conservationists, and land managers is the impact that managed honey bees can potentially have on native wild bees and native plants via competition for resources. I decided to wade into the science on this topic in last year's March and September *Notes from the Lab* columns [162(3):325-327 and 162(9):1025-1027, respectively]. I highlighted two papers that show how high densities of honey bees near apiaries can cause native wild bees to forage less on certain plant species. In other words, both studies provide indirect evidence for resource competition near apiaries.

The reception to these columns surprised me: Instead of people throwing tomatoes, 100% of people who reached out to me said they enjoyed the articles and wanted to learn more about the topic. So, brave readers of this column, you have spoken (or at least your fellow vocal readers of this column have spoken!) and we're going to dive even deeper into the topic of competition between managed honey bees and native wild bees. But there's a twist: This time we're going to consider impacts of honey bee-native bee competition from a plant's perspective, not the bees' perspective.

Are native wild bees better pollinators of a native plant compared to managed honey bees? If so, is there evidence that high honey bee densities near apiaries can displace native wild bees and interfere with plant reproduction? These are the topics for the sixty-third *Notes from the Lab*, where I summarize ***"Honey bee introductions displace native bees and decrease pollination of a native wildflower,"*** written by Maureen Page & Neal Williams and published in the journal ***Ecology* [2023].**

For their study, Page & Williams focused on pollination of *Camassia quamash,* an abundant plant in the western U.S. that's visited by a wide array of pollinators, including native wild bees and managed honey bees. *Camassia* benefits from receiving outcrossed pollen via its pollinators (i.e., *Camassia* plants that receive pollen from a different *Camassia* plant produce more seeds).

The authors conducted their study on *Camassia* plants at 15 wildflower fields located at varying distances from four apiaries in the region surrounding Sierraville, California. Ten of the fields were located south of Sierraville. At this location, the authors worked with commercial beekeepers (Randy and Eric Oliver of Golden West Apiaries) to introduce 20 hives to each of three apiaries halfway through the bloom period of *Camassia*. The remaining five fields were located north of Sierraville near a fourth apiary, which contained ~100 hives and was present throughout the season. Overall, the 15 wildflower fields were located 0-8 km from the four apiaries. In other words, there was a very nice gradient to assess how proximity to apiaries influenced honey bee and native wild bee visitation to *Camassia.*

At each of the 15 fields, the authors measured bee visitation to *Camassia* flowers ("visitor community" in Figure 1), pollination ("pollen deposition" and "pollen tubes"), and seed set ("fertilized ovules"). Visitation was assessed by documenting all visitors to *Camassia* flowers in a timed period. Pollen deposition was assessed by collecting styles from flowers of pre-marked *Camassia* plants, staining and mounting them on slides, and counting the number of *Camassia* and "other" pollen grains via microscopy. Pollen tube formation was similarly assessed by revisiting the pre-marked plants 72 hrs after pollen deposition, collecting the style, and staining and counting any pollen tubes that had formed via microscopy. Finally, seed set was assessed by revisiting the pre-marked plants two weeks after pollination and counting fertilized vs. unfertilized ovules.

Maureen L. Page

Photo 1 *A bumble bee visiting* Camassia quamash

Illustrations by Maureen L. Page.

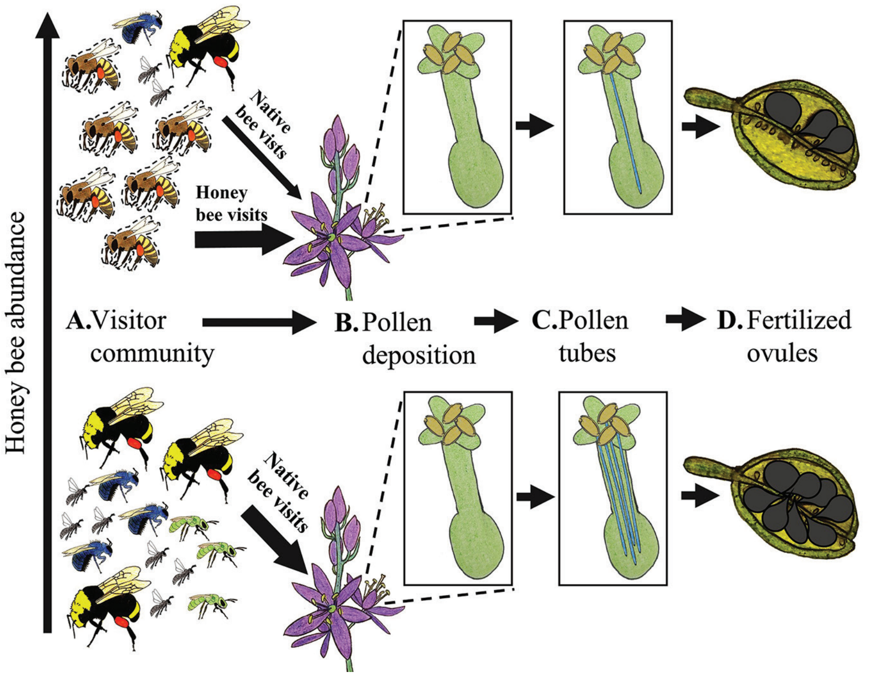
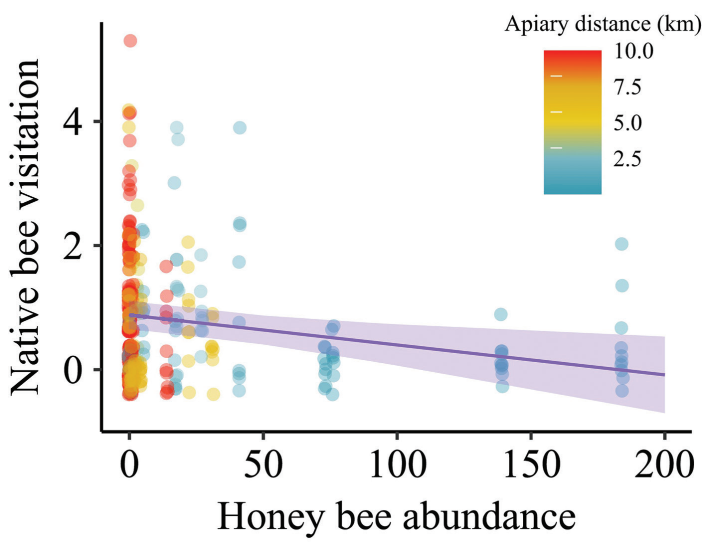


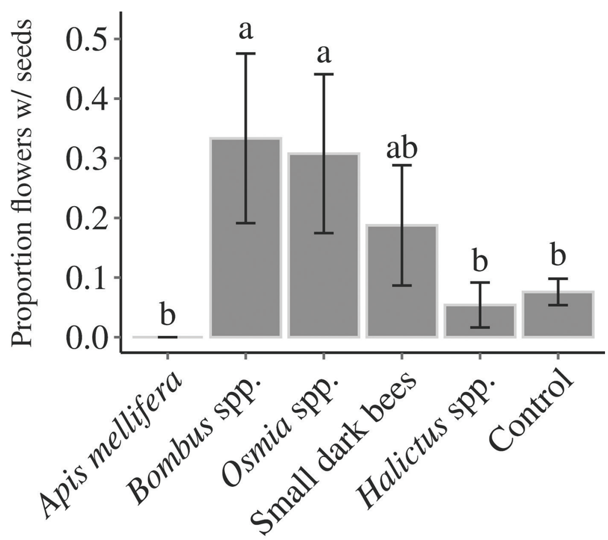
Fig. 1 *Summary schematic showing the data collected and overall results of the study. As honey bee abundance in meadows increased,* Camassia quamash *received more visits from honey bees (outlined in dotted black) and fewer visits from native bees. Increased honey bee visitation and decreased native bee visitation (A) did not influence the number of conspecific pollen grains on stigmas (B) but led to fewer pollen tubes growing in styles (C) and reduced ovule fertilization (D). These results suggest that pollen quality declines when honey bees replace native bees as* Camassia *visitors, leading to reduced plant reproduction.*

The last piece of data the authors collected was single-visit effectiveness of each pollinator that visited *Camassia*. Flowers were bagged to prevent visitation for several days, then bags were removed and a single visit from a pollinator was allowed before flowers were re-bagged to prevent further visitation, and fruits were collected two weeks later. Pollinators were grouped into categories: *Apis mellifera*, *Bombus* spp. (bumble bees), *Osmia* spp. (mason bees), Small dark bees (small sweat bees and mining bees), and *Halictus* spp. (medium-bodied sweat bees).

So, what did they find? Did honey bee abundance impact native bee visitation to *Camassia*? Yes. As seen in Figure 2, greater honey bee abundance in meadows resulted in decreased native bee visitation to *Camassia* flowers. When apiaries were close to fields, honey bees were particularly abundant and native bees visited relatively few *Camassia* flowers (see blue dots). When apiaries were farther from fields, honey bees were less abundant and native bees visited more flowers (see yellow, orange, and red dots). Overall, there were 0.03 fewer native bee visits to *Camassia* per hour and 0.04 more honey bee visits per hour for every additional honey bee observed in the fields.

Which bees were effective pollinators of *Camassia*? On a visit-by-visit basis, Figure 3 shows that bumble bees (*Bombus* spp.) and mason bees (*Osmia* spp.) were the most effective pollinators of *Camassia*. Honey bees were particularly ineffective *Camassia* pollinators, likely because they almost exclusively collected nectar, sometimes "robbing" plants by visiting from behind petals (Photo 2). Native bees did not rob nectar and often collected pollen. Overall, 77% of native bees contacted stigmas during the single-visit trials compared to only 15% of honey bees.





(L) Fig. 2 *Relationship between honey bee abundance (bees per hour per m²) and native bee visitation rates to* Camassia quamash *focal plants (bees per plant per 10 min). Points are the raw data, colored by distance to nearest apiary, and purple lines and shading show model estimates and error. Higher honey bee abundance was associated with decreased native bee visitation.*

(R) Fig. 3 *Single-visit effectiveness, measured as the proportion of visits resulting in fertilized seeds, for different insects visiting* Camassia quamash. Bombus *spp. (bumble bees) and* Osmia *spp. (mason bees) were more effective than* Apis mellifera, Halictus *spp. (sweat bees), and unvisited controls, but were as effective as "Small dark bees." Letters above bars indicate significance for pairwise comparisons at $p < 0.05$. Error bars show standard error.*

Interesting. So if honey bees were ineffective *Camassia* pollinators and they also suppressed native bee visitation, does that mean they interfered with *Camassia* reproduction? Yes. And the mechanism is simultaneously intuitive and interesting! In meadows with greater honey bee abundance, the probability of detecting nectar in flowers decreased by 3% for every additional honey bee. At the same time, native bee visitation to flowers decreased. In other words, honey bees were tanking up on nectar and making the flowers less attractive to native bees by doing so.

The change in native bee visitation to *Camassia* flowers had consequences. Less native bee visitation did not result in less *Camassia* pollen deposited on styles (see explanation below), but it did result in fewer pollen tubes growing to the base of *Camassia* styles and fewer fertilized ovules in *Camassia* fruits, such that ovule fertilization decreased by 3% for every additional honey bee observed in fields. Add these interactions together and the consequence is that reproduction of this native plant was compromised when honey bee abundance was high.

The fact that honey bees and native bees deposited similar amounts of *Camassia* pollen grains on styles but fewer pollen tubes grew, and therefore fewer ovules were fertilized, when the pollen was deposited by honey bees (see Figure 1) is interesting. Honey bees often moved within *Camassia* inflorescences and therefore were more likely than native bees to transfer pollen within plants instead of between plants. Cross-pollination increases seed set compared to self-pollination in most self-compatible plant species, including *Camassia*, and self-pollen can even interfere with cross-pollination. Because of this, a lower proportion of pollen deposited by native bees probably translated to reduced outcrossing and fewer fertilized ovules.

Obviously this doesn't make honey bees look very good. Because of this, it's important to point out that honey bees are extremely important pollinators for many plants, including the plants that produce much of the food we eat. They're literally the pollination poster child for most crops! But that doesn't mean they're always excellent pollinators. The study by Page & Williams shows that fact very clearly.

Overall, I think there are two important and interconnected take-home messages from this study. The first is that introducing honey bees to a location can have ecological consequences. The authors show very elegantly how this is true for one native plant. But what about all the other plants they didn't monitor? Was pollination compromised or improved for other plant species? We need more studies to understand the broader implications of honey bee introductions in Sierraville, CA, and in nearly every other region of the world. Thankfully, a growing number of scientists are starting to brave the controversial waters and conduct these studies. Their results will shed light onto introducing managed honey bees.

In addition to the ecological consequences of introducing honey bees, there are also human consequences. For example, I think it's important to share that one of the landowners where Golden West Apiaries had a seasonal yard decided they were worried about *Camassia* and ultimately asked the Olivers to place their hives elsewhere. This obviously impacts Randy and Eric's beekeeping operation. But anyone who knows Randy knows how responsible and sympathetic he is to good hard data. He writes, "Your experiments were well-designed and executed! And your findings well presented (nice drawings too). Not something that beekeepers want to hear, but good data is good data. My quandary now is the tradeoff between the advantages of using [the yard] vs. not wanting to cause adverse effects upon the surrounding native flora and pollinators. We beekeepers can't always just 'get our way.' We also need to be good stewards of the ecosystems that we may impact." I think this is a remarkable quote from a very astute and successful beekeeper.

Randy offered an additional comment on the study:

What was interesting Scott, is that I also spent a lot of time observing the various flowering plants over the course of the season, both within Maureen's wet meadows, and in the surrounding forests, where there was sometimes abundant bloom.

It was often difficult to find a single pollinator on the flowers, as compared to any number of other areas that I've visited. And I was unable to tell which flowers our honey bees were getting nectar from (the colonies put on weight), since honey bees are normally "patch pollinators" and don't bother with widely-spaced individual plants.


Maureen L. Page

Photo 2 *A western honey bee (*Apis mellifera*) "robbing" nectar from a Camassia quamash flower*

So I was surprised by Maureen's findings that there was that much competition for resources.

There will always be a tension between use and preservation of land. The important point is to consider sustainability. Let's take the controversy out of this topic by continuing to have data-driven and open-minded conversations while we improve our knowledge.

Until next time, bee well and do good work.

Scott McArt

References:

Page, M. L. and Williams, N. M. 2023. Honey bee introductions displace native bees and decrease pollination of a native wildflower. *Ecology* 104:e3939. **https://doi.org/10.1002/ecy.3939**

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