Notes from the Lab:

The Latest Bee Science Distilled

by Scott McArt

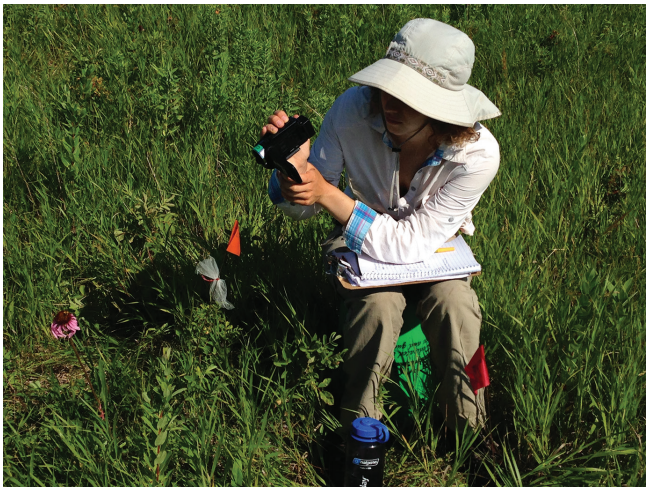
How good are honey bees at pollinating compared to other pollinators?

When I speak with most people about pollination, they talk about honey bees as the prime example of a highly effective pollinator. But this contrasts with the opinion of many scientists. Many of the scientists I speak with consider honey bees to be OK at pollinating, but not nearly as good as other pollinators, especially wild solitary bees.

So, what gives? Are honey bees excellent at pollinating? Or are they only *average* at pollinating? What are the attributes of effective vs. important pollinators, and do honey bees have these attributes? These are the topics for our forty-eighth Notes from the Lab, where we summarize ***"A meta-analysis of single visit pollination effectiveness comparing honeybees and other floral visitors,"*** written by Maureen Page, Charlie Nicholson, and other colleagues at UC Davis and published in the ***American Journal of Botany*** **[2021].**

For their study, Page and colleagues took a deep dive into the literature on single-visit effectiveness (SVE) for pollination. Single-visit effectiveness is a measure of how good a pollinator is at pollinating a flower on a per-visit basis. For example, SVE for a European honey bee (*Apis mellifera*) can be compared to SVE for a yellow-faced bumble bee (*Bombus vosnesenskii*) by measuring the amount of pollen deposited on a stigma (female part of the flower) when each of the bees visits the flower once. The honey bee would have higher SVE than the bumble bee if more pollen grains were deposited during that one visit.

In addition to pollen deposition, SVE can be measured by counting the number of developed pollen tubes, number of seeds produced in a fruit, number of fruits produced, or other measures of plant reproduction. Because lots of researchers have measured lots of different things for SVE, and more than 100 studies have been conducted on this topic, it can be difficult to summarize all of this infor-



Co-lead author Maureen Page painstakingly gathers single-visit effectiveness (SVE) data in the field. Once a particular pollinator visits a flower, a bag is placed over the flower so no other pollinators can interact with it. This allows researchers to compare the effectiveness of different types of pollinators (e.g., honey bees vs. bumble bees vs. flower flies).

mation in a meaningful way. Enter something called meta-analysis.

Meta-analysis is a technique that's used to summarize lots of studies in a rigorous and quantitative way. Meta-analysis controls for the type and quality of data from each individual study and allows researchers to compute an *effect size*, or magnitude of an effect with associated error. This allows researchers to say things like, "honey bees are 40% more effective than bumble bees," or "honey bees are not significantly different from bumble bees" across all the studies that have been conducted on a topic. In total, the authors conducted their SVE meta-analysis on 168 studies that summarized 1,564 SVE measures for 240 plant species. A very nice dataset!

One way to think about SVE is that it represents the *quality* of a pollinator. In other words, once the organism is at the flower, SVE tells us how effective it is as a pollinator. But another factor that governs the importance of a pollinator is the *quantity* of visits it makes to flowers. For example, some pollinators might be extremely good at pollinating when they visit a particular plant, but if they rarely visit that plant, they may not be an important pollinator for the plant. To get a handle on the importance of various pollinators, the authors were able to use 26 studies of 50 plant species that assessed SVE and visitation frequency among at least five different species of pollinators. They compared the SVE (i.e., quality) and visitation frequency (i.e., quantity) data to estimate the importance of different pollinators.

So, what did they find? Are honey bees better or worse pollinators compared to other pollinator taxa? As seen in Figure 1, honey bees are less effective than the most effective non-honey bee pollinators (panel A), but as effective as the average pollinator (panel B). The most effective pollinators are often birds (e.g., hummingbirds; blue data points) and non-honey bee bees (green data points).

To interpret the figure, remember that honey bees are being compared to all other pollinators (categories: wasps, moths, flies, butterflies, birds, beetles, non-honey bee bees, and ants). If honey bees are as effective as another pollinator, the data points will fall on the vertical dashed line at x = 0. But instead, there's a wide range in where the data points lie. The overall average for non-honey bee pollinators is indicated by the solid vertical line. Because the solid line is significantly further to the right of the dashed line in panel A, it indicates that the best non-honey bee pollinators are more effective than honey bees. However, even though the solid line is further to the right of the dashed line in panel B, it isn't significantly different, indicating the average non-honey bee pollinator is as effective as a honey bee.

What about agricultural crop vs. non-crop flowers? Are honey bees particularly good at pollinating crops? Not compared to other bees. This might be surprising to many people since the narrative often conveyed via popular media is that honey bees are highly effective crop pollinators. As seen in Figure 2, honey bees are less effective crop pollinators than the best and average non-honey bee bees (green data points in panels A and B). For non-crop plants, honey bees are only slightly less effective than the best bee pollinators (gray data points in panel A), and there's no difference between honey bees and the average bee (gray data points in panel B).

OK, does this mean other pollinators are more important than honey bees for pollination? No. Remember, SVE measures pollination quality, but it doesn't measure pollination quantity, which is the frequency of visits. Honey bees are often the most frequent visitors to plants, in part because they're often the most abundant pollinator. There are simply a lot of

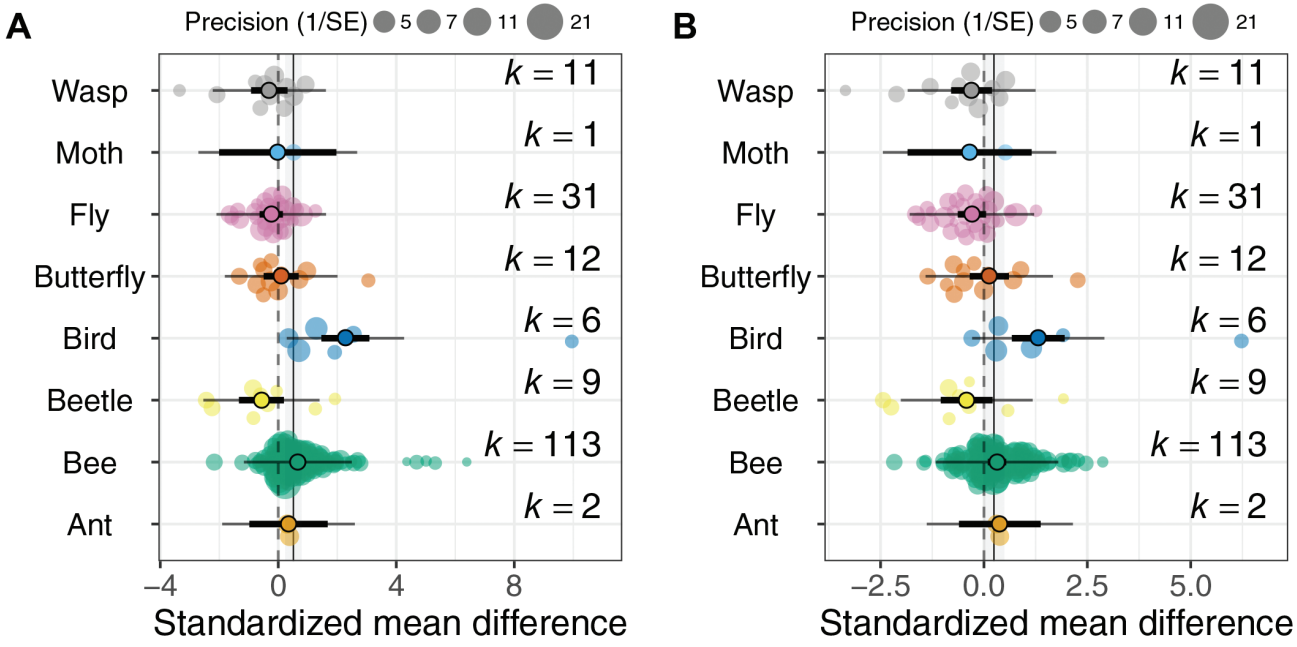


Figure 1. *Meta-regression results for single-visit effectiveness differences (A) between honey bees and the most effective non-honey bee taxon within each group, and (B) between the average effectiveness across all non-honey bee taxa within each group for a given plant-study. Standardized mean differences (SMD) were used to calculate effect sizes. Meta-analytic means are represented as point estimates with their 95% CI (thick lines) and prediction intervals (thin lines). Point estimates from meta-regressions are depicted with their 95% CI (thick lines) and prediction intervals (thin lines). Individual effect sizes are scaled by their precision (1/SE). Positive SMD values (points to the right of zero) indicate that other pollinators were more effective than honey bees, while negative SMD values indicate the other pollinators were less effective than honey bees.*

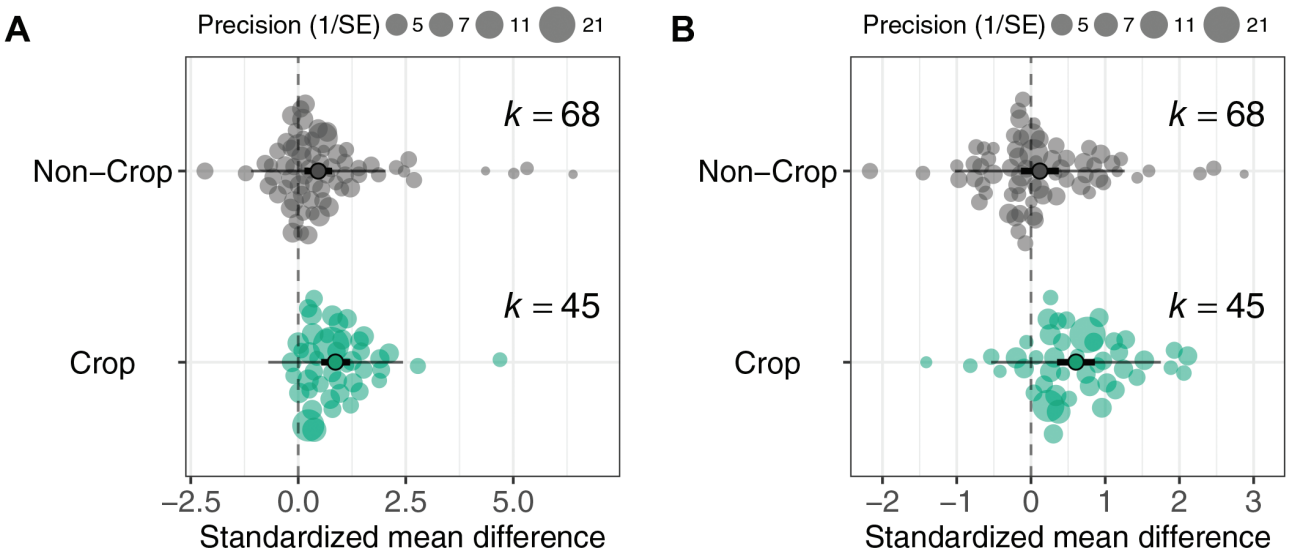


Figure 2. *Meta-regression results for crop single visit effectiveness differences (A) between honey bees and the most effective non-honey bee bee, and (B) between the average effectiveness across all non-honey honey bees and bee bees for a given plant-study. Effect sizes (standardized mean difference: SMD) were compared for non-crop (gray circles) and crop species (green circles). Meta-analytic means are represented as point estimates with their 95% CI (thick lines) and prediction intervals (thin lines). Individual effect sizes are scaled by their precision (1/SE). Positive SMD values (points to the right of zero) indicate that other bees were more effective than honey bees, while negative SMD values indicate the other pollinators were less effective than honey bees.*

honey bees out there! Because of this, they can be important pollinators.

But Page and colleagues found a very interesting relationship between SVE and visitation frequency that suggests the importance of honey bees as pollinators is complex. Specifically, they found an overall positive relationship between a pollinator's SVE and its visitation frequency, suggesting that more frequent visitors are often more effective. However, the positive relationship went away when honey bees were present.

What does that mean? Well, high honey bee visitation to flowers could mean that honey bees are taking lots of pollen and nectar and making plants less attractive to other highly effective pollinators. Since honey bees are only average pollinators in terms of effectiveness, this could mean that overall pollination is reduced. But this is obviously dependent on whether other highly effective pollinators are displaced by honey bees. During California almond pollination, that won't be true because there are virtually no other pollinators present. But in other crops in other regions, or in natural pollination systems, several studies suggest this may indeed be true.

Given increasing honey bee dominance world-wide, the authors suggest it's important to identify and protect highly effective pollinator communities that are present in both agricultural and natural systems. I agree. Beekeeping is one of my favorite things to do in life, but we must do our beekeeping sustainably if we're going to maintain healthy and productive plants and pollinators.

Until next time, bee well and do good work.

Scott McArt

Reference:

Page, M., Nicholson, C., Brennan, R., Britzman, A., Greer, J., Hemberger, J., Kahl, H., Müller, U., Peng, Y., Rosenberger, N., Stuligross, C., Wang, L., Yang, L. and Williams, N. 2021. A meta-analysis of single visit pollination effectiveness comparing honeybees and other floral visitors. *American Journal of Botany*. **https://doi.org/10.1002/ajb2.1764**

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