How do we know if we have enough bees?

Michael J. Holmes, Behaviour, Ecology and Evolution (BEE) Laboratory, University of Sydney

PH 16004: Securing pollination for productive agriculture: guidelines for effective pollinator management and stakeholder adoption

Bees are vital in ensuring the successful pollination of berry crops. While there are a variety of bees that can pollinate berries, honey bees remain the number one choice for many growers due to the relative ease of management and the sheer number that are able to be brought onto orchards during pollination.

But how many should we bring? How many are there in the first place?

We have developed a technique to rapidly and accurately assess the density of honey bee colonies, which could be a gamechanger in informing grower decisions as well as in improving honey bee biosecurity.

How many bees are there?

Every season, commercial berry growers rent honey bee hives to ensure their crops will be adequately pollinated. This is because in the majority of agricultural landscapes, feral honey bee colony densities are rarely high enough to provide pollination services. But how do we actually know that?

Assessing honey bee population densities is complicated, because feral colonies are difficult to locate. They are cryptic, often nesting in trees many metres of the ground. Therefore, assessing their densities via standard ecological techniques is not practical - the time and resources it would take to inspect every hollow in every tree in a particular patch of bushland makes it impossible.

The fact remains, however, that knowing how many colonies are present in the area surrounding a grower's orchard would be very useful, for two major reasons.

First, it would allow growers to be more informed about how much 'free' pollination they are likely to receive, and therefore how many hives they should rent.

Secondly, it has significant implications for honey bee biosecurity. As we have learned from COVID-19, disease outbreaks spread rapidly through dense populations and slower through sparse ones.

Knowing the colony densities in an area will allow authorities to determine where they should focus containment efforts in the event of an outbreak of a honey bee pest or disease. And improved honey bee biosecurity can only be good for the many agricultural industries that rely on them for pollination.

We have developed a new technique that allows us to rapidly and accurately assess the honey bee colony densities in an area - with no inspection of trees required.

Letting them come to us

Our technique exploits the unique mating behaviour of honey bees. Honey bees engage in 'lek-mating', a type of mating behaviour in which many males congregate in an area where a few females are present and compete for an opportunity to mate with one of them.

In honey bees, leks form at what is known as a 'drone congregation area' or DCA (male honey bees are often referred to as 'drones').

DCAs can be found anywhere that bees live. They consist of grassy areas ringed by tree line - forest clearings, sports ovals and the open space between orchard rows and bush remnants are likely spots.

During spring and summer, in mid-late afternoon, many thousands of drones from all the colonies within flight range will gather at these areas in the hopes of mating with a virgin queen.

Figure 1. A Williams balloon trap being deployed in a blueberry orchard in Corindi, NSW. Photo credit: Michael J Holmes

Figure 2. Close-up of Williams balloon trap. Drones can be seen inspecting the black lures, which have been soaked in queen pheromone. Photo credit: Michael J Holmes

Figure 3. Patsavee Utaipanon, BEE Lab PhD Candidate, marking drones for the flight-distance experiment. Photo credit: Michael J Holmes

It is this behaviour that allows us to assess their densities. We first locate likely DCAs - this is often as simple as a Google Earth search, or a leisurely drive to scout the area of interest. Once we've located the DCA, we launch a Williams balloon trap (Figure 1), a conical net suspended from a weather balloon. Within the net are lures soaked in queen pheromone, which tricks the drones that have gathered into thinking there is a particularly enticing queen inside the net (Figure 2). The drones are trapped in the net, where we collect them and take them back to the laboratory for analysis.

Once in the lab, we genetically analyse the captured drones to determine how many of them are brothers; that is, how many can be assigned as offspring of a particular queen. As there is only one queen per colony, when we know how many 'families' are represented in the trapped drones, we know this is a reliable estimate of the number of colonies within flight range (Utaipanon, Schaerf and Oldroyd, 2019). However, we can't know the density of the colonies without knowing how far drones actually fly when looking for a queen to mate with. Perhaps surprisingly, prior to our research there was no reliable estimate of this seemingly simple fact.

How far does a drone fly?

We determined drone flight distance with a simple but effective experiment (Utaipanon, Holmes and Chapman, 2019). In the winter of 2018, we stimulated a colony to produce drones by feeding it heavily.

We then brought this colony to Lyndhurst, NSW, at the end of that winter. As temperatures in Lyndhurst were still very low at the time, the local bee colonies were not yet producing drones - all the male bees in the area were most likely to be from our colony.

We paint-marked thousands of drones from our colony (Figures 3 & 4), and then launched the Williams trap at regular intervals of 250m in opposing directions from the colony. Every time we caught a paint-marked drone (Figure 5), we moved on to the next interval, and so on.

We caught a marked drone at every interval up to 3.75km from the focal colony, but none at 4km. Thus we are confident that drones fly up to 3.75km when searching for a queen to mate with, but not as far as 4km (Utaipanon, Holmes and Chapman, 2019).

Figure 4. Michael Holmes inspects the focal colony for drones for the flight-distance experiment.
Photo credit: Patsavee Utaipanon

Figure 5. One of the paint-marked drones caught in the Williams trap during the flight-distance experiment
Photo credit: Michael J Holmes

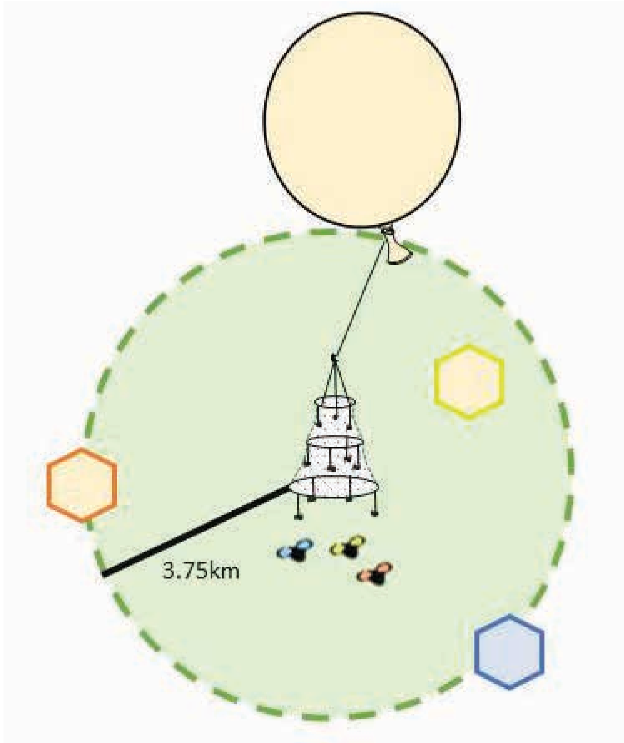

Figure 6. Area sampled by a Williams drone trap
Photo credit: Patsavee Utaipanon

Estimating densities

Now that we know how far drones fly, once we get the estimate of the number of colonies in the trap we can then work out colony density.

If drones fly 3.75km, this means that all colonies within a 3.75km radius of the trap potentially sent drones to the DCA. Thanks to high-school maths, we know that a circle with a 3.75km radius has an area of $44km^2$ (Figure 6).

So, if we caught 1000 drones, and found them to be the sons of 150 different queens, we now know that there are at least 150 colonies within a 3.75km radius - a density of 3.41 colonies per square kilometre.

How can this technique improve berry pollination?

In theory, a grower could deploy a trap on their property (or several in the case of very large orchards) prior to pollination season to get an idea of how many colonies are present in the area before they bring colonies in. Feral colony densities are rarely high enough to provide adequate pollination for most crops, so for the most part, growers will still need to rent hives. However, this technique could satisfy a grower's curiosity as to how many bees are already present and give them an idea of how much free pollination they are likely to receive.

If you would like to know more about the BEE Lab's research, please visit our website: bee-lab.sydney.edu.au

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Further reading:
Utaipanon, P., Holmes, M. J. and Chapman, N. C. (2019) 'Estimating the density of honey bee (Apis mellifera) colonies using trapped drones: area sampled and drone mating flight distance', Apidologie 50, 578–592.

Utaipanon, P., Schaerf, T. M. and Oldroyd, B. P. (2019) 'Assessing the density of honey bee colonies at ecosystem scales', Ecological Entomology 44, 291–304.