Why Bees and Tunnels Don't Always See Eye to Eye

Professor Alan Dorin, Monash University

In this article I offer some personal perspectives, observations and suggestions, related to insect pollination in polytunnels. As I explain below, there are many aspects of tunnels that make it hard for bees to visit crop flowers under plastic. Nevertheless, by offering this informal opinion piece (it's not a research article, but it is backed by my understanding of the literature, my own research and field experience) I hope to provide some food for thought.

I'm not a grower. You are the expert on your crops and know them much better than I do! My perspective is that of a computer scientist researching bee behaviour and pollination monitoring, simulation and management on semi-protected berry crops. I hope you'll find some relevant detail here on the complexity of pollination management, some clarity about why more research is needed, and also, why "quick fixes" to pollination issues may not work.

Bee vision

Honeybees' colour vision extends into the UV range where human vision doesn't respond, and it falls short of the range of colours we perceive as red. Honeybees have compound eyes that don't clearly image a scene like our own eyes. They can only resolve spatial detail about 170 times less effectively than humans. So, what do these factors mean for bees visiting crops?

Although we can easily detect a white flower at a distance of a few metres against a dark green background, for example a strawberry flower against foliage, it may not be easy for a honeybee to spot it. A cluster of white blueberry flowers, perhaps 5cm across, will be easier to detect from the same range. But factors such as the illumination, (green-) colour contrast, reflectivity of background surfaces such as leaves, mulch or weed-mat, will all also impact flower detection.

Sometimes, humans can easily distinguish between one variety of a crop flower and another planted nearby, or between a weed and a crop flower. However, under some circumstances a honeybee may find these seemingly very different flowers to be indistinguishable from one another, especially from a distance approaching the limits of their vision. The opposite can also be true. For instance, if a bee detects two flowers that look similar to humans, but one absorbs incoming UV light and the other reflects it, the flowers will be more easily distinguishable to the bee than to us.

An example of how a polytunnel looks from a bee-sized scale Photo credit: Alan Dorin

What does all this mean for a grower?

The "colour" and UV components of the illumination in your tunnels or protected environments might not be first and foremost on your mind when it comes to pollination. But bees must detect and select flowers to visit in these environments to achieve your pollination goals. Interfering with natural sunlight via artificial illumination, grow lights, or cladding that differentially filters sunlight, may invisibly alter key bee behaviours.

To understand the impact of illumination, imagine yourself trying to identify a colour-matched left sock in your dim wardrobe. Now imagine doing this by looking at a randomly arranged collection of tiny flower-sized colour swatches while staring through the bottom of a smudged beer glass inside a night club illuminated with coloured lights. If all your socks (or crop flowers) are the same and there are no "distractors", this doesn't matter much. Any choice will be a match to the right sock (or target flower variety). If you have non-crop flowers in the vicinity though, this may, under some circumstances, be a visual distraction to your bees. But it's not simple – a diversity of co-flowering plants can be of nutritional benefit to bees; maybe attractive co-flowering plants help to bring bees towards a less attractive crop that would otherwise be unvisited.

Bee navigation

Bees estimate the distance travelled by processing the amount and speed of scenery passing through their vision; this is called "optical flow". They use sunlight polarisation to determine compass orientation.

Why might this matter to a grower?

Imagine you are a 2cm long honeybee in the middle of a 100m long polytunnel. You're relatively short-sighted and can only detect small things clearly within about a metre of your position. The polytunnel cladding is interrupting your view of the sky and may be interfering with the polarisation of the sunlight you use to orient yourself. Now also consider that the polytunnel infrastructure and the crop rows seem to endlessly repeat themselves in all directions. How would you efficiently approach a tunnel exit or move towards your hive? How would you locate an unvisited part of the crop to forage?

In addition to making navigation a challenge, polytunnels are hot and humid. This can be great for plants, but stressful for navigationally challenged bees, especially as they batter themselves into exhaustion against plastic cladding and through spiderwebs in a desperate attempt to escape a tunnel. Our protected cropping infrastructure helps us manage crop plants under climate change, but it can be an obstacle to bee navigation and free movement, which means it can be detrimental to bee pollination. It's not simple to design infrastructure that helps bees whilst maintaining protection to berry crops and research into this aspect of horticulture is essential but currently under-explored.

Honeybee resting in a polytunnel
Photo credit: Alan Dorin

Honeybees communicate the location of food by dancing

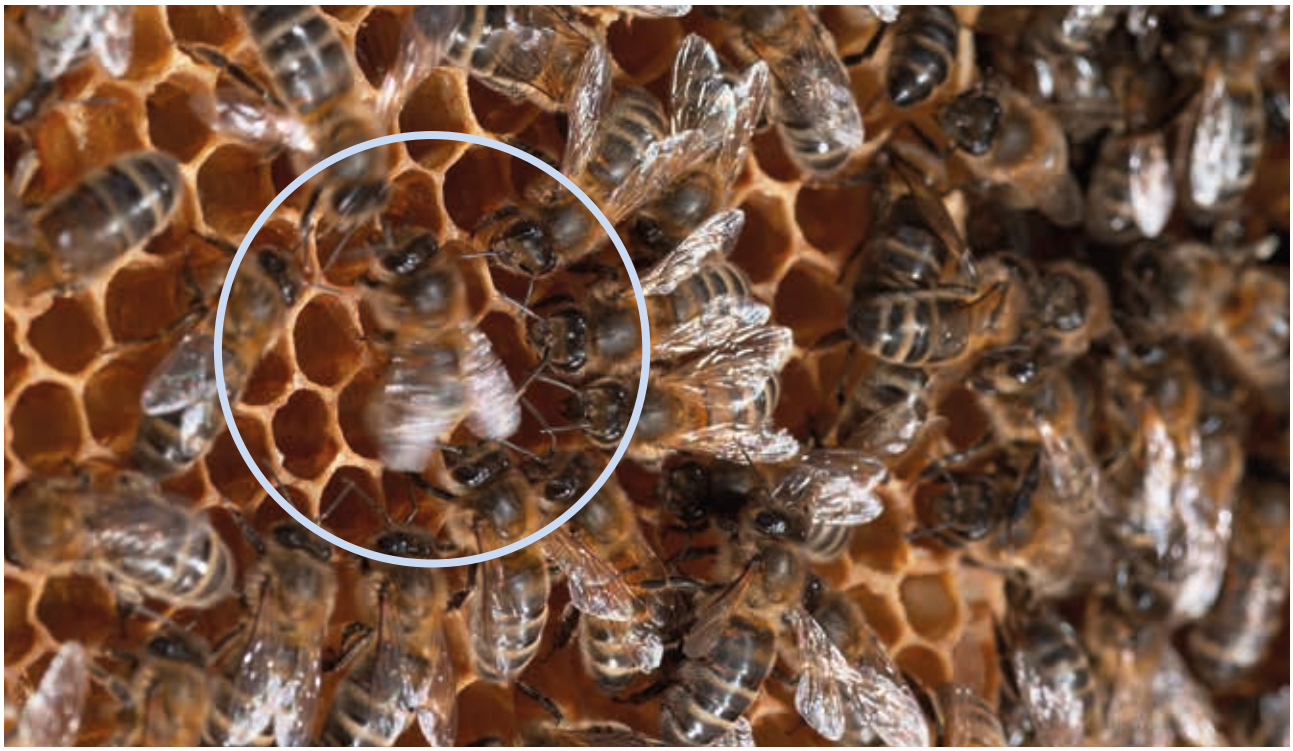
The honeybees' famous waggle dance communicates the location of a floral resource by distance (probably measured via estimates obtained from optical flow, as noted above) and the direction of travel (measured with respect to the sun's position in the sky determined by light polarisation). This is an amazing thing for insects to do, but it is limited in its expressiveness and precision.

The waggle dance didn't evolve under conditions that would ensure it could identify the locations of specific patches within a polytunnel. Instead, it is more effective at identifying the location of a large flowering tree in a forest, or a broad patch of flowers in a wide-open area. As a result, once the bees are in the vicinity of crop flowers, they can't rely on their communication skills to explain to their fellow workers how to find a specific sub-region that, from the perspective of the grower, requires pollination. We need to ensure access to crop flowers is easy so that bees can discover new areas via an unimpeded path. We can do this by providing as much open space in and out of polytunnels as we can, and either hope they find it, or coax them to specific areas somehow.

Several companies offer bee attractants for sale. I have not conducted research to understand their effectiveness, so I can't offer an informed opinion on their use.

Open space between crop rows can assist the insects to travel rapidly into central areas of the polytunnel parallel to the row. But if we'd also like pollen to flow across crop rows, we need to make this easy for bees by providing overhead space and ensuring that one crop row is visible from the next. Otherwise, the bees' dominant direction of travel will be along each row and cross-row pollination (for instance between berry varieties in adjacent rows) may be suboptimal.

If you want to see dancing bees and learn more about their moves, visit bit.ly/ABJ-Bee-Waggle



European Honeybee *(apis mellifera)* dancing to indicate the foraging area to other bees
Photo credit: slowmotiongli, Shutterstock.com

Bees can pass through netting, sometimes

Netting required to keep hail, birds, flying foxes or pest insects away from crops may hinder bee movement. Sometimes, it's necessary to install a mesh size that doesn't allow honeybees to pass at all.

How should pollination be managed under nets?

In an ideal scenario, nets remain open until after pollination is complete. However, this may not be feasible when fruit and flowers appear simultaneously on a plant.

My personal observations, not yet backed by rigorous data collection, indicate that even opening relatively short sections (say 10m) of net to make an opening between hives and crops for a relatively short time (a few hours) can successfully allow a useful bee highway to form. Hence, any opportunity to open otherwise closed nets can be of benefit if it can be managed.

It has been shown that hive health may decline if hives remain under netting for extended periods. However, it's not clear that they would suffer much if left for short periods under nets. More research is needed. If crops are kept under insect-proof nets, as with polytunnel cladding, ideally allow plenty of space above the crop for bees to fly freely beneath the net. The benefit of having the hive under the nets with the crops is that bee access to crops is simplified and, to the extent that bees may avoid travelling through the mesh, crop visitation might increase due to a reduction in bees flying offsite to your neighbour's crop or unmanaged roadside weed patch.

The downside of having hives under nets for a short period is that initially bees with experience of life beyond the net may trap themselves in the netting as they try to fly to regions outside. Eventually, bees will emerge from the hive that are unaccustomed to free flight beyond the netted area. These insects will be less interested in exploring beyond the net and, if all goes well, will visit your crop. But this will take time – and then the hives are clearly not under the net for a 'short' period so the overall hive health may suffer. Unfortunately, there's no simple fix to address these conflicting requirements.

Honeybee in netting Photo credit: Alan Dorin

Of course, only introduce bees under nets with crops when there are adequate flowers to keep the colony fed. If they are introduced prior to, or late in a flowering season, the hive may suffer from poor nutrition. At the very least it may need supplementary feeding to sustain it for a short while.

What if hives are placed outside the nets and bees have free access to the crop, and then one day the fine mesh nets must be dropped, even though flowers are still present and pollination is still required? In this case, bees that have learnt the location of the crop may attempt to travel through the net to reach food. If the weave is tight, they may fly or crawl across, up and down the net trying to find access they expect, from experience or from a bee dance, to be available. This may result in exhaustion or the bee becoming trapped. At best, it will result in wasted time, energy and stress for the bee.

If the nets feature a large mesh that allows bees to pass through, it will do little to restrict access for experienced foragers. I'm unsure what it might do to inexperienced bees though. From a distance a visible mesh may still, I expect, look like an unbroken wall to a bees' poor resolution vision system. Unless a bee has a reason to expect food to be beyond even a coarse net, it may be less inclined to attempt to travel through it than to an obvious flowering tree or open crop. The difference in behaviour when approaching coarse netting between net-experienced and inexperienced bees has, to the best of my knowledge, not been well explored. This is something that may warrant further investigation.

Growers may also like to re-visit Alan's previous article 'Precision Pollination of berry crops is not a pipedream' published in the Spring 2022 edition of this journal.

This article - along with all other articles published in the Australian Berry Journal - can be found in the industry Resource Library at bit.ly/BA-RL

MONASH University