A bumblebee visits a flower,

Bees Can Sense the Electric Fields of Flowers

A bumblebee visits a flower, drawn in by the bright colours, the patterns on the petals, and the aromatic promise of sweet nectar. But there’s more to pollination than sight and smell. There is also electricity in the air.

Dominic Clarke and Heather Whitney from the University of Bristol have shown that bumblebees can sense the electric field that surrounds a flower. They can even learn to distinguish between fields produced by different floral shapes, or use them to work out whether a flower has been recently visited by other bees. Flowers aren’t just visual spectacles and smelly beacons. They’re also electric billboards.

“This is a big finding,” says Daniel Robert, who led the study. “Nobody had postulated the idea that bees could be sensitive to the electric field of a flower.”
Scientists have, however, known about the electric side of pollination since the 1960s, although it is rarely discussed. As bees fly through the air, they bump into charged particles from dust to small molecules. The friction of these microscopic collisions strips electrons from the bee’s surface, and they typically end up with a positive charge.

Flowers, on the other hand, tend to have a negative charge, at least on clear days. The flowers themselves are electrically earthed, but the air around them carries a voltage of around 100 volts for every metre above the ground. The positive charge that accumulates around the flower induces a negative charge in its petals.

When the positively charged bee arrives at the negatively charged flower, sparks don’t fly but pollen does. “We found some videos showing that pollen literally jumps from the flower to the bee, as the bee approaches… even before it has landed,” says Robert. The bee may fly over to the flower but at close quarters, the flower also flies over to the bee.

This is old news. As far back as the 1970s, botanists suggested that electric forces enhance the attraction between pollen and pollinators. Some even showed that if you sprinkle pollen over an immobilised bee, some of the falling grains will veer off course and stick to the insect.

But Robert is no botanist. He’s a sensory biologist. He studies how animals perceive the world around them. When he came across the electric world of bees and flowers, the first question that sprung to mind was: “Does the bee know anything about this process?” Amazingly, no one had asked the question, much less answered it. “We read all of the papers,” says Robert. “We even had one translated from Russian, but no one had made that intellectual leap.”

To answer the question, Robert teamed up with Clarke (a physicist) and Whitney (a botanist), and created e-flowers—artificial purple-topped blooms with designer electric fields. When bumblebees could choose between charged flowers that carried a sugary liquid, or charge-less flowers that yielded a bitter one, they soon learned to visit the charged ones with 81 percent accuracy. If none of the flowers were charged, the bees lost the ability to pinpoint the sugary rewards.

But the bees can do more than just tell if an electric field is there or not. They can also discriminate between fields of different shapes, which in turn depend on the shape of a flower’s petals and how easily they conduct electricity. Clarke and Whitney visualised these patterns by
spraying flowers with positively charged and brightly coloured particles. You can see the results below. Each flower has been sprayed on its right half, and the rectangular boxes show the colours of the particles.

![Coloured particles reveal the electric fields of flowers. From Clarke et al, 2013](image)

The bees can sense these patterns. They can learn to tell the difference between an e-flower with an evenly spread voltage and one with a field like a bullseye with 70 percent accuracy.

Bees can also use this electric information to bolster what their other senses are telling them. The team trained bees to discriminate between two e-flowers that came in very slightly different shades of green. They managed it, but it took them 35 visits to reach an accuracy of 80 percent. If the team added differing electric fields to the flowers, the bees hit the same benchmark within just 24 visits.

How does the bee actually register electric fields? No one knows, but Robert suspects that the fields produce small forces that move some of the bee’s body parts, perhaps the hairs on its body. In the same way that a rubbed balloon makes you hair stand on end, perhaps a charged flower provides a bee with detectable tugs and shoves.
The bees, in turn, change the charge of whatever flower they land upon. Robert’s team showed that the electrical potential in the stem of a petunia goes up by around 25 millivolts when a bee lands upon it. This change starts just before the bee lands, which shows that it’s nothing to do with the insect physically disturbing the flower. And it lasts for just under two minutes, which is longer than the bee typically spends on its visit.

This changing field can tell a bee whether a flower has been recently visited, and might be short of nectar. It’s like a sign that says “Closed for business. Be right back.” It’s also a much more dynamic signal than more familiar ones like colour, patterns or smells. All of these are fairly static. Flowers can change them, but it takes minutes or hours to do so. Electric fields, however, change instantaneously whenever a bee lands. They not only provide useful information, but they do it immediately.

Robert thinks that these signals could either be honest or dishonest, depending on the flower. Those that carpet a field and require multiple visits from pollinators will evolve to be truthful, because they cannot afford to deceive their pollinators. Bees are good learners and if they repeatedly visit an empty flower, they will quickly avoid an entire patch. Worse still, they’ll communicate with their hive-mates, and the entire colony will seek fresh pastures. “If the flower can signal that it is momentarily empty, then the bee will benefit and the flower will communicate honestly its mitigated attraction,” says Robert.

But some flowers, like tulips or poppies, only need one or two visits to pollinate themselves. “These could afford to lie,” says Robert. He expects that they will do everything possible to keep their electric charge constant, even if a bee lands upon them. They should always have their signs flipped to “Open”. Robert’s students will be testing this idea in the summer.

Many animals can sense electric fields, including sharks and rays, electric fish, at least one species of dolphin, and the platypus. But this is the first time that anyone has discovered this sense in an insect. And in the humble bumblebee, no less! Bees and flowers have been studied intensely for decades, maybe centuries, and it turns out that they’ve been exchanging secret messages all this time.
Now, Robert’s team is going to take their experiments from the lab into the field, to see just how electrically sensitive wild bees can be, and how their senses change according to the weather. “We are probably only seeing the tip of the electrical iceberg here,” he says.