Dancing with the honeybees: our mathematical pollinators

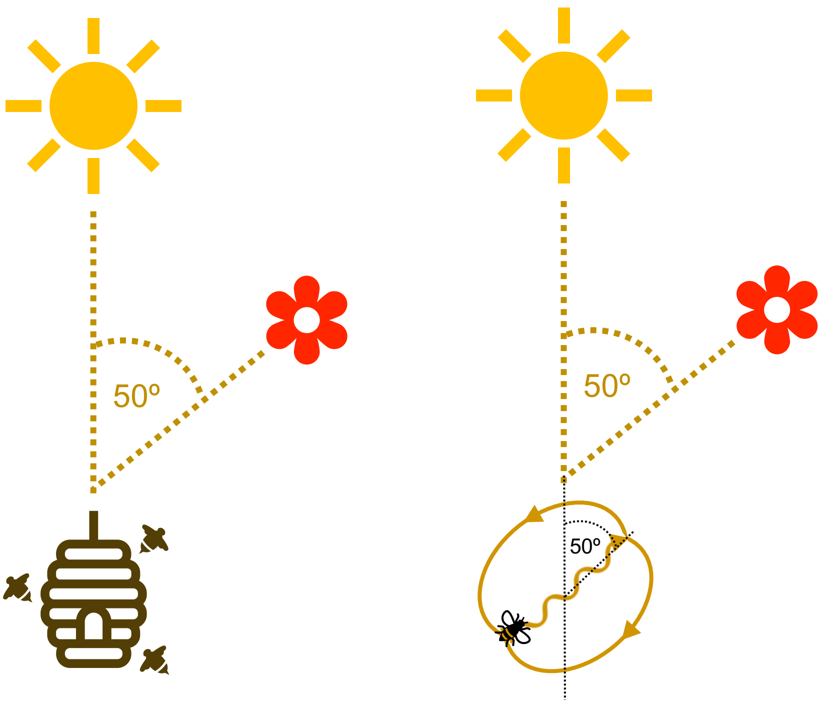
Who doesn't like a spoon of honey in their tea, on their pancakes or with a bowl of fresh fruit, yoghurt and muesli? As we are becoming more aware of our mental well-being and physical health we also are more concerned about our nutrition. Honey is considered a superfood as it boosts not only our energy levels but also the immune system, is known to help fight infections of the airways due it's anti-inflammatory properties, contains many antioxidants and has a number of other beneficial functions.

But did you know that a teaspoon of honey equals the lifetime work of 12 honeybees? The nectar of about 2 million flowers gives about 1lb of honey and one bee colony, visiting several hundred millions of flowers per season, can produce up to 90-100 lb honey in good times.

The waggle dance

This is where the maths comes in: bees share the location of a source of nectar with the other worker bees in their colony. Doing what is called the waggle dance, bees can point out the location quite accurately so that their colleagues know exactly in which direction to fly and how far away the promising sources is.

First, the bee gets the attention of her co-workers by standing on them and bussing her wings. She then proceeds to dance in circles. What looks random at first glance is actually a highly structured and very accurate way of transmitting a message. The alignment in relation to the sun shows the direction - the angle towards the sun equals the angle of the source in relation to the sun. The waggling time indicates the distance. The longer the waggle, the further away is the source.



The honeybee's waggle dance: the angle towards the sun indicates the direction, the waggle tells the distance.

The honeycomb structure

Bees then store the honey in hexagonal structures, the honeycombs. This, too, is a fascinating mathematical fact. Hexagons are the most space efficient shapes. Bees have figured out that this is the most efficient way to use the smallest amount of wax to cover an area with cells of the same size.

Worker bees filling their honeycombs with honey. Photo: Cordula Weiss.

Natural philosophers, scientists and mathematicians have long been amazed by the symmetry of honeycombs and the nature of stacking objects in the most dense packing (with the least space 'wasted' in voids between them) has been a problem that has been tackled by many. The honeycomb conjecture, supposedly going back to Marcus Terentius Varro in 36 BC, looks at a grid of tightly packed hexagons. The Kepler conjecture, concerned with the arrangement of identical spheres such as oranges in a tetrahedron shape, is another prominent example of investigating the best way of packing shapes as neatly as possible.

In 1998 and 1999, more than 2000 years after Varro first remarks on the fascinating symmetry of honeycombs, mathematician Thomas C. Hales first proved the Keppler conjecture, followed by proof of the honeycomb conjecture. According to physicist Denis Wearire, TCD, this is "a remarkable double-achievement".

Further reading: Peterson, I. (1999). The Honeycomb Conjecture. Science News, 156(4), 60.

Bees can understand zero

But this is not all the maths that bees are able to do. Recent research found that bees can distinguish between higher and lower numbers and even understand the concept of zero! Rewarded with food for the right choice, bees showed that they are able to select the lowest number of dots presented to them on cards. When a card with zero dots was added, the bees selected this one despite having never seen such a card before. These surprising results become even more astonishing when we consider that bees have 100,000 times fewer neurons in their brain that humans – and that only less than half of a group of 4-year olds got this right. The fact that bees can learn to understand zero is a big step in brain research and ultimately also in finding out more about how our own brain works.

Further reading: Howard, S. R., Avarguès-Weber, A., Garcia, J. E., Greentree, A. D., & Dyer, A. G. (2018). Numerical ordering of zero in honey bees. Science, 360(6393), 1124-1126.

Links and further information

All Ireland Pollinator Plan
https://pollinators.ie/
How do honeybees get their jobs? (National Geographic)
https://www.youtube.com/watch?v=9ePic3dtykk
The Waggle Dance (Smithsonian Channel)
https://www.youtube.com/watch?v=LU_KD1enR3Q
Bees zero in on nothing (RMIT University)
https://www.youtube.com/watch?v=KQkP85I2UJM
Bees can understand zero. Can you?
https://www.youtube.com/watch?v=-4vUklg2lCc
History of bees, life cycle of bees, how do bees make wax and honey and more
http://galwaybeekeepers.com/history-bees/