

LEARNING WHERE YOUR BEES ARE FORAGING FROM THEIR DANCES

Eavesdropping in the Apiary

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Did you know that honey bees and human beings are the only two species whose members can tell one another the locations of important resources, such as excellent sources of food?

We do this whenever we guide friends to an outstanding restaurant by giving them driving directions. Honey bees do this when they steer their hive mates to rich flower patches by performing waggle dances.

Thanks to the brilliant decoding of the bees' waggle dance by the Austrian zoologist Karl von Frisch, for which he was awarded the Nobel Prize for Physiology or Medicine in 1973, we can eavesdrop on the dances of honey bees and learn the locations of the food sources they are advertising. Indeed, we can determine to the nearest 100 or so metres where our bees are going to collect their food.

Observing the Waggle Dance

It is possible to watch a bee perform a waggle dance on a comb that you have pulled from a hive during a normal inspection. In this situation, however, it is very difficult, if not impossible, to take sufficiently precise measurements of the bee's dance to determine the direction and distance to the flowers that she is advertising. It works much better to watch the dances of bees performed inside an observation hive.

For the study described here, we used an observation hive that is stocked with bees over the summer, but then is taken down in the autumn so the bees can overwinter in a cosy polystyrene nucleus box. This observation hive sits on the workbench in a bee shed in Piperhill, Scotland (see Figure 1).

The bees enter and exit the hive via a glass-topped wooden tunnel. As they return from the field, the returning foragers are directed to one side of the combs by a wooden wedge in the hive entrance. This makes it easy to observe their waggle dances and other actions.

The main purpose of this hive has been as a teaching tool, enabling visiting local children and parents to watch safely, calmly and without fear, in awe and wonder as these beautiful creatures go about their everyday business. At all other times, these bees have the comfort of darkness and insulation, provided by sections of foam insulation inserted into the side covers.

Eavesdropping

However, on 13 September 2016, we had a perfect opportunity to eavesdrop on the dancing bees in this hive to learn where they were going to get their food. This was when one of us (Tom Seeley) was visiting Scotland for the Scottish Beekeepers' Association's Autumn Convention.

Apart from the observation hive full of bees, we needed the following tools: stopwatch, protractor, Ordnance Survey map for the area, calculator and pencil and paper. We also needed a computer, not for actual computing, but for looking up information online about the sun's azimuth (compass bearing) for each hour of the day using the following website: <http://aa.usno.navy.mil/data/docs/AltAz.php> (Note: readers in the US will use form A at this site, whilst those outside the US will use Form B.)

Figure 1. The observation hive used in this study. Photo taken in May, shortly after installing a small colony. By the time of the study in September, the colony had grown to cover both frames of comb completely

Figure of Eight

When a forager bee comes home, excited by having found a patch of flowers brimming with nectar or pollen, she pushes her way into the hive and climbs up onto a comb. Here she proceeds to run through the figure-of-eight pattern of a waggle dance to share her knowledge with unemployed foragers. She executes the waggle run portion of each dance circuit with great aplomb, giving it special emphasis through the lateral vibrations of her body and the up-and-down buzzing of her wings. Then she turns to the right to circle back to the starting point for another waggle run and then, after completing that waggle run, she turns to the left and circles back again to start another waggle run. And so on, again and again, making alternately left and right turns after performing waggle runs.

Direction and Distance

The direction and duration of each waggle run correlates closely with the direction



Photographs and diagram by the authors

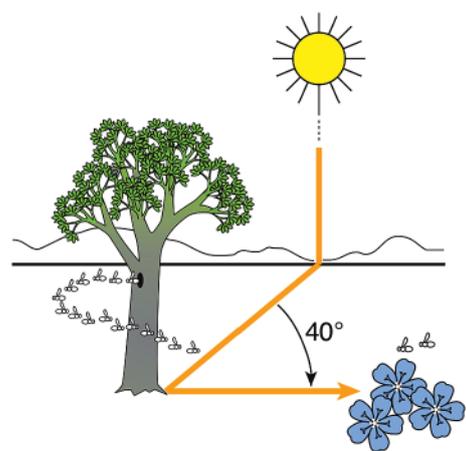
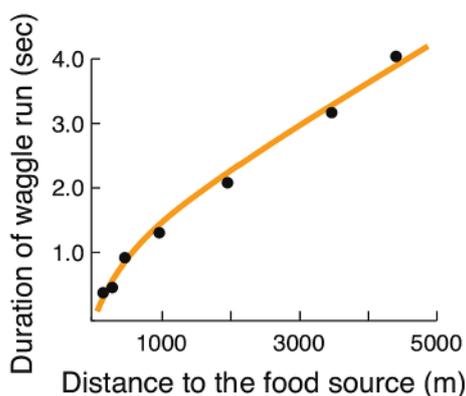
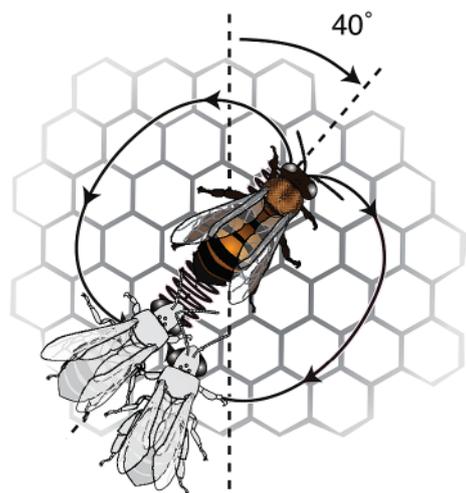


Figure 2. How a dancing bee provides information to other bees about the distance and direction to a rich food source

Top: The movement pattern of a bee performing a waggle dance

Middle: How distance information is expressed; the duration of each waggle run indicates the distance to the flower patch

Bottom: How direction information is expressed: the angle of the waggle run, relative to straight up on the comb, matches the angle of the bee's flight, relative to the direction of the sun

[From *Following the Wild Bees*, by Thomas D Seeley, and used with permission from Princeton University Press.]

and the distance to the flower patch that the bee has just visited. If the flower patch is located directly in line with the sun's direction, then the bee indicates this by performing waggle runs pointing straight up on the vertical comb. But, if the flower patch is located at some angle relative to the sun's direction, then the bee performs waggle runs at this angle relative to the direction of straight up on the comb. You can see an example of this in Figure 2, where the flowers lie 40° to the right of the sun's direction. The dancing bee's waggle run is tilted correspondingly at an angle of 40° to the right of the vertical. The distance between the hive and flowers is encoded in the duration of the waggle run. The further away the target, the longer the waggle run. You can see in Figure 2 that a waggle run lasting one second tells the other bees that they need to fly some 500 metres (0.3 miles) before they hit the jackpot and that a waggle run lasting two seconds indicates they need to fly about 2000 metres (1.2 miles) to find the bonanza.

Observations

We made our observations of the bees dancing in the observation hive on a predominantly sunny morning, between 10.15 and 11.05 am. There were a few, short, overcast spells and the temperature was around 15 °C (around 60 °F). We read the waggles dances of 11 bees performing strong dances that contained dozens of dance circuits. These lasted long enough for us to get several (6.5 on average) measurements of the waggle run duration with the stopwatch and at least one accurate reading of the waggle run direction

(relative to straight up) with the protractor.

For each bee, we determined the direction of the flower patch she was advertising, relative to north, by adding the angle of the bee's waggle runs relative to straight up and the angle of the sun's azimuth (ie, the sun's compass direction). For example, one bee's dance direction was 160° relative to straight up and at the time that she was dancing, the sun's azimuth (direction) was 156°. Adding these two numbers yields 317°, which is the same as 43° west of north. Another bee's dance direction was 220° when the sun's azimuth was 147° and adding these two figures yields 367°, which is the same as 7° east of north.

For each bee, we also determined the distance of the flower patch she was advertising by using the graph that shows how waggle-run duration varies with food-source distance (see Figure 2). This graph is based on the data reported by Karl von Frisch in his 1967 book, *The Dance Language and Orientation of Bees* (for more information, see Table 13 on p 100 of his book). The distance indicated by the 11 bees ranged from 500 metres (0.3 miles) to 3600 metres (2.2 miles). The average distance to the flower patches advertised by these bees was 2481 metres (1.5 miles). Pretty far!

Plotting the Locations

Once we knew the direction and distance of the flower patch advertised by each of our 11 bees, we plotted the locations of these 11 patches on the Ordnance Survey map for Nairn and Forres. This gave us their positions relative to familiar landmarks. We summarise our findings in Table 1 and in Figure 3.

Table 1. Directions, distances and map locations of the rich food sources advertised by the waggle dancing bees

Bee	Patch direction (°)	Patch distance (m)	Location on map
1	7°	2800	near Little Kildrummie (LK) Farm
2	7°	2400	along River Nairn, near LK Farm
3	307°	3600	along Loch of the Clans
4	25°	3200	along River Nairn, near Howford Farm
5	17°	2600	along River Nairn, near Allanaha Farm
6	317°	1700	along River Nairn, near Rosefield Farm
7	236°	500	village of Culcharry
8	316°	3000	wetland near Loch of the Clans
9	21°	2500	along River Nairn, near Allanaha Farm
10	6°	2400	along River Nairn, near LK Farm
11	311°	2600	Tomluncart Farm



Figure 4. A forager on a Himalayan balsam flower along the River Nairn. Note the distinctive stripe of pollen on her thorax and the creamy peach colour of the pollen load on her hind leg

We found that the sites fell into four groups:

- Sites along the River Nairn: bees 1, 2, 4, 5, 6, 9, 10. (Note: we suspect that we made a small error in timing the waggle runs of our first bee and overestimated slightly the distance to the flower patch she was advertising.)
- Sites around the Loch of the Clans: bees 3 and 8
- Site around Culcharry village: bee 7
- Site near Tomluncart Farm: bee 11.

Figure 3. A segment of the Ordnance Survey map for Nairn and Forres. It shows the location of the observation hive (yellow square) in the village of Piperhill and the locations of the 11 flower patches (purple circles) reported by the dancing bees. Grid squares are 1 km x 1 km. The map is oriented with north at the top

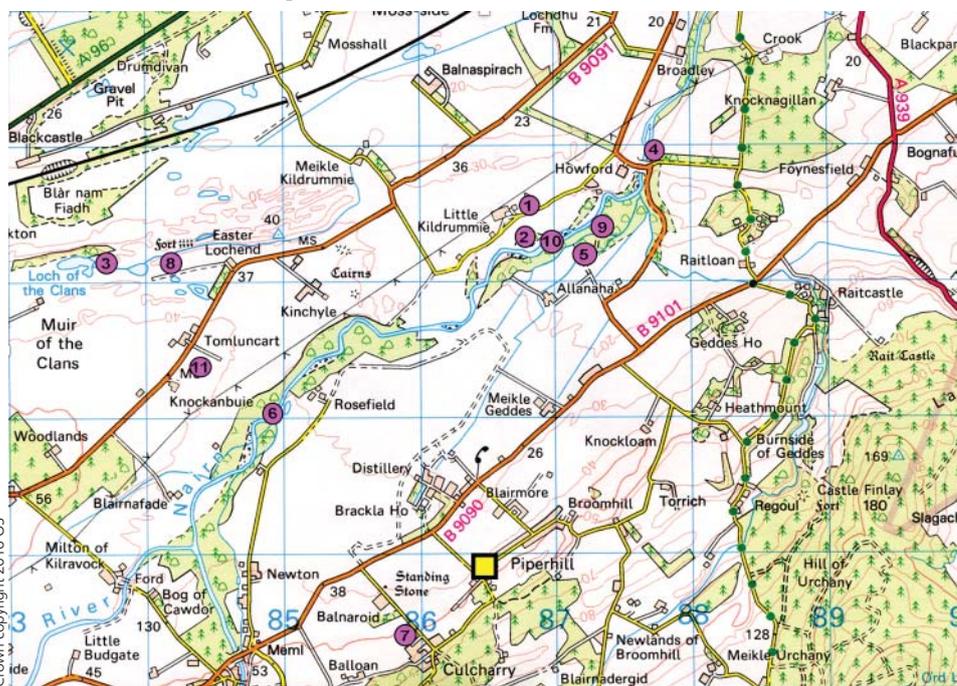


Figure 5. The Loch of the Clans, north of Piperhill, where the bees found marsh woundwort flowers

These results are consistent with what we found when we explored the locations indicated by the bees' dances.

River Nairn

First, we looked for flowers and bees along the banks of the River Nairn between Howford Farm and Little Kildrummie Farm. There we found dozens of stands of Himalayan balsam (*Impatiens glandulifera*) being visited by honey bees bearing silvery white stripes of pollen on the thorax (see Figure 4).

This matched what we had noticed when we were taking the measurements of the dancing bees: most, but not all, had a silvery white stripe of pollen down the centre of the dorsal surface of the thorax and some

had pollen loads that were a creamy peach colour. Both are typical of bees foraging on Himalayan balsam.

Loch of Clans

One week later, on 20 September 2016, one of us (AC) explored the areas around the Loch of the Clans (Figure 5) and the Alton Burn, which drains from the loch, and there she found marsh woundwort (*Stachys palustris*) being visited by bumblebees. However, no honey bees were observed on these flowers that day.

Interestingly, marsh woundwort is mostly visited by long-tongued species, in particular the scarce, and declining, great yellow bumblebee (*Bombus distinguendus*). Short-tongued bumble bees and honey bees will poke holes at the bases of these flowers to access nectar from the long flower-tubes.

Incidentally, the Loch of the Clans area is the site of a Neolithic dwelling where the remains of a canoe were found, along with flint and arrow heads. Also, 6000 government soldiers, led by the Duke of Cumberland, sheltered in local farms and barns and camped out here on the eve of the Battle of Culloden, back in the mid 1700s. The soldiers were given rum and cheese rations to celebrate the Duke's twenty-fifth birthday, which may have gone some way towards alleviating the miserably cold and damp camping conditions. This battle on 16 April 1746 was the last battle fought on British soil.

Culcharry Village

One of us (AC) also searched for flowers in Culcharry village, a month after we observed the bees' dances, and found an unused pasture with tall ragwort (*Senecio jacobaea*) plants still in bloom (Figure 6, overleaf).



Figure 6. Unused pasture in the village of Culcharry, with ragwort plants in bloom

This plant is unpopular with humans because it is toxic to horses, but is beloved by honey bees because its bright yellow flowers offer profuse quantities of nectar and pollen.

Tomluncart Farm

We also searched around Tomluncart Farm for flowers that might have stimulated bees to perform waggle dances, but found none.

It is possible that our measurements of the waggle run duration for bee 11 were slightly mistaken, so that we either underestimated or overestimated the distance to the flower patch that she was advertising. If so, then it is likely that this bee was visiting flowers around the Loch of the Clans or along the River Nairn.

These are places that are in the same direction as Tomluncart Farm but are, respectively, around 1000 m (0.6 miles) further from and 600 m (0.4 miles) closer to the hive than Tomluncart Farm.

Conclusions

So, what did we learn about the foraging activity of our observation hive colony by measuring and deciphering some of the waggle dances performed by its foragers?

- Many of this colony's foragers were exploiting Himalayan balsam flowers along the banks of the River Nairn, from

close to Rosefield Farm in the west to near Howford Farm in the east.

- Some of the colony's foragers were exploiting at least two other sites with flowers besides those dotting the banks of the River Nairn: patches of marsh woundwort in or around the Loch of the Clans and a pasture containing ragwort in the village of Culcharry.
- The main source of forage at the time of our data collection was Himalayan balsam.
- The bees were travelling impressive distances to collect their forage: nearly all were going at least 2 km (1.2 miles) and on average they were flying 2.5 km (1.5 miles) to reach their food sources. We saw no sign of foragers travelling more than 3.6 km (2.2 miles) from their hive.
- The colony's foragers were not spread uniformly over the countryside around

their hive but instead were focused on a few distinct and widely spaced sites that had (presumably) the most profitable flowers.

Go Out Sleuthing

We hope that this article rekindles your interest in this astounding aspect of honey bee behaviour, reminding you of just how intrigued you were when you first learned about the bees' amazing waggle dance. For some it may be a complete revelation that has got you reaching for the books to learn more.

However you have reacted, we hope that you feel inspired to go out to try this bit of sleuthing for yourselves. Reading the bees' dances and then searching for the flowers they are advertising is a truly amazing experience that leaves beekeepers feeling excited, fulfilled, and profoundly in tune with their bees. ✨

The Authors

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