Show me the honey

Have we misread the messages in the bee's famous waggle dance, asks Caroline Williams

WHEN Karl von Frisch decoded the secret language of bees in 1946, even he couldn't quite believe what he had found. Was it really possible for a creature with a brain smaller than a pinhead to do something so clever? "It is conceivable that some people will not believe such a thing. Personally, I also harboured doubts in the beginning," he said in his Nobel lecture in 1973.

Countless experiments later, the bee's waggle dance has become an established scientific fact. Even schoolchildren are taught that honeybees dance to tell hive-mates about good food sources. Most researchers have long since stopped asking whether bees communicate in this way and concentrated on working out how the dance – among the most sophisticated forms of animal communication outside of primates – evolved.

In the waggle dance as described by von Frisch, a bee returning from a plentiful food source heads for one of the hive's vertical honeycombs, where it runs in a figure of eight. On the straight part of the run, the bee buzzes its wings and vibrates its abdomen – the "waggle" (see diagram, right). Von Frisch's insight was that this middle portion of the dance contains two crucial pieces of information about the location of food.

First of all, direction is given in relation to the sun's position. If the food source can be found by flying directly towards the sun, the middle of the dance is perfectly vertical. Any angle to the right or left of the sun is communicated by running at the same angle to the vertical. Distance, meanwhile, is communicated by the duration of the waggle. The longer the bee waggles, the further away the food is: about 75 milliseconds is added to the waggle for every 100 metres. These two pieces of information are what von Frisch dubbed "the dance language".

The dance, which can go on for several minutes, attracts other bees, which become increasingly excited as they watch the dancer. Once a follower has observed five or six runs, it leaves the hive and flies directly to the food, as if by satnav. This behaviour is seen as crucial to a hive's success.

Or that's how the story goes. In recent years, some researchers have begun to suggest that the waggle dance is too good to be true. While they accept that the dance contains information about the location of food, they argue that its importance has been massively overstated. A litany of recent evidence suggests that while bees can follow the dance, they often fail to decode it properly, or ignore it completely (*Trends in Ecology and Evolution*, vol 24, p 242).

"I think the atmosphere is changing," says Christoph Grüter at the University of Sussex in Brighton, UK. "People are much more open to the idea that the dance language is not that important."

In one study, Grüter and his colleague Walter Farina of the University of Buenos Aires in Argentina found that among bees that attend to a dance, 93 per cent ignore the instructions and head to a food source they already know about (*Proceedings of the Royal Society B*, vol 275, p 1321). Similarly, bees often seem unable to follow the instructions. Some watch more than 50 runs and make several sorties out of the hive but never find the food.

The waggle dance also turns out to be much less important to foraging success than has been suggested. Hives in which the honeycombs are laid horizontally, preventing the bees from

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indicating direction properly, don't fare any worse than others, except when natural food sources are severely depleted.

So why hasn't this been noticed before? Grüter points out that most waggle dance experiments are carried out in highly unnatural conditions, using artificial feeders filled with sucrose solution in areas where there are few natural food sources. While this eliminates the confusion of having lots of bees dancing about lots of different food sources, it gives an overly simplistic picture.

Experiments designed to be more like the natural world would give different results, Grüter says. "If we were to provide them with several feeders of different quality and with different odours – to mimic a situation more similar to spring – we might get more useful information about what bees do in nature." Several experiments like this have now been done, and they seem to support the view that under natural conditions, foragers rarely rely on the dance alone, if at all.

Instead, Grüter and colleagues believe the waggle dance is just one component of a more complex system for directing foraging. The dance doesn't just convey spatial information, they say, it also passes on odour clues and generally motivates other bees to go foraging. Bees also glean information by observing their colleagues flying off to gather food.

Grüter says he now sees location information as "back-up". He has found that when the dance is the only information available about the location of a feeder, bees struggle to follow the directions. "If you don't add scent [to the feeder] and the bees don't see other bees foraging, it is extremely difficult for bees to find the feeders," he says.

Similarly, Joe Riley, an entomologist from Rothamsted Research in Hertfordshire, UK, found that of 19 bees that followed directions to an unscented feeder, only two of them actually found it (*Nature*, vol 425, p 205). "This was in an environment deliberately chosen to be devoid of food sources other than our odourless feeders. Using coded location data was their only real option," Riley says.

Not everyone is ready to downgrade the importance of the dance language. Moushumi

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Sen Sarma and Axel Brockmann of the University of Illinois at Urbana-Champaign argue that there are plenty of studies that show the dance is important and that bees routinely follow it. "We do not think it is a matter of controversy," says Sen Sarma (*Trends in Ecology and Evolution*, DOI: 10.1016/j.tree.2009.06.005).

What everyone can agree on is that we still don't understand a crucial aspect of the waggle dance. Almost all research to date has focused on the information the dancer imparts, while almost nothing is known about what the followers pick up. Working this out is key to knowing how important the dance really is. "A communication act is only understood if we understand what the receiver is doing," Brockmann says.

As entomologist Kirk Visscher of the University of California, Riverside, points out, different bees might be getting different kinds of information from the same dance. Some may smell or taste the nectar, some may be able to see the exact angle of the dance, others may be close enough to translate the length of the waggle. "There are suggestions that exactly where you are relative to the dancing bee makes a difference, and I'm not very convinced that we know where that sweet spot is," says Visscher.

Abandoning the neat story of the waggle dance will be difficult. Even so, it is still amazing to think that an insect can compute direction and distance accurately and communicate it to other bees. If they choose to ignore that information – well, so be it. ■

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Hive talkin'

The honeybee's waggle dance is among the most impressive pieces of animal communication ever discovered, but has its significance been overblown?