

Creature comforts

Do bees choose flowers that trap heat over their cooler neighbours? **Beverley Glover** thinks this could be a reason for natural selection for certain petal types.



Most molecular labs are used to constant deliveries of enzymes and primers, but not many get a regular delivery of bumblebees. The arrival of a small box that buzzes and hums has become a regular event in our lab in the last two years, to the constant surprise of the rest of our department. Working with bumblebees could be seen as a strange direction for a lab interested in flower development, but combining our ideas with the skills of bee behavioural scientists has allowed us to start dissecting the adaptive significance of different floral traits. For instance, last year we published a paper showing that bees showed an active preference for warmer flowers, even if cool flowers contained the same amount and concentration of nectar, and that bees could learn to associate different flower colours with different temperatures. This result tells us that plants might be using any of a whole range of tricks to attract pollinators and that rewards can come in many different forms.

With our current NERC-funded project we are trying to establish exactly how the shape of the cells on the outer layer of petals make them attractive to pollinators. The petals of around 80 percent of flowering plant species have an outer layer (epidermis) made up of cone-shaped cells. For decades people argued about the likely role of these cells, suggesting that they might trap light, increasing the amount absorbed by the flowers' pigment, and so affecting the way the flower looked or the way the flower felt. But we only established exactly what these cells do when we identified a mutant plant that didn't produce them in a species that normally does. That's where our molecular genetic model plant, the garden snapdragon (*Antirrhinum majus*), comes into the story. The snapdragon normally has tiny conical cells on its petals, and is a deep velvety magenta colour. One variety of snapdragon, known as the *mixta* line, has a mutation in the single gene responsible for producing conical cells. This mutation means the petals have flat epidermal cells, just like the cells on the rest of the flower. The flower is also a paler colour, looking less velvety. We know this gene inside out on a molecular genetic level, and know that the only difference between the wild type (normal) and mutant lines is the shape of the petal epidermal cells. This allows us to ask, what are the benefits of these conical petal cells?

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Over several years we have shown that the conical cells make the flower look a deeper colour by focusing light into the region of the cells where the pigment is concentrated. We've shown that bees can see this colour difference but have no intrinsic preference for one colour over the other. But we've also shown that bees prefer conical-celled flowers. If we grow mixed plots of the two lines outside, and remove their anthers so they can't self-pollinate, the conical-celled flowers produce much more seed than the flat-celled flowers, telling us that they receive more visits from bumblebees.

So now we have to explain why bees might prefer the conical-

celled flowers in the field when they don't actually prefer one colour over the other. That's where the idea of looking at temperature arose. If conical cells trap light and make flowers look brighter, they might also trap heat. There is some data to suggest that conical-celled flowers are warmer than flat-celled flowers. But nobody knew whether bees preferred warmer flowers. There is plenty of evidence that bees bask in warm spots, and that some flowers produce a lot of heat as a metabolic reward, but we weren't

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looking at those extreme situations. We wanted to know whether, if two flowers were just a bit different in temperature but had the same nutritional reward, would the bees prefer the warmer flowers?

We started to test this by simply offering bees in a flight arena a choice of two feeders of sucrose, one at 18.5°C and the other at 29.5°C. We found the warmer feeder attracted 62.8 percent of bee visits, telling us that they did like warmer food, given the choice. We then went on to test whether bees could learn to associate a particular flower colour with warmer nectar. To do this we took tubes and filled them with water at different temperatures. We painted the caps of the tubes in two slightly different shades of pink, to represent the different colours of the wild type and *mixta* mutant lines. We placed a drop of sucrose in a cup on the lid of each tube. Then we warmed one set of tubes up in a water bath to 20.8°C, and the other to 28.8°C. When we put the tubes out in our flight arena and watched what the bees did, we found that 60 percent of their visits were to the warmer ones. This tells us that the difference in bee responses to the wild type and *mixta* mutant flowers could be due to small temperature differences that the bees learn to associate with their different colours. Of course, we need to test this out further by analysing exactly how the temperature of the two lines varies. We also need to work out why the bees prefer warmer flowers – it might be because the heat acts as a small metabolic reward, but it's also possible that the warmth confuses the bees' sucrose receptors into thinking that the nectar is sweeter than it really is. And we also have lots of experiments on the go to see whether the bees can tell the two flower types apart by feel, if we take away all the other cues (by using epoxy resin casts of the petals). All in all, using bumblebees has taught us a lot about how flowers work, and is also proving to be lots of fun! ■

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