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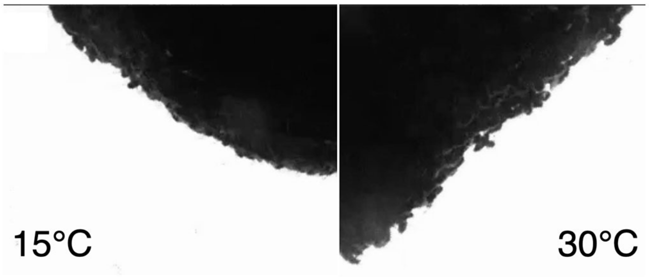
INSIDE JEB

# Honeybee clusters seethe to keep cool as air temperatures rise



Cross-sections of a honeybee cluster at 15°C and 30°C. The cluster is wider and longer at higher temperatures. Photo credit: Jacob Peters.

Packing up to relocate is always daunting, but imagine uprooting an entire community and setting forth with no final destination in mind. This is the prospect faced by swarming honeybees as they depart in search of pastures new. Having located a nearby tree, the swarm settles while scouts venture off in search of a new home, yet the cluster continually seethes and churns to maintain a stable temperature within. However, no one had detailed the precise changes that a swarm makes as air temperatures rise and fall. To learn more, Jacob Peters and L. Mahadevan from Harvard University, USA, with Orit Peleg from the University of Colorado, USA, secured a box containing a queen bee to an inverted weighing scale and encouraged the colony to swarm around her, to find out how they adapted as the temperature rose and fell.

However, the team quickly found that they were best conducting their experiments at night. 'On warm sunny days the bees would fly off as if to a new nest site', recalls Peters. So he and Peleg warmed the clusters from 15°C to 30°C at different rates before keeping the insects warm for 5 h. During that time, the duo took 360 deg snapshots of the clusters every 4 min by swinging a camera around the cluster, taking a picture every 9 deg, to build a 3D profile. Then the duo cooled the air around each cluster at the same rate, to find out how the bees reacted. In addition, James MacArthur from Harvard University designed a bespoke temperature sensor for the bees to cluster around that recorded the temperatures experienced within the colony as it churned in response to the changing air temperatures.

Reconstructing time-lapse movies of the clusters, the team could see them become longer and broader as the temperature rose, almost doubling their volume at the highest temperature. 'A quick look at the time lapse showed dramatic and predictable changes', says Peters. However, even after 5 h at 30°C, the swarm never achieved a stable structure, continuing to ripple and pulse until Peters and Peleg turned the thermostat down. Yet, the time-lapse movies of the cooling colonies appearing to deflate weren't simple rewinds of the warming expansions. 'The cluster shrinks quickly in response to cooling but expands sluggishly to its original size as it warms back up', says Peters.

The team also noticed that at one point during the heating process the cluster stopped lengthening and began shortening instead, even though the base continued to broaden, probably because there is a stage when the honeybees within are at full stretch and can no longer cling on to each other if the cluster continues growing longer to avoid overheating. 'This [manoeuvre] allows them to increase their surface area without a dramatic decrease in density', says Peters. And, when the temperature around the colony fell, the colony shortened more rapidly than it narrowed, probably because it is easier for bees to climb up and down chains of their sisters than it is for the insects to move inward carrying their colony mates suspended below. The colonies' pulsating manoeuvres also successfully maintained relatively warm temperatures within (30–36°C), while remaining cooler at the periphery.

So, honeybees are able to regulate the temperature within a cluster by spreading apart as air temperatures rise, but they can only go so far before the swarm is in danger of disintegrating. Peters also warns that if environmental temperatures continue to rise, the forces within expanding clusters may be too great for resting swarms to withstand shattering as they attempt to avoid overheating.

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