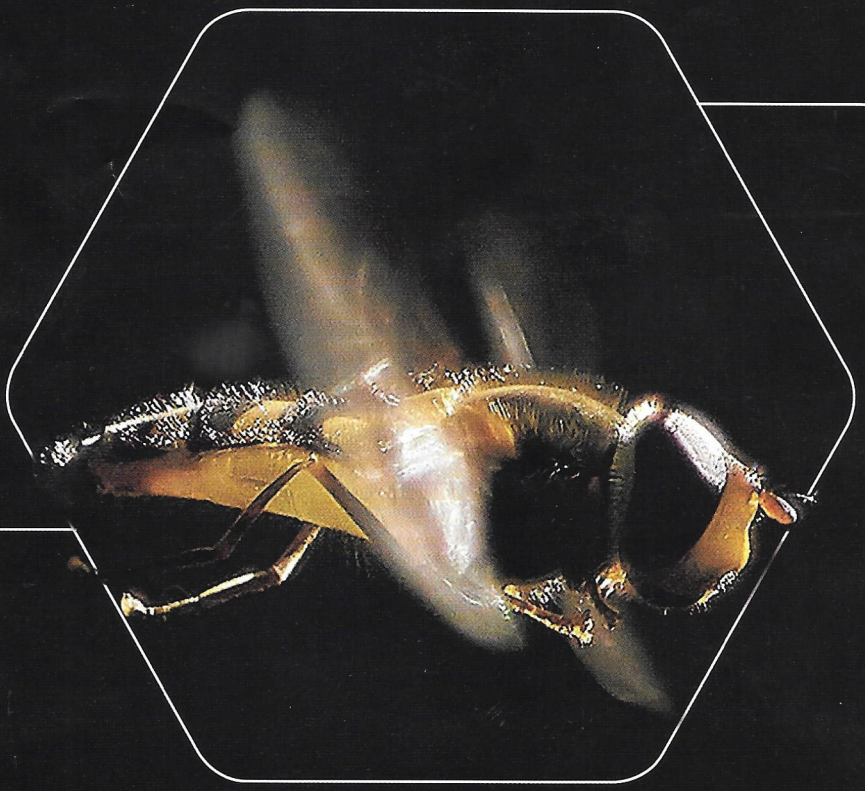
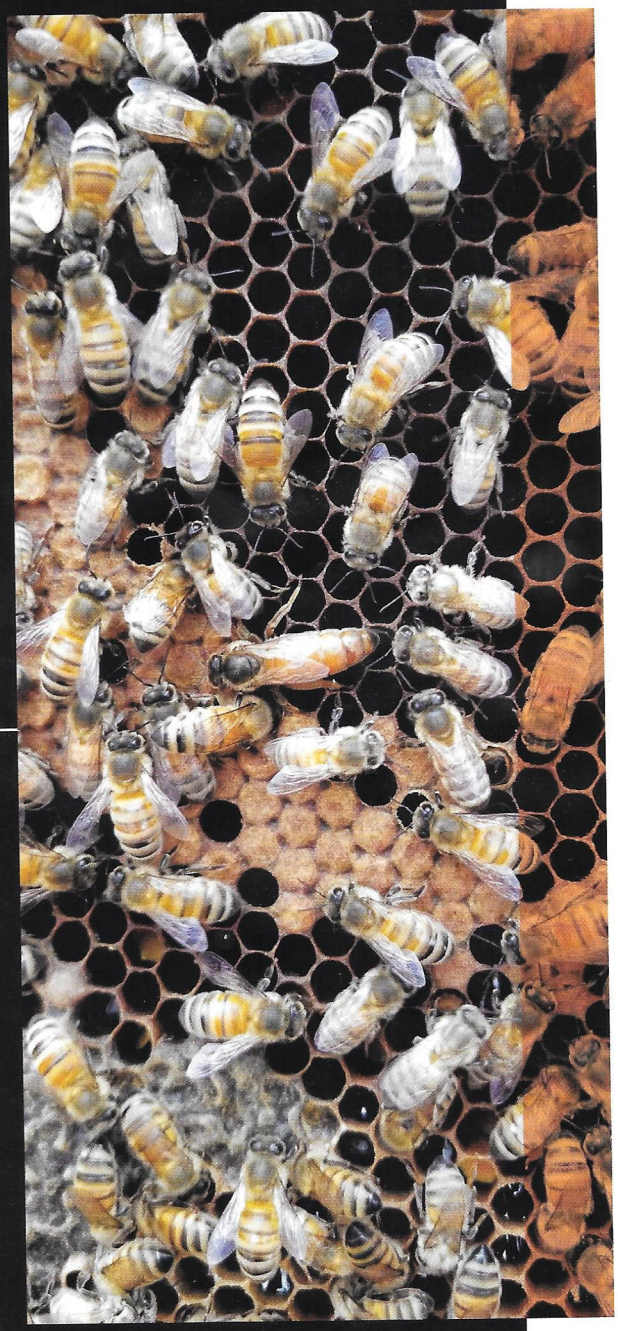
BIG DATA FOR BEES



With global bee populations on the decline, we venture inside the hive to see how innovative technology is changing the future of beekeeping.

/ BY TIANA CLINE /



WE HAVE A SERIOUS PROBLEM – bees are dying off. Beekeepers are struggling to keep their hives healthy and thriving. In fact, more than 40 per cent of bee colonies are being lost each year in the US, a mysterious phenomenon scientists are calling colony collapse disorder. Bees are vital for most of the food that we eat. A world without bees could affect a third of the world's crops, putting the global economy into disarray.

'One in every three bites of food we take on any given day was probably helped along by a bee somewhere,' says Jon Hoekstra of the World Wildlife Fund. Luckily, there's a lot of buzz around innovative technology such as sensors, artificial intelligence, machine learning and big data that could bring us closer to exploring and understanding bee health.

One exciting project is The World Bee Project's Global Hive Network (GHN), the first globally coordinated honeybee monitoring programme. The hives have sensors that collect data such as ambient temperature (outside of the hive), brood temperature (around the frame in the hive where the queen is laying eggs), humidity, rainfall and acoustic data – the noise or 'hum' that bees make.

'The real "smart" bit is what happens when those hives are connected to GHN. By pulling all the information that is coming from hives into one big global database, GHN can generate new insights about bee health and its relationship with weather patterns, diseases, parasites, predator species and pesticides,' explains Sabiha Malik, executive president of The World Bee Project. The goal is that the resource of data is made available to beekeepers, farmers, researchers, governments and other stakeholders, so they can work together to help protect bees, and our planet.

But to make a real impact, GHN needs to generate millions of billions of rows of data a day. 'Just one of our monitored hives can produce a million data points a day – that's exciting, but to make a real impact we must expand GHN,' adds Malik. 'To that end, we are hoping that industry and technology companies will support our work, not only because of the exceptional opportunities it offers them but also because they too carry the responsibility for caring for humanity.'

Using this technology will provide new ways to understand how bees are interacting with each other, and behaving in particular environments. It enables researchers to closely monitor and detect patterns, in turn protecting colonies in the long-term, which will ultimately contribute to protecting ourselves, and our planet.

The World Bee Project uses Oracle Cloud technology. Oracle, a global tech company, provides GHN with its artificial intelligence (AI), machine learning (ML) and analytics capabilities. You might be wondering why. Well, there's inherent value in the data that's currently gathered from the hives. For example, bees are extremely good at maintaining the temperature of the hive around the brood frame during the months in the year when they are foraging for nectar and pollen and while the queen is actively laying eggs. Regardless of the hive's ambient temperature, they keep it a constant 34.5°C inside. If, however, the sensors pick up a significant change in temperature that cannot be easily explained (such as during a hive examination), it can mean there's another problem that needs urgent investigating.

Oracle's design innovation director Andy Clark says that if the data from The World Bee Project's hives is brought into the autonomous database in the Oracle Cloud, they'll be able to overlay that data with other data that's freely available – things such as pollution, habitat and farming practices. 'We can use Oracle's AI/ML to look for new associations and insights that aren't readily apparent in the existing data and with its existing technology,' continues Clark. 'We're thrilled to be working with Sabiha and her team on this critical mission – collectively, we want to inspire the next generation to explore a range of scientific- and technological concepts, as well as issues such as climate change and food security.'

A TO BEE GLOSSARY

Apiarist: Another name for a beekeeper.
Brood: All the immature bees (eggs, larvae and pupae) that live in a hive.
Cell: Honeycomb inside a hive is made up of hexagonal wax cells – this is where bees keep larvae, honey and pollen.
Drone: A male honeybee.
Nurse bee: A young worker bee that produces food for the brood.
Queen bee: A female honeybee.
Robber bee: Bees that enter weak- or dying colonies to steal honey.
Swarm: When a large group of bees leave an established colony to start a new colony.
Tooting, piping or quacking: The sound a queen bee makes as she chews her way out of a cell.
Worker piping: Excited worker bees also make a piping sound when they're about to swarm.

DECODING THE WAGGLE DANCE

Monoculture farming is a key reason why bee colonies are on the decline. Bees thrive in biodiverse areas, with an all-year-round food supply. However, one crop blooms for only a limited period, so bees need to seek food elsewhere, and often far away. This means finding the best flowers. To achieve this, they use a waggle dance.

Beefutures in Norway partnered with IT consulting company Amesto NextBridge to decode the bee waggle dance in real time using SAS Viya technology. When decoded manually, there are only a few specialists who are able to do it, and they decipher around 100 dances a year from only a handful of hives. 'Real-time decoding processes 100 dances an hour, and the analysis can happen at many more locations,' explains Christophe P Brod, CEO of Beefutures. 'This means continuous monitoring of large areas over a longer duration.'

And these are exciting developments. With climate change being one of the biggest challenges of our time affecting insects and the greater ecosystem, making sense of the waggle dance can mean turning observation hives into ecosystem stations that communicate real-time impacts.

To decode the bee waggle dance, Beefutures uses recorded and real-time video sources captured inside the hives. Video feeds at the hive entrance are used for additional data analysis. Through video-based AI, bees are detected, tracked and counted as they leave and enter, assessing foraging levels and possible poisoning episodes (by gauging non-returning bees and detecting abnormal drops). To further assess bee-colony strength, evolution, health and foraging activity, the beehive is equipped with a sound-monitoring system, a digital weight scale and discrete temperature- and humidity monitoring.

'As a biologist by training, what surprised me most was how all-inclusive the bee waggle dance is,' adds Silje Nord, a data scientist at Amesto NextBridge. 'I learned that bees can disagree with each other, and that they communicate this by interrupting each other's dance. They also try to sell their spot as the most-optimal food location by turning up the intensity of their dance.'

Ultimately, waggle-dance technology can help growers to rehabilitate monoculture areas into pollinator ponds, ensuring the shortest distance to food at all times of the year. 'These are the conditions needed to create a suitable environment that entices pollinators back and re-establishes a natural ecosystem,' says Brod. 'By creating suitable living areas for pollinators all-year round, soil enrichment increases, while, at the same time, growers also benefit from the wild pollinators.'

Opposite: Bee hives may look like simple wood structures, but the technology inside will surprise you. **Below:** Beekeepers around the world are using AI, ML, IoT and the cloud to better understand honeybees.

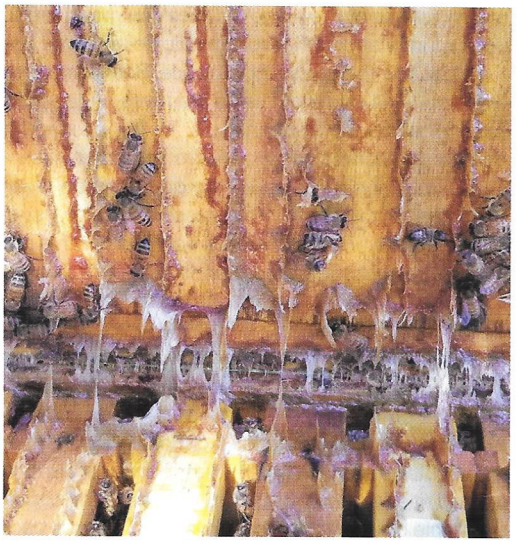
BEEHERO TO THE RESCUE

Honeybees pollinate crops, but what happens when there simply aren't enough local bees? Can you bring in more? Is it healthy to move hives? The Internet of Things (IoT) can help beekeepers to manage their hives better using BeeHero, a smart IoT device on the top bar of a hive frame that measures temperature, humidity and sound via sensors. All the data is sent to BeeHero's cloud and, using machine-learning algorithms, the data is analysed and compared to a bigger database.

In its early stages, BeeHero collected data from 10 hives; it now works with more than 20 000. It's so highly regarded, because instead of delivering endless streams of raw data to a beekeeper, it provides usable insights and alerts, such as if a queen is missing or if a hive is about to storm.

'Not only does this keep hives healthy and strong, but it also helps beekeepers to manage their operational costs,' explains Itai Kanot, co-founder and COO of BeeHero. 'We work with commercial beekeepers running pollination contracts. BeeHero was originally made for beekeepers, but it also means we can help beekeepers to provide better pollination services to farmers.'

How's that for precision pollination!



Left: SAS has an established environmental programme; they welcomed hives to their North Carolina campus a few years ago. **Right:** One challenge is seeing inside a hive without disturbing the bees.

BACK TO BASICS

Managed bees and wild bees both pollinate. This is important because pollinators hold biodiversity and natural ecosystems together. If it weren't for pollination we wouldn't have plants, and without plants we wouldn't have healthy soil or clean air. And while grains, for the most part, are pollinated by wind, at least 75 per cent of the world's food crop relies on pollination, including nutrient-rich foods such as fruit, vegetables, nuts and seeds, as well as cash crops such as coffee and cocoa.

GOOD VIBRATIONS

Anya McGuirk (*pictured right*) is a research statistician at data and analytics company SAS. Based in North Carolina, she works in the IoT division and has just finished a study on vibration and how it can be used to monitor machines. She's an avid beekeeper and it just so happens that SAS has four beehives on the Raleigh campus. We chatted to her about her work with bees.

POPULAR MECHANICS: What inspired you to use big data for bees?
Anya McGuirk: I was out inspecting one of my beehives and I opened it up and heard all this rumbling going on, and thought, 'Oh geez, something's up!' I realised I needed to monitor the acoustics in my beehive more closely to assess what's going on. I'm a beekeeper and, like so many others, I needed help, so this project naturally appealed to me.

PM: How did the project initially evolve?
AM: We started putting sensors on the beehives. Initially we placed a scale underneath the hives – that was pretty cool, but it required connecting your phone via Bluetooth while near the hives. Still, it enabled us to get readings every 15 minutes. I started collecting data, and then found some internal temperature-, humidity- and sound sensors, which we added in. We were now able to monitor weight, internal temperature, humidity and the acoustics.

PM: You researched the effect the queen's presence has on the sound of the hive. Tell us about that.
AM: I wasn't sure what we were going to discover, but I'd heard many experienced beekeepers say that you can tell when a hive is 'queenless' by the change in sound. So I made a split – where you take a big hive that has lots of bees, and remove a few frames of the brood and put it in a new hive. If there are already eggs there, the new hive will make a queen. But we wanted to see what was going to happen when the new hive figured out that it didn't have a queen. Not knowing if we'd hear something, or notice if things would go crazy, we inserted the microphone and recorded it continuously for about 21 hours.

PM: What did you learn from the recording?
AM: The sensors are able to detect either queen piping (the sound she makes) following a swarm, or worker piping, which happens when a colony is queenless. This information can be hugely beneficial for beekeepers, warning them that a new queen may be emerging and giving them the opportunity to intervene before significant loss of life in the hive occurs, which happens when a queen bee dies.

PM: How did you isolate the hum of the hive from ambient noise?
AM: To ensure only the hum of the hive was being used to determine the bees' health and happiness, we used robust principal components analysis, and it worked beautifully – it separated out all of the aeroplanes and sirens from the general hum of the hive, leaving us with distilled sound.

PM: Have you found that other beekeepers are interested in your work?
AM: They're fascinated! They know you have to thermoregulate temperature, but when they realise you can actually monitor that without going into a hive, they get excited. With more companies selling products, sensors are becoming cheaper, making them more accessible to beekeepers.

PM: What's next for your research?
AM: SAS has 49 hives on different campuses across the world, and I can't wait to really let this take off at all of these sites, getting everyone to add sensors to their beehives. At SAS, we're demonstrating how our algorithms are solving an important societal problem; we're showing what we can do with beehives, but it's applicable to many other industries. **PM**

DID YOU KNOW

that honeybees (*Apis mellifera*) are represented by just 10 species, while there are 20 000 other species of 'wild' bees, as well as butterflies, moths, wasps, beetles, certain flies, thrips, hummingbirds and even bats that pollinate.