Fera: Behind the scenes at the bee labs

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The National Bee Unit (NBU) is well-known to beekeepers, playing an important and widely acknowledged role in maintaining the health of our honey bee colonies. Less well known is the part played by Fera, the organisation that provides testing, analysis and much of the scientific information on which their advice and support is based. The *BeeCraft* editors visited the Fera laboratories, just outside York, to hear the inside story about what happens there.

1 **Preserved small hive beetle specimens**
2 **Ben Jones inspecting a sample frame**

History of Fera

Originating as the Plant Pathology Laboratory established at the Royal Botanic Gardens, Kew, in 1914, The Food and Environment Research Agency (Fera), formally the Central Science Laboratory (CSL,) was formed in 2009.

In 2015, Fera Science Ltd was created as a joint public/private venture between the Department for Food Environment and Rural Affairs (Defra) and Capita. The National Bee Unit and several other departments were split off to become part of the Animal and Plant Health Agency (APHA).

Today, Fera and APHA are two separate entities that work together to support beekeeping in England and Wales. Broadly, APHA works on the front line, inspecting bees, advising beekeepers, overseeing sentinel apiaries and searching for and destroying Asian hornet nests when an incursion has been confirmed. Fera provides the background science, helping to give an understanding of how outbreaks might spread and be controlled. They are also tasked with disseminating information to beekeepers about various pests and diseases and how best to treat for them. They also provide expert science-based evidence that informs initiatives such as *The Healthy Bees Plan 2030* and *The National Pollinator Strategy*.

Sand Hutton

Fera's sprawling campus at Sand Hutton, near York, houses scientists and researchers working in a huge range of disciplines including chemical regulation, crop health, food safety and environmental science. The campus is a slightly incongruous mix of sleek, modern office buildings along with ponds, greenhouses and vegetable beds. Science and research relating to honey bees and beekeeping is a relatively small, yet important, part of the work done on the site and, along with the dedicated bee laboratories, there are two onsite apiaries with more in the surrounding countryside. In all, some 300 honey bee colonies support Fera's scientific work, all cared for by a full-time apiarist, Jack Wilford.

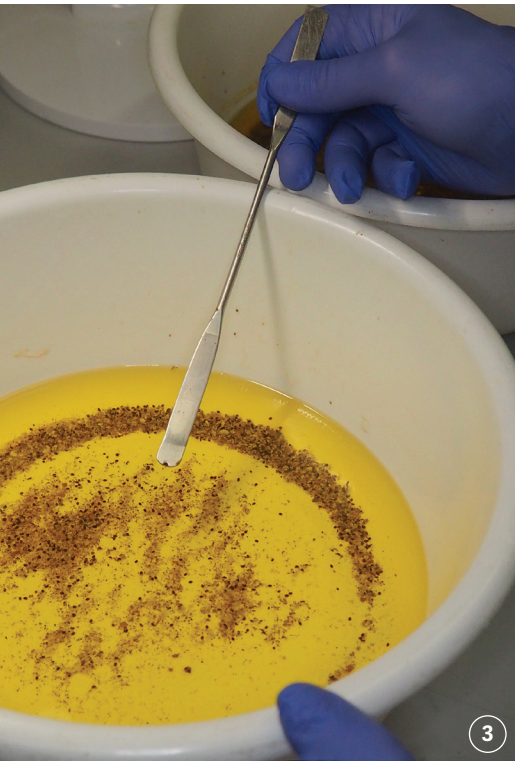
At reception we were met by Ben Jones, manager for the bee health work carried out by Fera on behalf of Defra. Ben spent the day with us and began by explaining the background to the current relationship between Fera and other government agencies, as well as describing and demonstrating the work done at the Sand Hutton site.

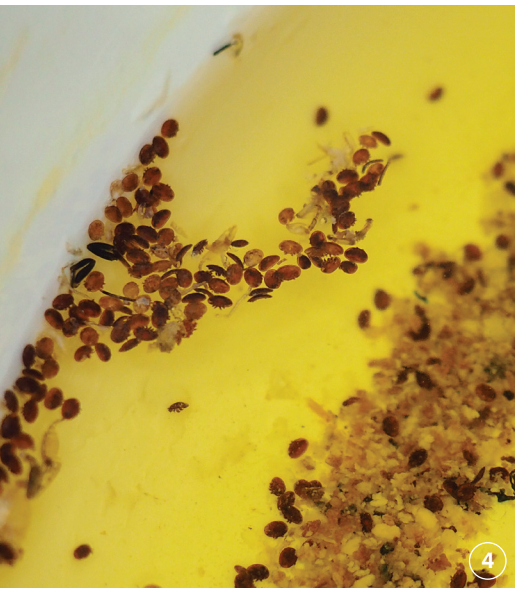
After negotiating labyrinthine corridors and donning white lab coats, our first visit was to a laboratory used for various honey bee pest and disease diagnostics. Much of the work here is to evaluate samples supplied by bee inspectors and beekeepers. The lab specialises in fast-turnaround diagnostics, with bee inspectors who send in foulbrood lateral flow kits and brood samples receiving test results and reports within 24 hours. Beekeepers who suspect foulbrood can send brood samples directly, although will normally first contact their local bee inspector, who can then inspect their colonies and send samples to the laboratory at Fera.

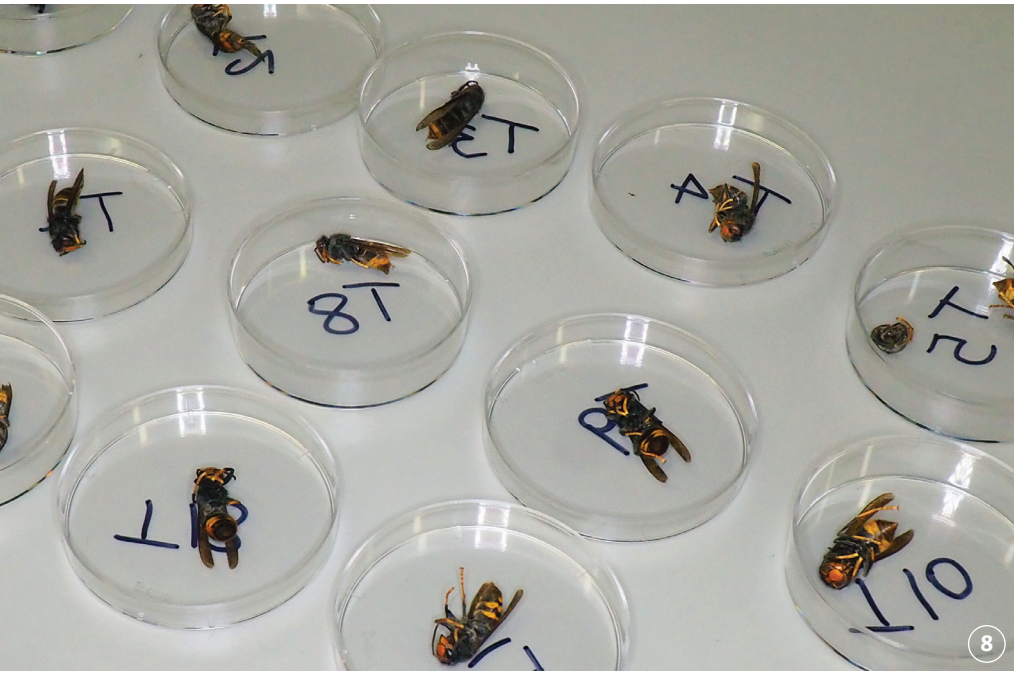
Beekeepers, whether or not they are part of the sentinel apiary scheme (see January), can send debris samples collected from hive inspection trays. Ideally, they should be mailed in sealed plastic bags, but in practice they are received in a wide variety of sometimes eccentric packages which have to be opened very carefully to protect the material inside. The samples are screened by mixing them with 100% ethanol, which helps to separate the debris from any fauna lurking within it. The inevitable results are varroa mites, their chitinous bodies making them float while most other items sink. It was this method that first detected varroa in the UK in 1992. That initial sample, containing hundreds of varroa mites, still exists as a slightly grim piece of British beekeeping memorabilia.

Also commonly found are earwigs, woodlice and a range of harmless scavengers. Onsite entomologists study the finds and produce a biological report for the beekeeper. The tests are primarily aimed at looking for small hive beetle and tropilaelaps mites. Although the team know well what these exotic pests look like, their diagnostic methods are reviewed and updated in line with current knowledge. They do sometimes run exercises using dead samples of these pests so that they know exactly what to expect should they one day appear in a sample.

Samples of EFB and AFB (European and American foulbrood) are frozen and stored for future reference. EFB samples are characterised using multilocus sequence typing (MLST) techniques utilising an impressive array of next-generation gene-sequencing machines that were demonstrated by Victoria Tomkies, manager of the bee health diagnostic laboratory. The genetic information gained in this way has been used to build an EFB gene reference library which allows patterns of spread to be analysed. Victoria wrote more on this subject in *BeeCraft*, July 2022.







Asian hornet

A major challenge in recent years has been the multiple incursions of Asian hornet (*Vespa velutina*), an invasive non-native species. Nests retrieved from the field are sent to the Fera labs for analysis. The nests will have been treated with insecticide and, when received, are frozen at -20C for 72 hours to ensure that nothing within can remain alive.

The nests are dissected to ascertain whether they have yet produced gynes (queens) and therefore the potential likelihood of future nests being found in the same location. Genetic analysis of each colony helps to determine whether a population is closely related to others so far discovered. To date, none of the retrieved nests has been closely enough related to be direct offspring of previously found UK nests. So far, the genetics indicate incursions from Europe but not from the Far East.

On a laboratory counter, a phalanx of dead Asian hornets sat in petri dishes. One key measure used to distinguish workers from gynes is weight, with gynes weighing on average 100 micrograms more than workers. However, caught individuals are preserved in liquid ethanol ready for genetic analysis, altering their weight and making it difficult to distinguish between gynes and queens. The samples on the bench were being studied to see how their wet weight could be back-calculated to give a dry weight, therefore indicating whether they were workers or gynes.

Fera's laboratory work with Asian hornets and their nests is fed to APHA personnel who have developed models that can be used to predict how the Asian hornet

3 Hive floor debris in ethanol

4 Varroa floating on the surface are removed and counted

5 An Asian hornet queen

6 A positive rope test on a suspected AFB sample

7 Small hive beetle larva buried in sand before pupation

8 Asian hornet queens sorted for weighing

9 Victoria Tomkies using gene sequencing machines

may spread following an incursion. The variables can be altered to produce results that help inform policy decision making and contingency planning across departments. For example, it can indicate how parameters such as the likelihood of nest reporting and the extent of inbreeding in found nests impacts on how quickly hornet colonies can spread.

Previous modelling work has demonstrated that the speed at which nests can be detected and destroyed after reporting has a significant effect on controlling spread. The Asian hornet track-and-trace app, developed by Fera for use by bee inspectors, has significantly sped up this process.

Small hive beetle

Some parts of the Sand Hutton campus are strictly off limits to visitors, including those areas used to house and study live exotic pests. Among its malignant menagerie, Fera holds in strictest security the UK's only population of small hive beetles (SHB – *Aethina tumida*).

Small hive beetles have been kept at Sand Hutton since 2006, with two lines originating from South Africa and one from the USA. The beetles are bred and studied to provide insights into their reproductive biology, lifestyle and possible methods of control. When we visited, the cultures – as they are referred to – had reached their 72nd generation.

Biosecurity is very strictly controlled. Those visiting the live SHB must first go through swipe-card security doors, past closely monitored CCTV security cameras and then change into distinctive, red-coloured protective clothing before walking through an isolation corridor kept at -15C.

The quarantine unit itself is designed somewhat like the Pompidou centre, with its service pipes and wires on the outside so that technicians do not have to access the inner sanctum to perform maintenance work.

The culture room at the heart of multiple rooms of containment, is held at a temperature of 22C. The SHB cultures are housed in specially designed secure containers that allow them to be securely transferred from one container to another still within the quarantine unit.

Fun though it would have been to see the beetles and witness the sci-fi movie-style containment measures, so strict is the security that we were not permitted to get near any live specimens. However, some preserved dead larvae and adults floating in sample bottles were brought to us to look at. For such a potent threat to beekeeping, they looked rather benign, suspended in bottles of what turned out to be antibacterial hand wash.

With the SHB came the two specialists charged with their care, but such is the sensitivity of their role that we have been asked not to reveal their names. They gave a fascinating account of how they cultivate their stocks of SHB. The beetles are kept in containers in groups of 30–40 adults and are given plastic slides with tiny crevices in which to lay their eggs. When laying, the beetles use each new egg to push the last one further into the crevice. The slides are removed on a fishing line and placed in separate containers where the emerged larvae are fed their target food – honey bee brood. The SHB larvae are rapacious and each year bee brood, totalling the equivalent of that from about 20 colonies, is gathered, a few frames at a

time, from colonies in the Fera apiaries. A stock has to be built up for winter too and is stored in chest freezers.

When grown, the larvae become 'wanderers', beginning to move around looking for somewhere to pupate. This is when they would leave beehives and bury themselves in the surrounding ground. It is during this stage that SHB is most vulnerable

The beetles have been used to investigate some of their basic biology, such as the effects of temperature on breeding and development and also how long wandering larvae can last without eating and still successfully pupate – 80 days is the current record. At a basic level, the team wanted to know whether SHB would be able to survive and thrive in the UK. Sadly, the conclusion is that they would, and therefore detailed contingency planning is essential and continually revised. As with Asian hornet, what is discovered in the lab by Fera is fed into policy decision making and contingency planning and will guide practical measures taken by the bee inspectorate in the field.

Experiments to find possible eradication methods are ongoing – with a particular emphasis on practical techniques suitable for use by beekeepers. Various entomopathogenic fungi (harmful to insects) have been trialled without much success, but nematodes commonly used by gardeners to treat slugs are showing promise for their potential use in a contingency response scenario.

After 72 generations, the three strains of SHB kept at Sand Hutton risk becoming a little in-bred and samples from elsewhere in the world would be a useful addition to the collection. However, although all the official paperwork to allow the importation of more live specimens has been prepared, no commercial carrier will agree to carry the pea-sized passengers.

When beekeepers call on the help and advice of bee inspectors, few probably realise the wealth of scientific expertise and experience that informs the answers that are given. Our visit to the Fera laboratories gave us a small insight into the impressive technical facilities and vast experience that continually expand much of the knowledge on which we rely to maintain the health of our bees.