Parasitic honeybee mite jolts in the hive and uses vibrations to sense where it is

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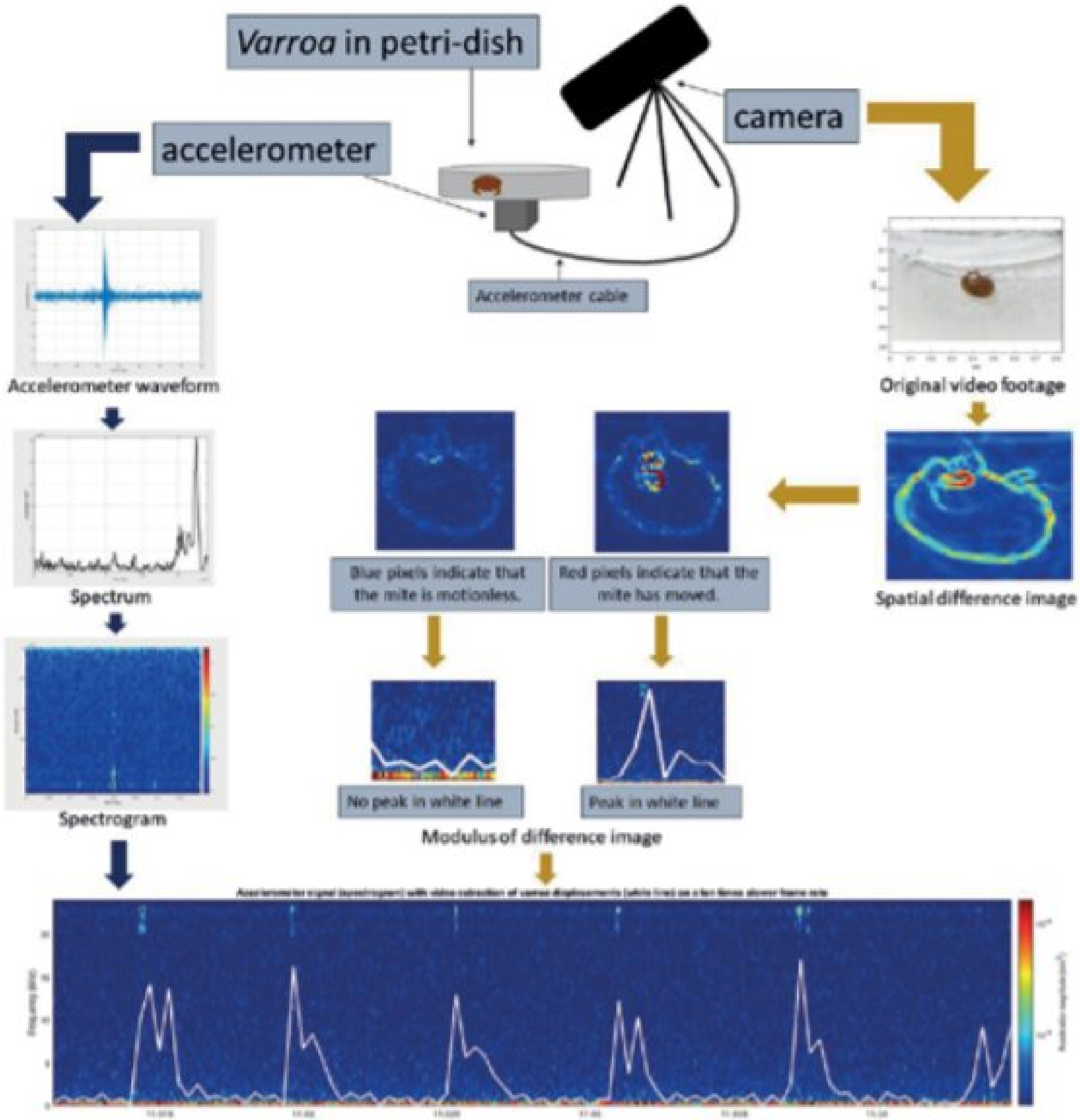

Fig. 1. A diagram to demonstrate the process of analysing the jolting pulse data. All three mites on each substrate underwent the same video analysis. The mite is placed on the substrate with the accelerometer attached and is filmed with the camera, producing a movie that has synchronous audio and video. The lefthand side of this diagram demonstrates how the vibrational data are processed. The raw accelerometer waveform of the movie is transformed into a spectrum, which shows the frequency (Hz) (x axis) and magnitude of acceleration (m/s2) (y axis) of the vibrational data. A collection of such spectra are then stacked into a spectrogram, which shows time (seconds) (x axis), frequency (Hz) (y axis) and magnitude of acceleration (logarithmic to the base 10) (pixel intensity). Dark red shows the highest magnitude and dark blue shows one 70th of this maximum. The maximum acceleration magnitude is forced to be that of the Varroa jolting pulses for better viewing, resulting in clipping of the irrelevant data at the lowest frequencies. The accelerometer recording for the entire original movie is transformed into a spectrogram, running with respect to time. The bottom panel shows a two-seconds long section of this movie. The right-hand side of the diagram demonstrates how the visual data are processed. The original video data that is collected is further cropped to better focus on the mite for the purpose of simple edge detection (by means of the spatial gradient of the pixel intensity). The modulus (absolute value) of the difference image shows the changes in pixel intensity in two consecutive frames as seen in the spatial difference image. In the modulus of the difference image, the mite is mostly dark blue when motionless, but exhibits edges that flash red when moving abruptly. The sum of the pixel intensities in this panel are then displayed as the white line that is superimposed on the spectrogram data of the bottom panel. This demonstrates the remarkable synchronicity between video-detected mite displacement and accelerometer trace. This processing is used to create the supplementary videos S9, S10 and S11. Credit: DOI: 10.1127/entomologia/2021/1407

Tiny parasitic mites, which are one the greatest threats to the honeybee, frequently send remarkably strong vibrational pulses into the surface they reside on, a new study has revealed.

Scientists at Nottingham Trent University, which led the work, argue that the vibration could be produced for the purpose of environmental probing, with the mite exploiting the material's response to the signal to probe its surroundings.

It is hoped that the fundamental discovery could lead to understanding how to manage and possibly even eradicate Varroa destructor mite infestations in the hive.

Using ultra-sensitive accelerometers—which have been able to detect vibrational waveforms originating from one individual mite—the team recorded the repeated knocking of the 1mm creatures, which they do by abruptly jolting their bodies.

The researchers are the first group in the world to capture such vibrational waveform from a mite of any species, which can also be heard as an audio track when driven through speakers.

Varroa mites—which cannot see or hear and weigh about half a milligram—live in honeybee colonies in most parts of the world and feed on adult bees and larvae, passing on a variety of viruses to their hosts and play an important role in the destruction of colonies.

The researchers were looking for vibrational traces coming from honeybees that may be infected but found unexpectedly that the individual mites were providing measurable vibrations of their own.

The vibration that occurs as a result of the mite's jolting is very short and rapidly produced—taking just 50 to 90 microseconds for the vibration to be transmitted—and the features of the signal vary strongly depending on the material the mite is stood on, providing a 'signature' of the substrate.

"It is known in other species, such as the Aye-Aye and some parasitic wasps, that a signal similar to the one we discovered is produced, so that the animal can gather environmental knowledge," said Harriet Hall, a researcher in Nottingham Trent University's School of Science and Technology.

She said: "If a mite becomes dislodged from its honeybee host, this could perhaps help it orientate back to a bee, especially as the animal can't see or hear. The mite jolting is a commonly observed behavior that is energetically demanding to produce—another sign that the mite produces this vibration deliberately, for its own benefit."

It is widely acknowledged that these mites respond to a variety of sensory stimuli such as temperature and pheromones to orient to bees and to synchronize their offspring development with that of the bee, but little research has been carried out in terms of vibration.

The team is now launching a new branch of investigations to help further clarify the purpose of the vibrations. It is hoped that deeper understanding of the function will enable them to manipulate the behavior to better manage and potentially eradicate the mite from honeybee hives.

It could also have repercussions for the study of other mites and ticks which may use similar signals.

Harriet added: "We could perhaps use the vibrational features of the jolting signal to search for mites in a honeybee colony using our vibration sensing technology, without the need to disturb the bees by physically inspecting the hive. This could lead to a new method of detecting mite infestation early on, enabling beekeepers to medicate their colonies before the mites get out of control or avoid medication altogether, if deemed unnecessary."

Dr. Martin Bencsik, a physicist at Nottingham Trent University, added: "The vibrational pulse coincides with a mite's abrupt body motion, which has never been seen before and which we have captured and showcased in our work. We have characterized a new behavior in this species, a discovery so fundamental that it could have numerous and unexpected repercussions.

"For the first time you can see the jolting behavior, the corresponding accelerometer trace, and even hear the repeated 'knocks' produced by this organism that weighs as little as a single strand of human hair and is 200 times lighter than a honeybee.

"It is the first study to show that an individual mite is not only a receiver of vibrations, but also a transmitter of vibrations. On the basis of the vast energy spent by the mite to deliver these, they are probably not by-product vibrations of its activity, but deliberately transmitted by the animal for its own benefit.

"The signal is very common in the hive. We found that the animal is capable of slowly winding up energy in some kind of internal 'spring' system than it can then suddenly release, providing a super strong, super short vibrational pulse delivery."

The work is the latest Nottingham Trent University study looking at honeybee communication in the hive. Previous work has found that Queen bees 'toot' to instruct the colony to keep them safe, that honeybees drum on the comb to prompt others in the hive to start getting busy, and that surprised honeybees give 'whooping signal' in the hive.

The latest research, published in the journal *Entomologia Generalis,* also involved the University of Warwick.

More information: Harriet Hall et al, Varroa destructor mites regularly generate ultra-short, high magnitude vibrational pulses, *Entomologia Generalis* (2021). DOI: 10.1127/entomologia/2021/1407

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