Hearing the same sound twice in each ear helps insects locate their mates, new research reveals

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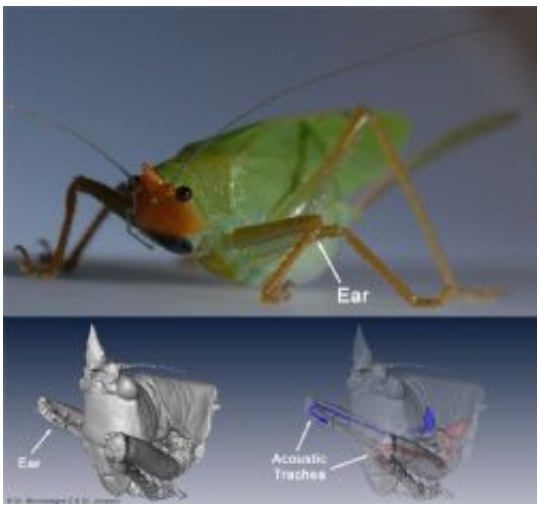

Credit: University of Lincoln

An incredibly advanced hearing system which enables a group of insects to listen to the same sound twice with each ear, helping them to locate the sound's origin with pinpoint accuracy, has been discovered by scientists at the University of Lincoln, UK.

The new Leverhulme-funded research set out to explore how Copiphora gorgonensis – a bush-cricket native to Colombia, South America – is able to hear sound signals from potential mates and to detect the sound source.

Unlike vertebrates, bush-crickets' ears are located in their forelegs. Each front leg exhibits a single ear below the knee with two eardrums (also known as tympanic membranes), which are backed by a narrow cylindrical tube (the acoustic trachea) running along the leg internally and opening out on the side of the insect's body.

The researchers found that a single sound actually arrives at the bush-crickets' ears twice, at different times and with different amplitudes, using the external and internal paths. The eardrums in each leg receive sound from the external side, and internally via the tracheal tube, making this type of ear a 'pressure difference receiver'. This dramatically improves their ability to locate the sound source.

This significant new discovery helps to explain how these nocturnal insects use their advanced hearing systems to successfully locate their mating partners in the dark.

Dr Fernando Montealegre-Z from the University of Lincoln's School of Life Sciences led the study. He explained: "Our research used advanced technologies to show how these bush-crickets receive sound signals in a way that enables them to detect their original source. We showed that the sound arrives at each tympanal membrane twice; externally at the normal speed of sound in air and then again internally via the acoustic trachea inside the animal, at a slightly slower speed. Curiously, the sound travelling inside the tracheal tubes is also amplified because the tube has the effect of an acoustic horn, a bit like an ear trumpet. Taken together, this means this tympanal membrane is receiving the signal twice – the first time at normal sound speed and with no amplification, and the second time slower but louder.

"In mammals, ears are located on the sides of the head and their position and distance is enough to cause slight differences in the time a signal arrives, and also to produce amplitude differences between both ears. As

these insects are too small to have ears in their heads, their location in the legs coupled with the tubing system allows the insect to hear a sound four times; twice in each ear. As they are nocturnal and the males sing to attract distant females for mating, these findings explain how females are so good at finding the best singing males in the dark and helps us to really understand how such sensitive and efficient hearing systems work."

The research was conducted as part of a pioneering project funded by the Leverhulme Trust to examine how insects have evolved incredible ultrasonic hearing abilities. A grant of £250,000 was awarded to support Dr Montealegre-Z's work, which aims to develop an integrated understanding of the evolution of ultrasonic hearing in bush-crickets.

The findings are published in the *Journal of the Royal Society Interface* in a new paper authored by Dr Thorin Jonsson, also from Lincoln's School of Life Sciences.

Dr Jonsson said: "Scientists previously had relatively little knowledge about the workings of the acoustic trachea and what happens to a sound signal when inside this part of the ear. The results we gathered are therefore extremely interesting, as they show just how the speed of the sound is slowed down to delay it reaching the internal surface of the eardrum. This produces a time-lag and ultimately means the insect has the opportunity to hear the same sound twice.

"Understanding this highly sensitive and very delicate mechanism provides a fascinating insight into how these insects use their ears to locate potential mates and might also inspire other areas of research, such as engineering or micro-robotics."

More information: Thorin Jonsson et al. Auditory mechanics in a bush-cricket: direct evidence of dual sound inputs in the pressure

difference receiver, *Journal of The Royal Society Interface* (2016). DOI: 10.1098/rsif.2016.0560