Moth ears are activated by movement the size of an atom

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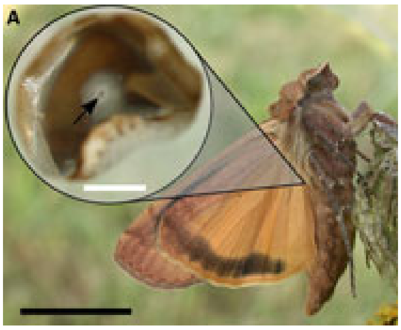

The neurons in the ear of the Large Yellow Underwing Moth are activated by movement of the eardrum the size of an atom. Image by Maurice Chambaret

(PhysOrg.com) -- Moths are so finely tuned to the ultrasonic calls of predatory bats that the nerve cells in their ears are activated by displacements of the eardrum the size of a small atom, according to new research from the University of Bristol. This means that if a moth's eardrum was scaled up to the thickness of a brick wall, a displacement of that wall equivalent to the diameter of a hair would be detectable to the moth.

Sensory organs are the brain's window to the world. The small nervous systems of insects have been used for decades to study how the world is coded by neurons. Moths have ears to detect the sonar calls of attacking bats, and the study of moth hearing systems has contributed significantly to our knowledge of the ecology and evolution of predator-prey interactions.

When sound hits the eardrum, it starts vibrating and this activates the auditory neurons attached to it. The neurons contain small molecular units that pick up the vibrations and convert the movement into electrical impulses that are sent to the brain. Vibration can be described by its velocity, that is, how fast the eardrum moves, or its displacement, that is, how far the eardrum moves back and forth. Until now, it was unknown which of these properties is translated into neural activity.

Five researchers from Bristol's School of Biological Sciences teamed up to measure simultaneously the activity of moth auditory neurons and the vibration of the eardrum while playing sounds of different frequencies and intensities.

Dr Hannah ter Hofstede said: "Combining these methods was an important step forward in studying the mechanics underlying moth hearing. We were able to validate decades of previous work by showing that the actual procedures necessary to obtain neural recordings from moths do not greatly alter the mechanics of the eardrum."

A displacement of only 140 picometers, the size of some atoms, was necessary to activate the neurons. Dr Holger Goerlitz said: "When the neurons where just able to detect a sound, this tiny displacement was the same for all sound frequencies, whereas the velocity was not. Auditory neurons are thus activated by the tiny displacement of the eardrum, not its velocity."

There was one exception: at low frequencies below 15 kHz, the neurons were only activated by larger displacements of the eardrum. Dr Hannah ter Hofstede explained: "This makes moths deaf to low-pitched, harmless background noises and enables them to tune in to more important sounds, the ultrasonic echolocation calls of their predators."

The research is published in *Naturwissenschaften*.

Provided by University of Bristol