It's not only size, but scales that matter in some male moth antennae

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Heliozelidae moth in Western Australia. Credit: Liz Milla

Male moths have evolved intricate scale arrangements on their antennae to enhance detection of female sex pheromones, which allows them to

keep their antennae small enough to maximise flying, new research suggests.

The work was led by researchers at the University of Melbourne with RMIT University, Walter and Eliza Hall Institute, Beijing Forestry University and is published today in *Proceedings of the Royal Society B*.

Charles Darwin was among the first to consider how the type of antenna might influence how male insects detect sex pheromones produced by females, said Professor Mark Elgar from the University of Melbourne's School of Biosciences.

"Darwin predicted that sexual selection, arising from competition among males, would favour more elaborate antennae in male moths, as they ensure more rapid detection of female sex pheromones.

"Moth sex pheromones are detected by receptors on structures called sensilla on the antennae.

"Conventional wisdom is that the feathery, bipectinate antennae in moths, arranged like two combs with numerous branches, provide a larger surface area to house the pheromone-detecting sensilla.

"But what we see in nature is that the majority of moth species have simple, filamentous-shaped antennae, which led us to ask why, if they are better at detecting sex pheromones, bipectinate antennae are less common in moths."

To understand this evolutionary dilemma, the team used scanning electron microscopy (SEM) to build finely detailed three-dimensional models of the structure of the filamentous antennae in Heliozelidae moths. Then they used computational fluid dynamics techniques to simulate the airflow field around the model antennae of moths of

different sizes and scale arrangements.

Dr Qike Wang led the experimental work which used nanoparticles in the fluid dynamic model to represent common sex pheromones and microparticles to represent environmental particles such as dust.

"We found that the angle of the scales concentrated the signal molecules to the downwind side of the antennae," said Dr Wang.

"By creating an area with slow airflow around the antennae, the scales ensure pheromones linger within the detection zone, thereby increasing the efficiency with which they interact with receptor."

"Furthermore, the scales are also effective at diverting away larger contaminating particles, such as dust. In a sense, they sift through the different particles only retaining the favourable ones."

"This is particularly important for species, like moths, that cannot groom the full length of their antennae."

The study found the effect of the scales on retaining sex pheromones is much greater for smaller than larger moths. For smaller moths with filamentous antennae, antennal scales improve signal detection by 25-48 per cent.

The team also found different types of scale arrangements, which ranged from those aligned parallel to antennae to those arranged in complete rings around the antennae, changed how well the scales functioned to concentrate sex pheromones to the receptor regions in the sensilla.

"The scales increase the diameter of the antennae and must, therefore, increase aerodynamic drag. We predict that the ability to find a mate through improved pheromone detection is likely to be a benefit that

offsets this cost," said Professor Elgar.

"More complex, bipectinate antennae may be favoured in large moths because they offer an additional surface area that can support more sensilla and thus a greater capacity to perceive chemical signals. Larger moths may be less impacted by reduction in flight speed due to their greater size and power."

"It's fascinating that Darwin's theory is still supported, but we needed modern techniques such as electron microscopy and computational fluid dynamics to confirm that it is antennal scales, and not size that make them more effective and detecting those crucial sex pheromones," Professor Elgar said.

More information: Antennal scales improve signal detection efficiency in moths, *Proceedings of the Royal Society B*, rspb.royalsocietypublishing.or … .1098/rspb.2017.2832

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