3-D printing blossoms into powerful new tool for ecologists

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3D printing has been used to make everything from cars to medical implants. Now, ecologists are using the technology to make artificial flowers, which they say could revolutionise our understanding of plant-pollinator interactions. Their study involving hawkmoths - a close relative of the species made famous by the film Silence of the Lambs - is published in the British Ecological Society's journal *Functional Ecology*.

Since long before Charles Darwin, ecologists have been fascinated by flower shape, and in particular how animal pollinators have shaped the evolution of floral traits. But studying the impact of flower shape on pollinator behaviour is difficult.

Ecologists have either relied on plant breeding (which means they can only study flower shapes found in nature) or made flowers by hand from paper maché (which can be time consuming and could make it difficult for ecologists to test each other's results).

Now, Eric Campos and colleagues from the University of Washington have used 3D printing to make artificial flowers so they can investigate how flower shape affects foraging behaviour in the hawkmoth Manduca sexta.

They made flowers of two different shapes, one curved like a trumpet and the other a flat disc with a hole in the centre. After filling each artificial flower with sugar water to simulate real flowers' nectar, they arranged equal numbers of curved and flat flowers on a square grid.

Then they then allowed hawkmoths to fly freely around the artificial flowers for five minutes and compared how many of each flower shape the moths emptied.

They found the moths fed much more successfully from the curved than the flat flowers, which suggests that this nocturnal species is using touch rather than sight as the primary means of finding nectar.

According to Campos: "With their long proboscis and nocturnal habits, finding a flower's nectar source isn't easy for the fist-sized hawkmoths we used in our study. Imagine being given a garden hose that's almost twice your height in length. Now imagine trying to thread the other end through a hole that's scarcely wider than the hose itself - at dusk as the sun is setting or at night during a full moon. It may seem like a silly proposition, but it's not too far off from what night-flying hawkmoths have to contend with to get a meal."

Equally importantly, by showing how 3D printing can be used to make artificial flowers, the research opens up new ways for ecologists to study animal pollinators and the evolutionary role they play in shaping the flowers we see in nature today.

"3D printing is a unique opportunity to explore the interactions between floral form and pollinator performance. Our ability to manipulate mathematically-specified flower morphology means that we can investigate the role of minute but potentially important differences in floral form on pollinator foraging performance.".

"Such studies can help elucidate the details of how pollinator visitation influences the evolution of floral shape in nature, and the extent to which floral forms are the result of specializations between one plant and one pollinator species," he says.

Also known as the tobacco hornworm because the larvae feed on tobacco, the hawkmoth *Manduca sexta* is common in the Southern and Southeastern regions of the USA. With a human thumb-sized body and fist-sized wingspan, adult moths are adept at flying and hovering, which they do to feed from trumpet-shaped flowers such as *Datura*, *Petunia* and *Nicotiana*.

More information: Eric Campos, Harvey Bradshaw and Daniel Thomas (2015). 'Shape matters: corolla curvature improves nectar discovery in the hawkmoth Manduca sexta', DOI: 10.1111/1365-2435.12378 , is published in *Functional Ecology* on 15 April 2015.

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