Hovering is a bother for bees: Fast flight is more stable

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Image credit: Wikipedia.

Bumblebees are much more unstable when they hover than when they fly fast, according to new research published this month in the *Journal of Theoretical Biology*.

The authors of the paper, Na Xu and Mao Sun from Beijing University of Aeronautics & Astronautics in China, used a mathematical model to analyze the way bumblebees fly at different speeds, showing that the bumblebee is unstable when it hovers and flies slowly, and becomes neutral or weakly stable at medium and high flight speeds.

The instability at hovering and low speed is mainly caused by a sideways wind made by the movement of the wings – a 'positive roll moment'. As the bee flies faster, the wings bend towards the back of the body, reducing the effect of the sideways wind and increasing the stability of its flight.

According to the authors the results could be useful in the development of small flying machines like robotic insects.

"Dynamic flight stability is of great importance in the study of biomechanics of insect flight," said Mao Sun. "It is the basis for studying flight control, because the inherent stability of a flying system represents the dynamic properties of the basic system. It also plays a major role in the development of insect-like micro-air vehicles."

In recent years, with the understanding of the aerodynamic force mechanisms of insect flight, researchers have been devoting more effort to the area of flight dynamics.

The study further refutes the persistent misconception that, according to physics, bumblebees shouldn't be able to fly. The fallacy can be traced back to Le Vol Des Insects (Hermann and Cle, Paris, 1934) by French entomologist August Magnan – on page 8 he mentions bumblebees, stating, "First prompted by what is done in aviation, I applied the laws of air resistance to insects, and I arrived, with Mr. Sainte-Laguë, at this conclusion that their flight is impossible."

This new research looks at bumblebee flight using the same methods as used in quantum mechanics. By using average measurements – such as wing size and shape, body mass, and upwards and downwards forces – the researchers made the stability analysis of the flapping flight of an insect mathematically the same as that of a rigid airplane. By using the mathematical model rather than studying live bees, the researchers could be more accurate in their analysis of mechanical flight.

"The computational approach allows simulation of the inherent stability of a flapping motion in the absence of active control, which is very difficult, even impossible, to achieve in experiments using real insects," Sun further explained.

Xu and Sun used a model of a bumblebee with wings approximately the same size and shape as a real bee's – flat plates with rounded edges, and with a thickness of three percent of the length of one wing. The outline they used of the body was also approximately the same as that of a bumblebee.

Previous research has looked at the hovering flight dynamics of different insects, including the dronefly, fruit fly and bumblebee. However, in hovering flight, there is no consideration of forwards movement, and the forces created by the wings cancel each other out. This study details that both vertical and horizontal movement need to be taken into consideration to determine how stable the flight is overall.

The results show a significant difference in stability measurements between bumblebees and droneflies – something the researchers think is connected to the size and shape of the insects' wings. They plan to conduct further research in this area to compare the stability of flight at different speeds of bumblebees and droneflies.

More information: This article is "Lateral dynamic flight stability of a model bumblebee in hovering and forward flight", by Na Xu, Mao Sun – Beijing University of Aeronautics & Astronautics, China (doi: 10.1016/j.jtbi.2012.11.033). The article appears in *Journal of Theoretical Biology*, 319 (2013) 102, 21 February 2013

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