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Avery Thompson

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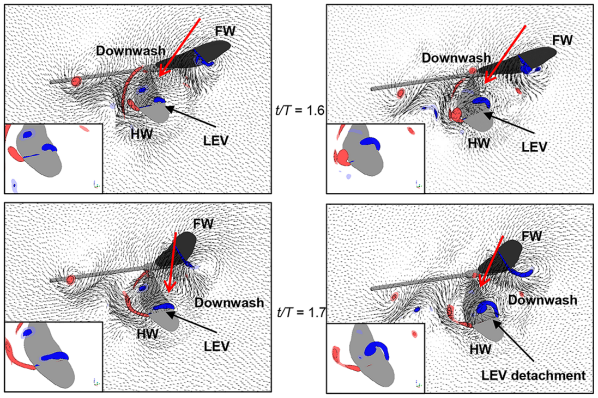
Optimizing damselfly hindwing kinematics can improve the efficiency of similarly structured micro-aerial vehicles.



Of all the flying animals, one of the most maneuverable is the damselfly, a large insect with two pairs of wings. Having two pairs of independent wings gives a damselfly significant advantages in flight, contributing to its position as a fearsome hunter. Understanding how the damselfly uses its unique wing arrangement to achieve its speed and maneuverability can improve the design of artificial small aerial vehicles.

Lai et al. computationally investigated the hind pair of damselfly wings, measuring their impact and determining the optimal kinematics.

“A damselfly can control flight and achieve an optimal aerodynamic efficiency through adjusting the hindwing kinematics,” said author Yu-Hsiang Lai. “The hindwing kinematics enhance the overall thrust efficiency up to 22 percent.”

While the damselfly’s forewings provide most of the lift and thrust, the hindwings still play an important role. The team used their simulation to examine several hindwing kinematics, such as stroke plane angle, wing phase, and rotational duration. They found the most optimal pattern for long distance flight is a large stroke plane angle and a small rotational duration, while the opposite configuration is ideal for hovering flight.

The authors hope their work will inform micro-aerial vehicles that rely on flapping motion. They are planning to expand their simulation to account for the impact the kinematics can have on stability.

“Varied wing kinematics can affect flight stability, thus leading to the body pitching,” said Lai. “We are currently developing a numerical simulation method for calculating the passive pitching of the body.”

Source: “Optimal thrust efficiency for a tandem wing in forward flight using varied hindwing kinematics of a damselfly,” by Yu-Hsiang Lai, Sheng-Kai Chang, Bluest Lan, Kuan-Lun Hsu, and Jing-Tang Yang, *Physics of Fluids* (2022). The article can be accessed at https://doi.org/10.1063/5.0093208.