The secret of dragonflies' flight

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A collage of dragonflies during recovery flight. Yellow arrows indicate the body orientation, and the circles on the wings are tracked points, overlaid on top of the image.

Dragonflies can easily right themselves and maneuver tight turns while flying. Each of their four wings is controlled by separate muscles, giving them exquisite control over their flight.

Researchers from Cornell University are investigating the physics behind this ability by recording high-speed video footage of dragonflies in flight and integrating the data into computer models, and they will present their findings at the 67th annual meeting of the American Physical Society (APS) Division of Fluid Dynamics, held Nov. 23-25 in San Francisco.

"Dragonflies tend to have unpredictable flight—that's what makes them fascinating. They hover for a bit, and every so often they'll make a quick, sharp turn. They rarely stay right in front of your camera for us to contemplate on," explained lead researcher Jane Wang.

In collaboration with Anthony Leonardo at Janelia Farm, the research campus of the Howard Hughes Medical Institute, Wang devised a unique experimental method to make dragonflies perform repeatable aerial maneuvers: to attach a tiny magnet to the underside of each insect that allowed them to hang upside down from a metal rod. When the magnet is released, said Wang, "Dragonflies somehow understand the orientation and they do a stereotypical maneuver: they roll their body to make a 180-degree turn."

By tracking the body and wing orientations using high-speed video recording of this rapid roll in high resolutions, the team uncovered how dragonflies were altering the aerodynamics on their wings to execute the turn.

"The wings on an airplane are oriented at some fixed angle. But insects have freedom to rotate their wings," explained Wang. By adjusting the wing orientation, dragonflies can change the aerodynamic forces acting on each of their four wings.

The iridescent insects can also change the direction in which they flap their wings—known technically as their "stroke plane." The new data showed that dragonflies can adjust the stroke plane orientation of each wing independently.

With so many different variables, understanding how dragonflies control their flight is a complicated task. "Our job is to try to find out the key strategies that dragonflies use to turn," explained Wang. She and her graduate student James Melfi Jr. are incorporating their data into a computer simulation of insects in free flight, which allows them to examine the separate effect of each kinematic change.

Wang described her group's work as "using physical principles to explain animal behavior."

"Even though biological organisms are complex, they still obey some basic laws—in this case, fluid dynamics. … I'm hoping to understand how these basic laws influence evolution of insects and the wiring of their neural circuitry."

More information: meetings.aps.org/Meeting/DFD14/Session/F1.16

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