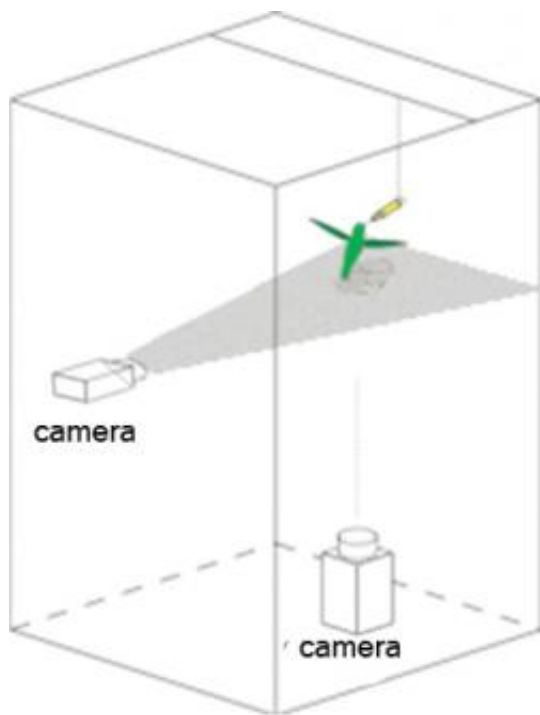


Study shows hovering hummingbirds generate two trails of vortices under their wings, challenging one-vortex consensus

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This cartoon shows the experimental setup. High-speed cameras recorded the hovering of hummingbirds in the lab. Credit: Altshuler Lab, UC Riverside.

As of today, the [Wikipedia entry for the hummingbird](#) explains that the bird's flight generates in its wake a single trail of vortices that helps the bird hover. But after conducting experiments with hummingbirds in the lab, researchers at the University of California, Riverside propose that

the hovering hummingbird instead produces two trails of vortices—one under each wing per stroke—that help generate the aerodynamic forces required for the bird to power and control its flight.

The results of the study could find wide application in aerospace technology and the development of unmanned vehicles for medical surveillance after [natural disasters](#).

The researchers used high-speed image sequences—500 frames per second—of hummingbirds hover-feeding within a white plume (emitted by the heating of dry ice) to study the vortex wake from multiple perspectives. They also used [particle image velocimetry](#) (PIV), a flow-measuring method used in [fluid mechanics](#), to quantitatively analyze the flow around the hummingbirds. PIV allowed the researchers to record the particles surrounding the birds and extract velocity fields.

The films and velocity fields showed two distinct jets of downwards airflow—one under each wing of the hummingbird. They also revealed that vortex loops around each jet are shed during each upstroke and downstroke.

The researchers therefore propose in their [paper published online](#) last month in the journal *Experiments in Fluids* that the hummingbird's two wings form bilateral vortex loops during each wing stroke, which is advantageous for maneuverability.

"Previous studies have indicated that slow-flying bats and faster flying birds produced different structures in their wakes," said Douglas Altshuler, formerly an assistant professor of biology at UC Riverside, whose lab led the research. "We have been investigating the wake structure of hovering hummingbirds because this allows us to decouple the effects of different types of wings—bat versus bird—from different forward flight speeds.

Hummingbirds each weigh 2-20 grams. Because they can hover with high precision, they are able to drink nectar from flowers without any jiggling movement to their bodies. Besides using upstrokes and downstrokes, hummingbirds can rotate their wings. They can even flap their wings from front to back with a 180-degree amplitude.

"We began this study to investigate how the hummingbird used its tail while hovering," said Marko Princevac, an associate professor of mechanical engineering and a coauthor of the research paper. "After all, many insects also hover, but they have no tail. Instead, however, our research showed something interesting about the hummingbird's wings: the bilateral vortex structure. Hummingbirds hovering should cost a lot of energy but these birds are able to hover for long periods of time. Ideally, unmanned vehicles need to be operated with a very limited energy supply, which is why understanding how the hummingbird maximizes its use of energy is tremendously beneficial."

Sam Pournazeri, a former Ph.D. graduate student in Princevac's lab and a co-author on the paper, explained that in a downstroke, the air pressure difference developed as a result of wing movement creates flow from the bottom to the top of the wing. The result is a circular movement or vortex.

"Based on theories in fluid mechanics, this vortex should close either on the wing/body or create a loop around it," he said. "It's these loops that provide circulation around the wings and cause the hummingbird to overcome its weight. Hovering requires the bird to create a lift that cancels its body weight. Although the two-vortex structure we observed increases the hummingbird's energy consumption, it provides the bird a big advantage: a lot more maneuverability."

Next, the research team plans to study the hummingbird in a wind tunnel to closely observe how the bird transitions from hovering to forward

motion, and vice versa.

"Current technology is not successfully mimicking how living things fly," Princevac said. "Drones don't hover, and must rely on forward motion. Research done using [hummingbirds](#), like ours, can inform the development of the next generation of drones."

More information: [link.springer.com/article/10.1 ...
07/s00348-012-1439-5](https://link.springer.com/article/10.1007/s00348-012-1439-5)

Provided by University of California - Riverside

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