

# Bats save energy by drawing in wings on upstroke: study

April 10 2012

---



By folding their wings in toward their bodies on the upstroke, bats use 35 percent less energy and reduce aerodynamic drag, compensating for heavier, more muscular wings. Credit: Breuer and Swartz/Brown University

(Phys.org) -- Bat wings are like hands: meaty, bony and full of joints. A new Brown University study finds that bats take advantage of their flexibility by folding in their wings on the upstroke to save inertial energy. The research suggests that engineers looking at flapping flight should account for wing mass and consider a folding design.

Whether people are building a flying machine or nature is evolving one, there is pressure to optimize [efficiency](#). A new analysis by [biologists](#),

physicists, and engineers at Brown University reveals the subtle but important degree to which that pressure has literally shaped the [flapping wings](#) of bats.

The team's observations and calculations show that by flexing their wings inward to their bodies on the upstroke, bats use only 65 percent of the inertial energy they would expend if they kept their wings fully outstretched. Unlike [insects](#), bats have heavy, muscular wings with hand-like bendable [joints](#). The study suggests that they use their [flexibility](#) to compensate for that mass.

"Wing mass is important and it's normally not considered in flight," said Attila Bergou, who along with Daniel Riskin is co-lead author of the study that appears April 11 in the *Proceedings of the Royal Society B*. "Typically you analyze lift, drag, and you don't talk about the energy of moving the wings."

The findings not only help explain why bats and some birds tuck in their wings on the upstroke, but could also help inform human designers of small flapping vehicles. The team's research is funded by the U.S. Air Force Office of Sponsored Research.

"If you have a vehicle that has heavy wings, it would become energetically beneficial to fold the wings on the upstroke," said Sharon Swartz, professor of ecology and evolutionary biology at Brown. She and Kenneth Breuer, professor of engineering, are senior authors on the paper.

## **The physics of flexed flapping**

The team originally set out to study something different: how wing motions vary among bats along a wide continuum of sizes. They

published those results in 2010 in the *Journal of Experimental Biology*, but as they analyzed the data further, they started to consider the intriguing pattern of the inward flex on the upstroke.

That curiosity gave them a new perspective on their 1,000 frames-per-second videos of 27 bats performing five trials each aloft in a flight corridor or wind tunnel. They tracked markers on the bats, who hailed from six species, and measured how frequently the wings flapped, how far up and down they flapped, and the distribution of mass within them as they moved. They measured the mass by cutting the wing of a bat that had died into 32 pieces and weighing them.

The team fed the data in to a calculus-rich model that allowed them to determine what the inertial energy costs of flapping were and what they would have been if the wings were kept outstretched.

Bergou, a physicist, said he was surprised that the energy savings was so great, especially because the calculations also showed that the bats have to spend a lot of energy — 44 percent of the total inertial cost of flapping — to fold their wings inward and then back outward ahead of the downstroke.

"Retracting your wings has an inertial cost," Bergou said. "It is significant but it is outweighed by the savings on the up and down stroke."

The conventional wisdom has always been that bats drew their wings in on the upstroke to reduce drag in the air, and although the team did not measure that, they acknowledge that aerodynamics plays the bigger role in the overall energy budget of flying. But the newly measured inertial savings of drawing in the wings on the upstroke seems too significant to be an accident.

"It really is an open question whether natural selection is so intense on the design and movement patterns of bats that it reaches details of how [bats](#) fold their [wings](#)," Swartz said. "This certainly suggests that this is not a random movement pattern and that it is likely that there is an energetic benefit to animals doing this."

Provided by Brown University

Citation: Bats save energy by drawing in wings on upstroke: study (2012, April 10) retrieved 19 April 2024 from <https://phys.org/news/2012-04-energy-wings-upstroke.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.