

Flight of the Honey Bee

Explaining the aerodynamics of honeybee flight has been a difficult problem for those who try to understand such processes. In fact, just 8 years ago - *in 2005* - researchers at Caltech published the first full description of how bees fly. Before that, just *how* these common creatures do what they do so well was not well understood. In fact, French researchers had famously concluded - in 1934 - that *bee flight was impossible ...* or, at least, not describable by the laws of physics. In *Le Vol Des Insects*, French entomologist August Magnan 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." His error was trying to fit equations of fixed-wing flight mechanics to the moving wings of the bee.

The Caltech scientists recorded freely hovering bees with high-speed (6,000 frames per second), high-resolution digital cameras, and then closely analyzed the images. They then constructed mathematical models of what they saw and tested their aerodynamic equations of flight using a robotic bee.

Honey bees use a flight mechanism different from many other insects, with a *low wing stroke amplitude of 90 degrees* (a wide 165 degree stroke would be more typical for an insect their size) and a *high wing beat frequency off 230 beats/sec* (instead of expected 150 beats/sec) during hovering. The creation of *wing-generated vortices* at specific locations with respect to the beating wing is what generates the low-pressure areas, providing lift for honeybee flight. Of course, the wings are just one part of the flight machine ... the bee's musculature *and neural control mechanism* provide the force and direct the purposeful wing movement that delivers honey bee flight, as the bee moves from flower to flower to flower and back to the hive.

The attached references include a mathematical description of honeybee flight and brief slow-motion videos of bee flight.

1) PNAS Caltech article: <http://www.pnas.org/content/102/50/18213.full.pdf>

2) videos of bee

flight: <http://www.newscientist.com/data/images/ns/av/dn8382.avi>

3) article / video of bumblebee

flight: <http://www.physics.org/featuredetail.asp?id=32>