Insect aerodynamics at high frequencies

Richard Bomphrey*[1], Marcos Georgiades[1], Rachel Tran[2], and Simon Walker[2]

[1]Royal Veterinary College – United Kingdom
[2]University of Leeds – United Kingdom

Abstract

Insects flap their wings at high frequencies. Some flap more than an order of magnitude faster than even the fastest hummingbirds. Consequently, their aerodynamics remained poorly understood until cameras with sufficient frame capture rates became available. High-speed cameras facilitate measurements of the flow field *in vivo*, and can also acquire wing positional data with sufficient accuracy for computational fluid dynamics analysis (CFD). We remain somewhat limited by frame rate; for example, even cameras operating at 800 Hz would only capture a single image per wing stroke cycle of many mosquitoes or midges, which is inadequate for time-resolved particle image velocimetry or CFD. Using a synchronised ten-camera array, operating at 12 kHz, we used a voxel carving method to extract the geometries of mosquitoes across a range of temperatures. As the temperature increases, so does the wing beat frequency. Concomitantly, the wing stroke amplitude decreases until the wing sweeps through the air for approximately just one chord length before flipping and reversing direction for the next half stroke. With these kinematics, estimates of lift and thrust from traditional aerodynamic theory that has previously been used to assess insect flight, such as quasi-steady blade element theory, deteriorates. Direct numerical simulations show that a greater proportion of the forces required for weight support are generated in the rapid rotations at stroke reversal. Here we present an exploration of the aerodynamic mechanisms at play.

*Speaker

sciencesconf.org:biolocomotion:485775