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# Fluid Mechanics by Insects


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## ABSTRACT:


Each insect is a compact autonomous system that thrives in air and water. Their small sizes contend with the complex interaction of fluid forces. Through morphological and behavioral adaptations, insects find a way to locomote, communicate, and feed in dynamic fluid environments. In this talk, I will show interesting hydrodynamic adaptations of two beloved insects, the dragonfly and honeybee.

Dragonflies live underwater in their larval stage. For their underwater life, they have a highly modified gut that works as a pump, which produces reciprocal jetting for respiration and propulsion. They control the jet's strength and direction by using their tri-leaflet valve. During the respiratory jetting, retraction of a single leaflet positions the opening in an off-centred locale, from which diagonally deflected jets emerge. During the propulsive jetting, concurrent partial retraction of the three leaflets results in the centred opening, and the resulting jet flows straight. The biological implications of dragonfly's passive flow control strategy and potential application to designing of prosthetic heart valve will be discussed.

Honeybees display a unique bio-locomotion strategy at the air-water interface. When water's adhesive force traps them on the surface, their wetted wings lose the ability to generate aerodynamic thrust. However, they adequately locomote, reaching a speed up to three body lengths·s-1. Honeybees use their wetted wings as hydrofoils for their water surface propulsion. Their locomotion imparts hydrodynamic momentum to the surrounding water in the form of asymmetric waves and a deeper water jet stream, generating approximately 20 μN average thrust. The wing kinematics show that the wing's stroke plane is skewed, and the wing supinates and pronates during its power and recovery strokes, respectively. Scaling analysis of the hydrodynamic forces associated with the wing motion indicates that the wings utilize added mass force (unsteady inertial force associated with the pulling of the water attached to the wing). Hydrofoiling highlights the versatility of their flapping-wing systems that are capable of generating propulsion with fluids whose densities span three orders of magnitude. This discovery inspires a novel aerial-aquatic hybrid vehicle.


## BIOGRAPHY:

Chris Roh received his B.S. in Bioengineering from Cornell University in 2012 and his M.S. and Ph.D degree in Aeronautics from California Institute of Technology (Caltech) in 2013 and 2017. He is currently a Research Engineer and Lecturer at Caltech. From a young age, Chris has been fascinated by the diversity of insects and different stories each insects tell. This deep-rooted passion combined with his new found love for the intricate ways fluid flow has led him to study the hydrodynamics of insects at Caltech under the guidance of Professor Morteza Gharib. In his thesis work, he studied the jet vectoring ability of aquatic dragonfly larva's tri-leaflet valve, as well as how honeybees swim using their wings. These studies have broad implications, as the tri-leaflet valve of dragonfly larvae helps us imagine a new prosthetic heart valve and honeybee's swimming demonstrates versatility of flapping wing systems. Chris continues to observe interesting ways insects interact with the fluid surrounding them with engineering applications in mind.