

# Aerodynamic Trends for Biological Flapping Flight

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**Abstract.** This study investigates the effects of air turbulence on the flight kinematics and metabolism of Annas hummingbirds (*Calypte anna*). Turbulent air flow is generated and controlled through the use of static mesh grids and an active array of fans. A Particle Image Velocimetry (PIV) system, consisting of a high speed camera (500 frames per second) and a Nd:YAG laser, were utilized to measure the flow. The flows Turbulent Kinetic Energy (TKE) and integral length scale were calculated from the PIV data using autocorrelation and autocovariance analysis, thereby quantifying the flows level of turbulence. Variations in wing and body kinematics were analyzed using multiple angle, high speed video while the metabolic rate was measured by the birds volumetric oxygen consumption rate during flight. Preliminary results did not show a conclusive correlation between the produced turbulent conditions and variations in the flight kinematics or metabolism of the tested hummingbirds. Future work will focus on expanding the range of tested turbulent conditions.