



CALIFORNIA STATE SCIENCE FAIR 2006 PROJECT SUMMARY

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Project Title An Experimental Analysis of the Thrust Produced by an Ornithopter at Low Reynolds Numbers	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective of this project was to determine important aerodynamic characteristics of an ornithopter configuration, Micro Air Vehicle [MAV] scale vehicle. This project investigated the thrust produced by a small scale, 15 cm wingspan, ornithopter. An important theory that was explored was the Weis-Fogh effect which states that the pulling apart of two wings creates extra thrust over the thrust from each individual wing.</p> <p>Methods/Materials To perform this experiment, a test vehicle was designed and constructed using Carbon Fiber, Mylar Plastic, small music wire, and a pager motor. Two configurations were tested. First, a monoplane ornithopter was tested with two, side-by-side wings. Second, a biplane ornithopter was tested with two additional wings (total of four wings) in the same side-by-side configuration.</p> <p>A testing apparatus was constructed using balsa wood to measure the thrust. Both configurations were tested multiple times using various input voltages which varied the flapping frequency of the wings. The thrust produced was recorded using a gram scale.</p> <p>Results The data was analyzed after applying the Reynolds Number [Re] as a leveling factor. The Reynolds Number involves the air viscosity, and the length and velocity of the test vehicle. Using the induced velocity, the Re was calculated to be 3.6×10^2 for the monoplane and 6.7×10^2 for the biplane; within the same range as that of a butterfly or a small insect. The thrust recorded ranged from 0.2 milliNewtons [mN] to 1.4 mN for the monoplane ornithopter and 0.3 mN to 3.0 mN for the biplane ornithopter.</p> <p>Conclusions/Discussion The Weis-Fogh effect was validated in this experiment by showing it was significantly adding thrust (66% of the monoplane ornithopter thrust). The results suggest that the Weis-Fogh effect seems to be dependent on flapping frequency. I would like to research this dependency further. The results indicate that the monoplane ornithopter is more efficient for long range flights while the biplane ornithopter has a greater carrying capacity.</p>	
Summary Statement This experiment studies important aerodynamic characteristics of small scale ornithopters and establishes that a biplane ornithopter produces significantly more than twice the thrust of a monoplane ornithopter, consistent with the Weis-Fogh	
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