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## AERODYNAMIC PROPERTIES OF AVIAN FLIGHT AS A FUNCTION OF WING SHAPE

**Andrew I. March**

Sibley School of Mechanical Engineering and Aerospace Engineering,  
College of Engineering, Cornell University

**Charles W. Bradley**

Department of Animal Science and Department of Biology,  
College of Agriculture and Life Sciences, Cornell University

**Ephraim Garcia, Ph.D.**

Sibley School of Mechanical Engineering and Aerospace Engineering,  
College of Engineering, Cornell University

### ABSTRACT

Presently, all man-made aircraft are optimized for one specific flight regime. Commercial aircraft fly at a specific cruising altitude at which they are most efficient, and military aircraft, which require excellent performance in many flight regimes are designed to be 'good' at all of them. A new concept in aviation, morphing aircraft, or aircraft that can fully change their shape, will allow for optimization at nearly any flight regime. This concept has been millennia in the making, well before mankind. Looking to various bird species, tails and wings can completely change shape to optimize their morphology for a given flight regime. Raptors, especially, have mastered the air in that they must out compete and overcome other birds while hunting. For soaring, these birds spread their wings fully to maximize their lift to drag ratio and maintain a low energy, long endurance flight. To maximize speed in a dive they will bring their wings close to their bodies to minimize drag.

This study seeks to quantify the aerodynamic properties of the wing. From bird wings the aerodynamic properties of shape changing elastic structures can be understood. The coefficient of lift versus angle of attack plot of a bird wing is not like that of a typical airfoil, it has no distinct point where the wing stalls, instead the bird wing will twist into the flow. Additionally, the induced drag of an avian wing is significantly less than the theoretical induced drag on a wing predicted by the aspect ratio. A flow visualization around the slotted wingtips of a bird reveals smooth streaklines near the primary feathers. These feathers are canted downward and

accordingly generate lift in the thrust direction of the wing, which acts to reduce the induced drag on the wing.

### INTRODUCTION

The ability of a bird to change the geometry of its wing allows it to maximize efficiency for various flight strategies. The raptor is a perfect example, utilizing a low energy gliding or soaring flight to travel great distances or search for prey as well as a high-speed dive in which it sacrifices stability for increased maneuverability and velocity. Stability and maneuverability are also a tradeoff in the natural world, but with the computing power of the brain, and fine-tuned adjustments through musculature, the two can be optimized. With the advancement of aircraft, the optimization of structure for specific flight tasks is becoming an attainable goal. Current technologies such as shape changing memory alloys, micro-processors, and minute actuators allow for a complex change in an aircraft's gross morphology.

Using deceased specimens of Red-tailed Hawk (*Buteo jamaicensis*) and Great horned Owl (*Bubo virginianus*), aerodynamic properties were measured at varied air speeds and angles of attack with varied angles of flexion in the wing. Only gliding flight was considered as a model due to the complexity of flapping flight, and the ease of reckoning these results with manmade aircraft.

Most of the literature regarding the aerodynamics of bird flight considers flapping flight, using living specimens in a wind tunnel, or even following them in aircraft (Bruderer et al, 2001; Park et al, 2001; Krus, 1997) Those that do consider gliding generally focus on kinematics and power consumption.