

Analysis of bat wings for morphing

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ABSTRACT

The morphing of wings from three different bat species is studied using an extension of the Weissinger method. To understand how camber affects performance factors such as lift and lift to drag ratio, XFOIL is used to study thin (3% thickness to chord ratio) airfoils at a low Reynolds number of 100,000. The maximum camber of 9% yielded the largest lift coefficient, and a mid-range camber of 7% yielded the largest lift to drag ratio. Correlations between bat wing morphology and flight characteristics are covered, and the three bat wing planforms chosen represent various combinations of morphological components and different flight modes. The wings are studied using the extended Weissinger method in an "unmorphed" configuration using a thin, symmetric airfoil across the span of the wing through angles of attack of 0° - 15° . The wings are then run in the Weissinger method at angles of attack of -2° to 12° in a "morphed" configuration modeled after bat wings seen in flight, where the camber of the airfoils comprising the wings is varied along the span and a twist distribution along the span is introduced. The morphed wing configurations increase the lift coefficient over 1000% from the unmorphed configuration and increase the lift to drag ratio over 175%. The results of the three different species correlate well with their flight in nature.

1. INTRODUCTION

At dusk, bats emerge to forage for food, and in doing so, put on a show of remarkable aerodynamic feats and unrivaled acrobatics in the air. Some species are known for soaring gracefully¹ whereas others are known to pull up to 4.5g's in obstacle courses². For this reason, we look directly to bats to see what about their wing morphologies allows them to achieve such unprecedented maneuvers. Bats' jointed hand-like skeletal framework allows them to morph their wings in flight, changing the shape of the wing profile to produce the optimum lift, drag, or moment for a desired effect. Bats have the largest control over the camber of their wings, which is the curvature of the cross-section of the wing (Fig. 1). If the wing of a small aircraft or MAV could be controlled in a similar manner, the morphing would allow for multiple tasks to be achieved, so that the wing could change to increase lift to carry loads, increase the lift to drag ratio for maximum efficiency, and create an asymmetric lift distribution for rolling and turning maneuvers.³⁻⁵

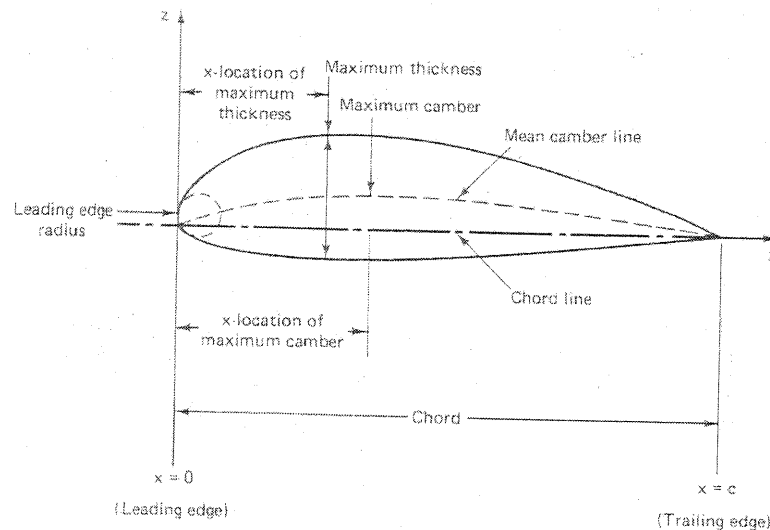


Fig. 1: Important geometry variables for airfoils [6].