21-23 October, Vilnius, Lithuania
13th International Conference
BIOMDLORE 2021

2D Numerical Investigations Derived from a 3D Dragonfly Wing Captured with a High-Resolution Micro-CT

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ABSTRACT

BACKGROUND: Due to their corrugated profile, the dragonfly wings have special aerodynamic characteristics during flying and gliding. Considering lift and drag coefficients these characteristics can be evaluated using Computational Fluid Dynamics (CFD) Analyses.

OBJECTIVE: The aim of this study was to create a realistic 3D model of a dragonfly wing captured with a high-resolution micro-CT. To represent geometry changes in span and chord length and their aerodynamic effects, numerical investigations are carried out at different wing positions.

METHODS: The forewing of a Camacinia gigantea was captured using a micro-CT. After the wing was adapted an error-free 3D model resulted. The wing was cut every 5 mm and 2D numerical analyses were conducted in Fluent® 2020 R2 (ANSYS, Inc., Canonsburg, PA, US).

RESULTS: The highest lift coefficient, as well as the highest lift-to-drag ratio, resulted at 0 mm and an angle of attack (AOA) of 5°. The lift coefficient increases for all wing sections at an AOA of 5° compared to the lift coefficient at 0°. Once the wing cross-sections were rotated about 10° or 15°, the flow around the wing stalled and a Kármán vortex street behind the wing becomes visible.

CONCLUSIONS: The velocity is higher on the upper side of the wing compared to the lower side. The pressure acts vice versa. The lower the pressure on the upper side, the higher the lift coefficient. Due to the recirculation zones that are formed in valleys of the corrugation pattern the wing resembles the form of an airfoil.

KEYWORDS: dragonfly wing, gliding flight, insect flight, computational fluid dynamics, aerodynamics.