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NUMERICAL INVESTIGATION OF A 3D DRAGONFLY WING CAPTURED WITH A HIGH-RESOLUTION MICRO-CT

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The special wing geometry of dragonflies consisting of veins and a membrane forming a corrugated profile leads to special aerodynamic characteristics. To capture the governing flow regimes of a dragonfly wing in detail, a realistic wing model has to be investigated. Therefore, this study aimed to analyze the aerodynamic characteristics of a 3D dragonfly wing reconstructed from a high-resolution micro-CT scan. Afterwards, a spatially high discretized mesh was generated using the mesh generator CENTAUR™ 14.5.0.2 (Centaur-Soft, Austin, TX, US) to finally conduct Computational Fluid Dynamics investigations in Fluent® 2020 R2 (ANSYS, Inc., Canonsburg, PA, US). Due to the small dimensions of the wing membrane, only the vein structure of a Camacinia Gigantea was captured at a micro-CT voxel size of 7 microns. The membrane was adapted and connected to the vein structure using a Boolean union operation. Occurring inconsistencies after combining the veins and the membrane were corrected using an adapted pymesh script [1]. As an initial study, only one quarter of the wing (outer wing section) was investigated to reduce the required computational effort. The resulting hybrid mesh consisting of 10 pseudo-structured prism layers along the wing surface and tetrahedra in the farfield area has 43 mio. nodes. The flow around the wing was considered to be incompressible and laminar using transient calculations. When the flow passes the vein structures, steady vortices occur in the corrugation valleys leading to recirculation zones. Therefore, the dragonfly wing resembles the profile of an airfoil. This leads to comparable lift coefficients of dragonfly wings and airfoil profiles at significantly reduced structural weight. The reconstructed geometry also included naturally occurring triangular prism-like serrated structures at the leading edge of the wing, which have comparable effects to micro vortex generators and might stabilize the recirculation zones. Further work aims to investigate the aerodynamic properties of a complete dragonfly wing during wing flapping.

REFERENCES

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