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Effect of wing deformation on the flapping flight of butterflies

Lingxiao Zheng[1], **Rajat Mittal**[1]

1. Mechanical Engineering, Johns Hopkins University, Baltimore, USA, 21218

E-mail: mittal@jhu.edu

Insect wings deform significantly in spanwise and chordwise directions, and this may have a significant impact on their aerodynamic performance. High-speed videogrammetry is used to capture the wing kinematics and wing deformation of a Painted Lady butterfly in forward flight and used to synthesize a high-fidelity computational fluid dynamics model. Besides this deforming wing model, four different rigid, flat-plate wing models, as well as a model which has twist but no camber were also constructed. The flow for all these models was computed using a high fidelity Navier-Stokes solver. Our results indicate that the wing model with realistic deformation outperforms all the rigid wing models in terms of lift production and power-loading (the ratio of lift to power) by at least 25% and 40%, respectively. The comparison with twist-only model suggests that wing twist is a key factor in determining the aerodynamic performance of a butterfly in forward flight. The aerodynamic basis of this observation is investigated by analyzing the computed flow features.

Keywords: flapping flight;insect flight;flexibility;deformation;butterflies;

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