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Inertial, Aerodynamic and Elastic scaling of a passively pitching insect wing[1] KIT SUM WU, JEROME NOWAK, KENNETH BREUER, Brown University — Evidence suggests that prominent features of insect wing pitching behavior are affected by inertial and aerodynamic forces with largely passive contributions from the wing hinge joint, which acts like a torsional spring. Motivated by the robotic applications of insect-inspired passive-pitching flapping wings, we study the scaling relationship between aerodynamics, inertia, and elasticity in the regulation of wing pitch and in the generation of lift forces in hovering flight. We measure forces and wing kinematics using an under-actuated robotic model with a prescribed wing stroke and an elastic wing hinge. Our data show that suitably defined dimensionless parameters accurately predict aerodynamic performance for wings of varying geometrical, physical, and operational parameters. We also observe a dependency of pitching kinematics on these dimensionless parameters, providing a connection between lift coefficient and pitch angle characteristics. Our results illustrate the trade-off between contributions to lift by quasi-steady and rotational dynamics associated with wing translation and wing rotation at stroke reversal. These results will be of value both in understanding the mechanics of insect flight as well as in the future design of under-actuated flapping aerial robots.

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