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Small, sleek, and in control: The body plan, sensory-neural control, and flight stability of insects LEIF RISTROPH, Cornell University, ATTILA BERGOU, Brown University, JOHN GUCKENHEIMER, Z. JANE WANG, ITAI COHEN, Cornell University — Flying insects have evolved sophisticated sensory-neural systems, and here we argue that the fast reaction times of these systems reflect the need to overcome an intrinsic flight instability. We formulate a theory that shows how the body plan and flapping-wing aerodynamics determine the instability growth rate, which in turn dictates the response time needed to suppress it. We experimentally validate this theory by manipulating the flight, sensors, and body plan of fruit flies. The theory is general enough to describe a broad class of flying insects and also furnishes stability criteria for flapping-wing robots. Plausible body plans for the first flyers are determined by conjecturing that these insects were intrinsically stable and only later evolved fast-acting controls for the added benefit of flight agility.

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