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How Do Fruit Flies Maintain Flight Stability?

Computational work by Cornell University researchers sheds new light on the role of motor neurons and steering muscles responsible for fruit flies' flight stability.

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WASHINGTON, D.C., November 23, 2015 -- Have you ever wondered why insects move in the funky ways they do? Or how physical laws shape the design of animals' sensors and neural computation for locomotion?

These are a just a few of the questions Cornell University researchers are exploring within this realm, and during the American Physical Society's 68th Annual Meeting of the Division of Fluid Dynamics, Nov. 22-24, 2015, in Boston, Mass., Z. Jane Wang, a Professor of Physics and of Mechanical and Aerospace Engineering, and one of her students, James Melfi Jr., will share their findings.

Tiny fruit flies use 17 "steering muscles" beyond their power muscles for flying, and Wang and her former student Song Chang recently zeroed in on the first "basilar" muscle, called "b1," as potentially being specifically responsible for maintaining the insects' flight stability. So they put it to the test with genetically modified fruit flies, whose b1 was altered.

Living organisms are governed both by the physical laws of movement, and by their own neural control circuitry. "Our idea is to infer parts of their neural feedback circuitry by understanding their influences over flight dynamics and control," explained Wang.

To this end, the researchers combined computational modeling of insect flight and direct experimental observations of flight dynamics. "The basic building blocks for computations involve fluid equations governing the interactions between flapping wings and unsteady air flow, as well as the equations governing the coupling between the motion of the body and the flapping wings," she added. "It also has a feedback scheme to make the model fly in a stable fashion."

One question they set out answer was: how often does a fly sense its orientation in order to maintain balance while in the air? As they reported in 2014 in the *Proceedings of the National Academy of Sciences*, they predicted using computational modeling that a fruit fly senses its body orientation every wing beat. "We further conjectured that one of the fly's steering muscles, 'b1,' is the key to its flight stability by interpreting our results within the context of neuro-anatomical and neuro-physiological studies of flies' steering muscles," Wang said.

This work is significant because the computational results are shedding new light on the role of motor neurons and steering muscles responsible for flight stability. "Various hypotheses can now be tested directly," she noted.

Few parts of a living system are amenable to descriptions and analyses based on first principles and, not surprisingly, studies of animal behavior are largely experimental.

In the case of insect flight, "by including the laws of motion, we start to build a theoretical framework in which to interpret the functions and designs of insects' internal machinery," Wang said. "These predictions can be tested experimentally by modifying specific neurons in animals, thanks to the advances in genetics."

Presentation #L27.1, "Initial observations of fruit flies' flight with its b1 motor neuron altered," is authored by Jane Wang and James Melfi Jr. It will be presented at 4:05 p.m. on Monday, Nov. 23, 2015 in Room 308 of the Hynes Convention Center in Boston. ABSTRACT: http://meetings.aps.org/Meeting/DFD15/Session/L27.1

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MEETING INFORMATION

The 68th Annual Division of Fluid Dynamics Meeting will be held at Hynes Convention Center in Boston from Nov. 22-24, 2015. More meeting information: https://apsdfd2015.mit.edu/

REGISTERING AS PRESS

Any journalist, full-time or freelance, may attend the conference free of charge. Please email: <jbardi@aip.org> and <dfdmedia@aps.org> and include "DFD Press Registration" in the subject line.

ON-SITE AND ONLINE PRESS ROOMS

Workspace will be provided on-site during the meeting. The week before the meeting, news, videos and graphics will be made available on the Virtual Press Room: http://www.aps.org/units/dfd/pressroom

LIVE MEDIA EVENT

A press briefing featuring a selection of newsworthy research talks will be streamed live from the conference at 1:00 p.m. ET on Monday, Nov. 23. For more information, email jbardi@aip.org.

ABOUT THE APS DIVISION OF FLUID DYNAMICS

The Division of Fluid Dynamics (DFD) of the American Physical Society (APS) exists for the advancement and diffusion of knowledge of the physics of fluids with special emphasis on the dynamical theories of the liquid, plastic and gaseous states of matter under all conditions of temperature and pressure. DFD Website: http://www.aps.org/units/dfd/index.cfm

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Image caption: Computational modeling of fruit flies in free flight. Credit: Jane Wang/Cornell University.