BIOINFORMATICS

Flight patterns

Flying animals ranging from bugs to bats use a common mechanism to maintain control in turns a discovery that reveals hidden advantages of flapping-wing flight.

Having gotten its fill of nectar, a hummingbird veers sharply to the left and flits away. In doing so, it has executed what is known as a yaw turn: a maneuver that has been closely observed in a broad array of flying animals, yet remains incompletely understood.

To ensure that an animal turning in flight ends up in the proper position, a mechanism for controlled deceleration is needed. It was thought that birds achieve this through active changes in flapping behavior to counter inertia from the initial turn. However, after reconsidering the evidence, Tyson Hedrick of the University of North Carolina at Chapel Hill and Xinyan Deng of the University of Delaware began to suspect differently.

They proposed a mechanism termed flapping countertorque, in which the combined effects of body rotation and wing flapping during a yaw turn contribute to passive deceleration. Based on findings from fruit fly and hummingbird flight data, Deng and Hedrick expanded their study to incorporate data from hawkmoths, cockatoos and even bats.

Flapping rate turned out to be the key factor, and after normalizing their turning velocity data against wingbeat frequency for any given animal model, the researchers found that both simulations and experimental findings consistently supported the flapping countertorque model. "The physical effect is very hard to escape," says Hedrick, "and it turns out that a wide variety of species make use of it." This mechanism should also enable steadily flapping animals to compensate for perturbations such as wind gusts with little additional effort—although it remains to be seen whether more active mechanisms come into play when a hummingbird frantically flees a hungry predator.

These findings offer insights into the dynamics of animal flight, but for Deng, a mechanical engineer, they also have implications for vehicular design. Fixed-wing aircraft are limited by a fundamental dichotomy between maneuverability and stability; one always comes at the cost of the other. "But we found that in flapping flight, stability and maneuverability both scale with wingbeat frequency," she says. She concludes that these principles could inform the design of bird-sized robotic flyers, suitable for tasks from remote observation to delivery of cargoes.

Michael Eisenstein

RESEARCH PAPERS

Hedrick, T.L. *et al.* Wingbeat time and the scaling of passive rotational damping in flapping flight. *Science* **324**, 252–255 (2009).