© 2019. Published by The Company of Biologists Ltd | Journal of Experimental Biology (2019) 222, jeb204214. doi:10.1242/jeb.204214

INSIDE JEB

Muscles brake and bend joints to shape wings

Pigeons (*Columba livia*). Photo credit: Jolan Thériault.

The courage of the earliest human flight pioneers is genuinely inspiring. Fortunately, many of these innovators emerged relatively unscathed from the wreckage of their unsuccessful attempts, with the least successful models – usually based on flapping – never leaving the ground. Yet birds rarely endure the undignified collisions experienced by the first human aviators. 'Birds are capable of diverse flight behaviours and manoeuvres', says Jolan Thériault from the University of British Columbia (UBC), Canada, explaining that most of our current understanding of the mechanisms that allow birds to remain aloft is based on studies of the pectoral muscles, which power flight. However, much of bird's agility depends on the subtle ways in which they adjust the shape of their wings as they weave and dart through the air. 'The contribution of the wing muscles has received relatively little attention', says Thériault, who decided, with colleagues Joseph Bahlman (California State University, Sacramento) and Doug Altshuler and Bob Shadwick, also from UBC, to investigate how the humerotriceps muscle, which sits behind the humerus and extends the wing elbow joint, functions when flapping pigeons fly.

Muscles can absorb energy to function as brakes, in addition to consuming energy when contracting to bend limbs, so the team decided to measure the amount of energy generated or absorbed by the humerotriceps muscle during different muscle activation cycles that occur at different stages of wing beats. As nerve signals trigger muscles to either consume energy and contract, or absorb energy when lengthening and behaving like brakes, Thériault was able to take advantage of measurements of muscle length changes in response to nerve signals in flying pigeons, which had been previously recorded by Angie Berg Robertson and Andy Biewener. She used these values to simulate how the muscle performs during flight activation cycles in the lab, measuring the forces produced as the muscle contracted and as they absorbed energy. Next, Thériault plotted the force and muscle length values for each activation cycle on graphs to calculate the power generated, or absorbed, to find out how the humerotriceps muscle was contributing to shaping the wing during each wing beat.

Comparing the muscle's performances, it was clear that it contributed to extending the wing, generating force to spread the wing wide. However, the team could see the muscle absorbing energy, like a brake, during other activation cycles, which they suggest could hold the joint steady as the pigeon folds the wing during the upstroke of the wingbeat. And when they analysed the shape of some of the graphs where they had plotted force against muscle length, it looked as if the muscle could also store energy while stabilising the joint, ready for later use, much like a spring. Thériault also realised that, more impressively, the muscle could switch between exerting force to extend the joint and functioning as a brake within a single activation cycle and she suggests, 'birds could adjust wing shape by changing activation and/or length-change patterns, effectively helping them produce different flight behaviours'.

So pigeons are capable of fine-tuning how they use the muscles that control wing shape during flight and the team is eager to find out how these animals put their muscle versatility into practice to control their legendary manoeuvrability.

10.1242/jeb.204214

Theriault, J. S., Bahlman, J. W., Shadwick, R. E and Altshuler, D. L. (2019). Work loop dynamics of the pigeon (*Columba livia*) humerotriceps demonstrate potentially diverse roles for active wing morphing. *J. Exp. Biol.* **222**, jeb195578. http://jeb.biologists.org/content/222/7/jeb195578.

Kathryn Knight
kathryn.knight@biologists.com

Inside JEB highlights the key developments in Journal of Experimental Biology. Written by science journalists, each short report gives the inside view of the science in JEB.