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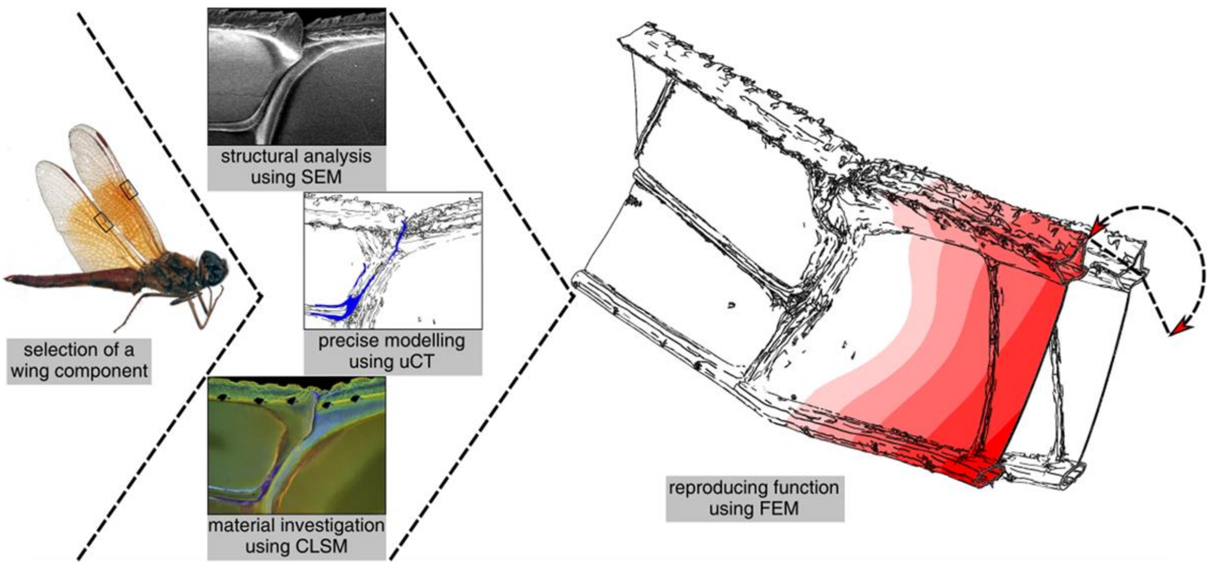
Researchers unlock the secrets of dragonfly wings

21 August 2017 | Cordelia Sealy

Since humans have attempted to fly, we have tried to mimic the flapping action of birds and insects. Scientists have continued to design bioinspired micro-air vehicles (MAVs) with flapping wings, but there is a gap between the proficiency of even the most novel flying machine and the simplest insect. That gap can only be addressed by a better understanding of exactly how insect wings work.

Researchers from Kiel University in Germany and the Islamic Azad University in Iran believe that their approach can unlock the design principles of the wings of one of nature's most remarkable aeronauts, the dragonfly [Rajabi *et al*., *Acta Biomaterialia* (2017), doi: 10.1016/j.actbio.2017.07.034].



From left to right: The dragonfly B. contaminata. The black rectangles on the wings show the parts of the wings investigated in this study, the nodus. (Top) SEM image of the nodus of the dragonfly. (Middle) Sketch of the nodus. (Bottom) CLSM image of the nodus. The blue color shows the resilin-dominated part.

“Dragonflies are known for their impressive flight performance,” says Hamed Rajabi of Kiel University. “They exhibit several flight styles and maneuvers of which many other insects are not capable.”

Although scientists have theorized about the origin of dragonflies’ superior flight capabilities, the role of each wing component in facilitating flight has remained elusive. Now Rajabi and coworkers are taking a new approach to untangling the structure-property-function of different wing components using a combination of wide-field fluorescence microscopy, confocal laser scanning microscopy, micro-computed tomography, scanning electron microscopy, numerical analysis and mechanical testing.

“Dragonfly wings are complex biological composite structures,” explains Rajabi. “At first glance, they appear to consist of two main structural components: an ultrathin membrane supported by reinforcing hollow veins. But, in more detail, they are a unique combination of further specialized components.”

These many specialized elements include the nodus, on which the researchers focused during this study. The team found that this hinge-like structure in the leading edge spar of the wing contains a rubber-like protein called resilin. The presence of the protein in the nodus allows the wing to deform without breaking during flight. The nodus also has a one-way locking mechanism to prevent too much deformation and protect the wing against failure in the event of mid-air collisions.

“The hinge-like structure containing a rubber-like material with high energy storage capacity facilitates wing camber formation, leading to better lift generation and playing a role as an energy absorber during collisions,” explains Rajabi.

The researchers believe that their on-going studies, which will explore other dragonfly species with different flight characteristics, will shed new light on how even very small micrometer-sized wing components affect the overall functionality of dragonfly wings.
Ultimately, understanding how the nodus contributes to the operation of a dragonfly’s wings could help improve the design of artificial wings for MAVs.