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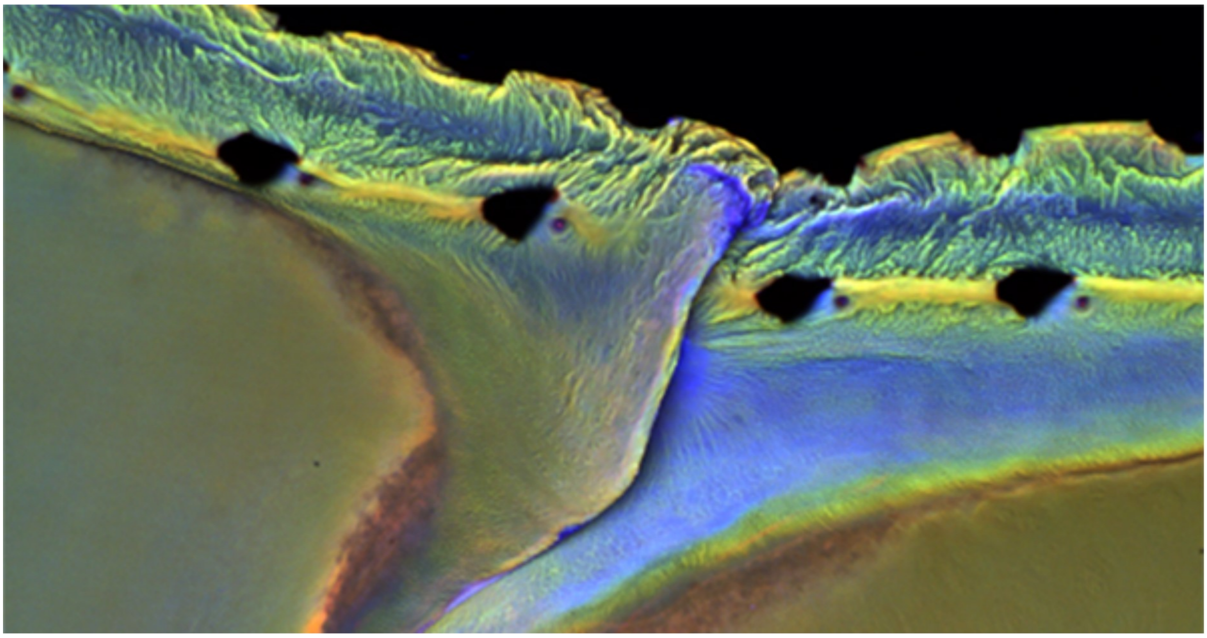
# Dragonfly wings with shock absorbers



Dragonflies are well known for their impressive flying skills. They manage manoeuvres that other insects are not capable of. The wings of these insects can be moved separately and deformed, enabling quick changes of flight direction. The wing deformability has now been investigated in more detail. A team led by Hamed Rajabi and Professor Stanislav Gorb, from the Zoological Institute at Kiel University (CAU) has now taken a closer look at the characteristics of the individual wing components. These studies on the Asian species, Brachythemis contaminata, have recently been published in the international scientific journal Acta Biomaterialia. The researchers investigated a “shock absorber” on the leading edge of the dragonfly wings, using four different imaging techniques. The findings from the Bachelor thesis of biology student Karen Stamm were also included in the publication.

The ultrathin and lightweight wings of the dragonfly are tougher than they first seem. The reason for this is the several structural elements that they are composed of. The fore- and hindwings are reinforced by a network of veins, with membranes between them. In the middle of the leading edge, there is a hinge-like structure. This wing component, also known as knot or ‘nodus’, can give way under pressure. But: “In the literature, it is widely accepted that the nodus provides reinforcement and acts as a shock absorber, but nobody can explain why or how exactly it works,” says Karen Stamm. The 21-year-old wanted to fill this gap in her Bachelor thesis with help from her supervisors, Hamed Rajabi and Esther Appel.

In this study, the team was able to, on the one hand, prove that resilin - an elastomeric protein - cushions the nodus. Because resilin is flexible, it reduces the risk of the wing being damaged in a collision. On the other hand, the 3D structure of the nodus ensures that the wing is only able to deform up to a certain limit. A 3D computer model demonstrated the locking mechanism preventing the wing from bending in the wrong direction - similar to the human elbow. This arrangement protects the insects in the event of a collision, but also against aerodynamic forces during the downstroke. Rajabi emphasises how these findings make an important contribution towards better understanding the structure-function relationship of the nodus in dragonfly wings: “At first glance, the structure appears very simple. We only see how complex it is when we utilize a combination of microscopy techniques to look at it much closer.”

For her investigations, Stamm used wide-field fluorescence microscopy (WFM) to prove where the soft resilin-dominated cuticle in the nodus is exactly located. Confocal laser scanning microscopy (CLSM) provided Stamm with very detailed images, giving the team additional information about the material composition. Scanning electron microscopy (SEM) and micro-computed tomography (micro-CT) then revealed the complex geometry of the nodus.

“In this area of research, it is rather unique to combine four types of microscopy techniques and allow Bachelor students to work with the most state-of-the-art equipment,” explains Rajabi. But precisely this is what is particularly important to the head of the research group, Stanislav N. Gorb, Professor of Functional Morphology and Biomechanics at Kiel University: “We involve our students in the scientific process from a very early stage of their career and make research part of their education.” The bachelor students are accordingly motivated and enthusiastic. It is Stamm’s first publication. “I am pleased to have contributed something to the scientific world and to have received insight into the research process.” Stamm will continue to dedicate her work to dragonflies in her Master project at Kiel University. She is already preparing her second publication on nodi from four different species of dragonflies.

Original publication:
H. Rajabi, N. Ghoroubi, K. Stamm, E. Appel, S.N. Gorb, “Dragonfly wing nodus: A one-way hinge contributing to the asymmetric wing deformation”. Acta Biomater. (2017) https://doi.org/10.1016/j.actbio.2017.07.034

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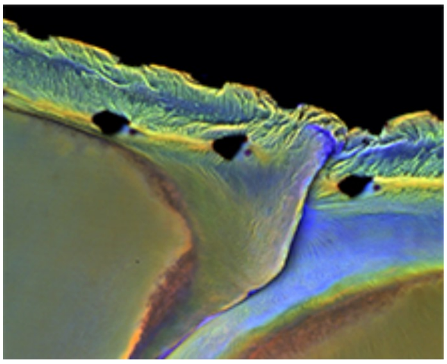

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The blue areas on the CLSM images indicate structures with a high resilin content in the nodus of the dragonfly wing. Green indicates chitin and red is for sclerotized cuticle. Scale: 200 micrometres
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In the middle of the leading edge of the fore- and hindwing, there is a break. This is known as 'nodus'. The species of dragonfly Brachythemis contaminata can be seen here.
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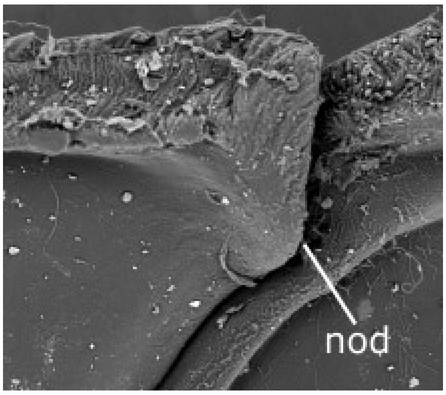


Under a scanning electron microscope, the interlocking mechanism which prevents large wing displacements can be seen. Scale: 200 micrometres.
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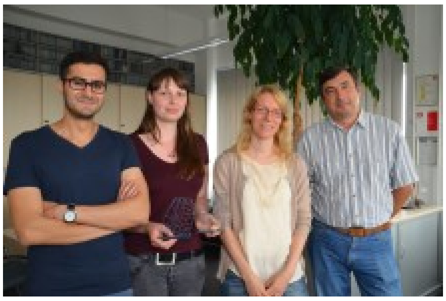

Hamed Rajabi, Karen Stamm, Esther Appel and Stanislav N. Gorb investigated the "nodus" in dragonfly wings and in doing so, also produced 3D printed models of dragonfly wings.
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