Bending Without Breaking – How Insects Feel Around Their Environment

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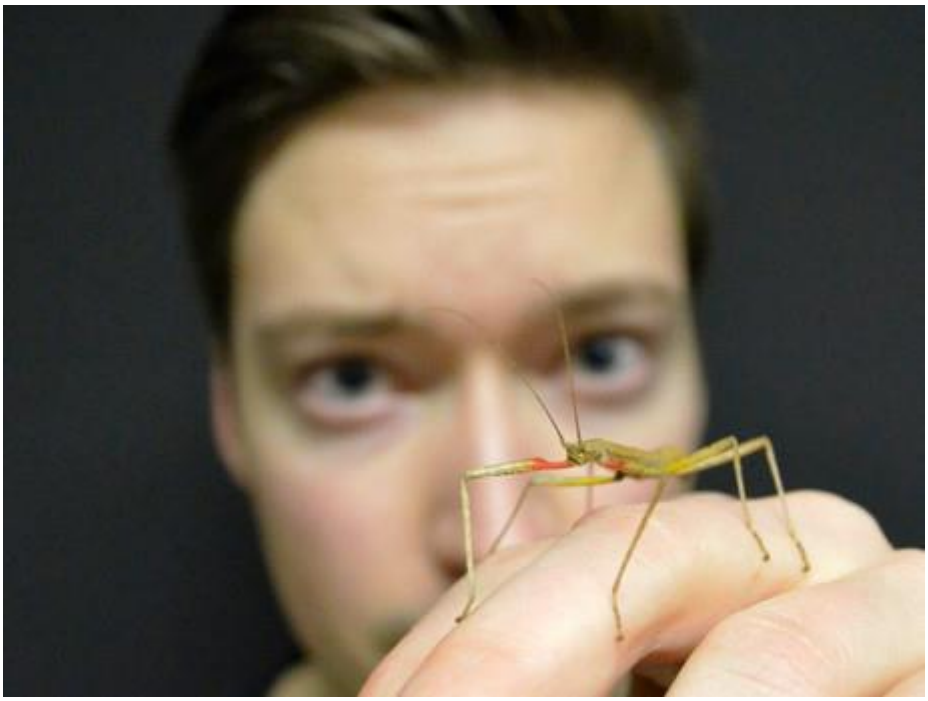
Researchers publish findings on insect antenna flexibility and structure

For hundreds of millions of years, insects have used specialized antennae to explore their surroundings. For this tactile exploration, the antennae have to stiff enough to allow for active, controlled movement, while at the same time compliant enough to prevent damage when coming into contact with objects. How do insects solve this problem? And can the solution be used for biologically inspired robots? In an interdisciplinary project, researchers from Kiel University, Bielefeld University, and the Hochschule Bremen City University of Applied Sciences are working together to get to the bottom of this question.



The stick insect explores its surroundings with its antennae. Photo: CITEC/Bielefeld University

Using precise measurements of the deformation of stick insect antennae as well as computer simulations, the team was able to show for the first time that the special biomechanical properties of antennae are a result of both the structure and the material that make up the

antennae.

“The insect antennae we studied consist of, in simple terms, a soft core surrounded by a stiff sheath,” says Prof. Dr. Dirks, of the Biomimetics-Innovation-Centre at the Hochschule Bremen City University of Applied Sciences. “While the stiff sheath largely determines the rigidity of the antenna, the soft core helps to avoid vibrations. In addition, the many indentations along the antenna and the conical shape of the individual segments ensure sufficient mobility of the structure.”

What set this research apart was the close interdisciplinary cooperation among the participating groups. “The use of computer simulations enabled us, for the first time, to perform even ‘impossible’ biological experiments in a virtual environment,” says Dr. Hamed Rajabi, of Kiel University. “We were thus able to influence specific features of the virtual antennae such as shape and material composition, which allowed us to investigate the effect of these factors on antenna flexibility.”

The findings from this work help, on the one hand, to answer fundamental questions regarding the function of insect antennae, which have very successful in evolutionary terms. The results could also be used in the future to build better biologically inspired tactile systems for robots. These projects are being conducted at Bielefeld University’s Cluster of Excellence Cognitive Interaction Technology (CITEC) in Prof. Volker Dürr’s research group.

Further studies will now investigate how insects are able to precisely localize contact with objects, and whether the principles uncovered here also apply to other antenna shapes and insect species.

Original Publication:

Hamed Rajabi, A. Shafiei, Abolfazl Darvizeh, Stanislav Gorb, Volker Dürr, & Jan-Henning Dirks: Both stiff and compliant: morphological and biomechanical adaptations of stick insect antennae for tactile exploration. Journal of the Royal Society Interface, 15(144), 20180246. doi:10.1098/rsif.2018.0246, published on 25 July 2018.

Prof. Dr. Volker Dürr heads the Biological Cybernetics research group at CITEC. Photo: CITEC/Bielefeld University**More information is available online at:**

Video “How to be both flexible and stiff? A lesson from insect antenna”: www.youtube.com/watch?v=OVma3rfEpRc

Another video can be viewed at: www.hs-bremen.de/internet/einrichtungen/presse/mitteilungen/2018/detail/2018-176pe.mp4

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