PROJECT TITLE: Adaptations of plant leaves for avoiding, dissipating or exploiting impact energy

HOST ORGANISATION: University of Bristol

Project start and duration: 1 October 2018, 4 years

Main supervisor: Dr Ulrike Bauer, School of Biological Sciences
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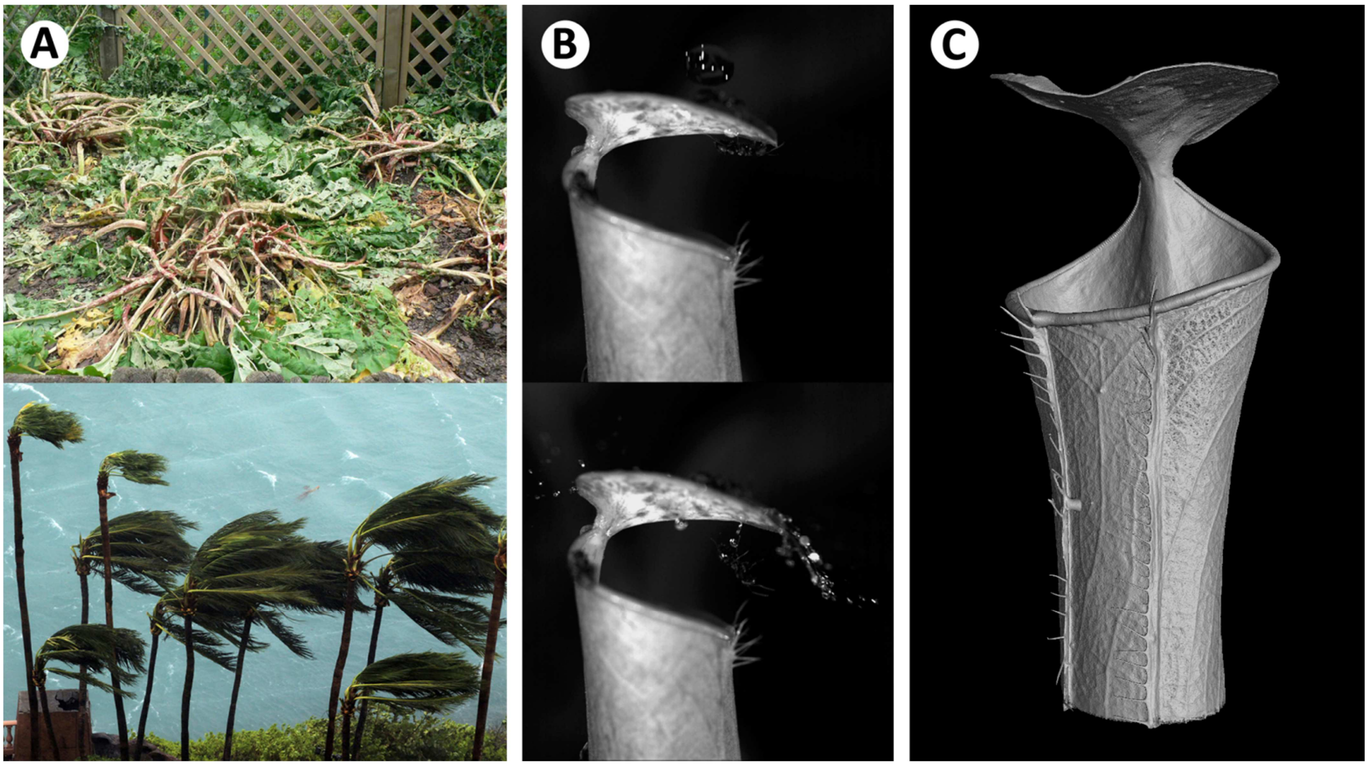

FIGURE: (A) Impacts from rain, hail and wind gusts can cause severe damage to plants and entail significant economic losses. **(B)** A carnivorous pitcher plant exploits the impact energy of rain drops to dislodge and trap insects. **(C)** 3D reconstruction of the upper section of a pitcher trap from micro-CT scanning images.

PROJECT BACKGROUND

One effect of climate change is an increased frequency of extreme weather events. Hail, wind and heavy rain can cause considerable damage to plants, with devastating effects on agriculture, horticulture and forestry. However, not all plants (and growth stages) are affected equally[1-2]. This project investigates physiological, structural and biomechanical adaptations of leaves and petioles that enhance their ability to withstand high wind forces and rain or hail impacts. In addition, it examines the structural adaptations that enable a carnivorous pitcher plant to exploit the impacts of rain drops for the capture of insect prey[3-4]. Understanding these adaptations will not only help to inform crop breeders of traits to select for in order to produce more resilient crop plants, but also provide inspiration for architects and engineers aiming to construct buildings that are better equipped to withstand earthquakes or increasingly frequent 'superstorms'.

PROJECT AIMS AND METHODS

This project investigates the adaptations that allow plants to (1) avoid impacts, (2) dissipate impact energy or (3) utilize impacts to dislodge insects from their leaves, and (4) aims to identify generally valid key determinants of impact resistance. Physiological responses such as the touch-triggered leaf folding in *Mimosa* *pudica* ("Touch-Me-Not") plants may provide a means to reduce the exposed area and avoid impacts. Adaptations of the leaf material properties and geometry may function to dissipate impact energy or result in spring-like properties that enable the plant to utilise the impact energy to dislodge insects or contaminating particles. Studying these adaptations in a broad range of plants will help to identify key factors for impact resistance. Within this framework, the project offers opportunities to pursue various alternative research avenues with a more ecological or more technological focus, respectively.

Part of the project will make use of an established model system for the study of plant biomechanics: carnivorous *Nepenthes* pitcher plants. These plants capture prey in cup-shaped leaves (pitchers), each covered by a roof-like lid and attached to the leaf blade via a coiled tendril. We will investigate the role of the tendril for impact dissipation and damage prevention during heavy rain or wind. We will also study the structural adaptations of the trap that allow some species to use the lid as a rain-driven springboard to dislodge and capture prey. Similar adaptations may help other plants to shake off herbivorous insects or photosynthesis-reducing dirt particles. Understanding the properties underpinning the 'lid spring' or the remarkable impact resistance of some leaves may inspire novel approaches to energy harvesting from natural impact forces, or engineering solutions for improving the impact resistance of man-made buildings.

The project combines experimental methods (manipulations of plant material properties, simulating rain, hail or wind impacts, quantification of damage levels, high-speed video analysis and laser Doppler vibrometry) with state-of-the-art imaging techniques (micro- and nano-CT, SEM and TEM) and methods from engineering and materials science (FEA modelling, material testing procedures).

CANDIDATE

The ideal candidate will have a solid background in mechanical engineering, materials science or physics and a keen interest in the unique solutions that the living world has found for the challenges presented by extreme weather events. A biology student with a solid knowledge of maths and physics and an interest in biomechanics and biomaterials would also be well suited. In either case, excellent marks, high levels of motivation, and willingness to learn and apply a variety of biological and engineering techniques are essential. Experience with FEA modelling and a good understanding of statistical procedures would also be desirable. Please note that the studentship will only cover fees at the EU/UK level, and overseas students would have to provide evidence of additional funding to cover the difference in fees.

TRAINING AND SUPPORT

The student will receive comprehensive training and support from the interdisciplinary supervisory team. This will include training in the relevant methods, imaging technologies and modelling as well as support with experimental design, data analysis, data presentation and paper writing. The project-specific training provided by the academic supervisors will be complemented by the excellent training and support offered by the School of Biological Sciences and the University of Bristol to all PhD students. These include the provision of postgraduate mentors, regular review meetings with two internal scientific advisers, and specifically tailored postgraduate training lectures on topics from experimental design through statistical analysis to lab safety. In addition, the student has access to an extensive programme of personal and professional skills development courses through the Doctoral College and the University Career Service.

References

[1] Sanchéz *et al.* 1996. *J Appl Meteor* **35**: 1535-41.
[2] Cleugh *et al.* 1998. *Agrofor Syst* **41**: 85-112.
[3] Bauer *et al.* 2012. *PLoS ONE* **7**: e38951.
[4] Bauer *et al.* 2015. *PNAS* **112**: 13384-13389.

Links

How to apply: http://www.bristol.ac.uk/study/postgraduate/apply/

School webpage: http://www.bristol.ac.uk/biology/courses/postgraduate/

Ulrike Bauer webpage: http://www.bristol.ac.uk/biology/people/ulrike-bauer/index.html

APPLICATION DEADLINE: 23:59 GMT, Friday 26 January 2018