



Queensland University of Technology
Brisbane Australia

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(2013)

Plant structure and systematics research at the Queensland University of Technology (QUT), Brisbane.

Australasian Systematic Botany Society Newsletter, 155, pp. 17-24.

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Article for ASBS newsletter

Plant structure and systematics research at the Queensland University of Technology (QUT), Brisbane.

(submitted by Tanya Scharaschkin 25th June 2013)

This article provides a general overview of some of the plant research being conducted by a number of researchers at the Queensland University of Technology (QUT) Brisbane. Details about student projects and research facilities have been limited to those of relevance to plant structure and systematics. Academics, technicians and research students involved in plant research are in the Faculty of Science and Engineering, mainly in the School of Earth, Environment and Biological Sciences (EEBS), with a few exceptions. Our offices and laboratories are housed in a number of different buildings at the Gardens Point campus (e.g., P, Q, R, S, M Blocks) and we have strong collaborative links with Queensland Herbarium (BRI) and Mt Coot-tha Botanic Gardens.

Research and Teaching Facilities

In the past couple of years we have seen some major refurbishments to existing labs and the construction of the new Science and Engineering Centre. The Science and Engineering Centre, which was officially opened earlier this year, has achieved a 5-star Design Education V1 Certified rating from the Green Building Council of Australia and is a building worth visiting just for the sake of looking around and playing with the very large interactive computer displays. In mid-June we hosted the AGM of the Royal Society of Queensland, and one of the highlights was a tour of the new building with its innovate teaching and research space. A number of large labs, equipped with about \$17 million in new equipment, have been grouped together as the Central Analytic Research Facility (CARF). Of particular relevance to plant systematics and structure research are two CARF laboratories (Molecular Genetics and Analytical Microscopy) and two EEBS laboratories (Ecology and Plant Sciences). The combined central and school-level laboratories have greatly increased our research capacity. It is going to take a while for some of us to discover the potential these resources provide for developing new or different approaches to addressing our research questions. A summary of the major resources is provided below, but please refer to the CARF website for more information.

At the CARF Molecular Genetics laboratory (R block, Level 4) we have everything we need for DNA extraction, PCR and sequencing, including Life Technologies 3500 Genetic Analyser, QIAGEN QIAxtractor, QIAGEN Rotor-Gene Q, Life Technologies Ion Personal Genome Machine (PGM) Sequencer, Life Technologies Ion Proton Sequencer (**Figure 1**).

The CARF Analytical Microscopy laboratory (P block, Level 6) has microtomes and microscopes along with the necessary tissue preparation, processing and sectioning equipment. The microtomes include Leica EM UC6 Ultramicrotome, Leica EM UC7 Ultramicrotome, Leica RM2245 Rotary microtome. Scanning Electron Microscopes (SEMS) are JEOL JSA 6360A, Zeiss Sigma VP Field Emission, JEOL 7001F, Hitachi Analytical TableTop Microscope TM3000, FEI 3D FIB, FEI Quanta. Transmission Electron Microscopes (TEM) are JEOL 2100 LaB6, JEOL 1400 LaB6). For those of

us examining morphological characters for systematics studies, we have lots of options for image capture and analytical software in the light microscopy area associated with the following instruments: Leica M125 Zoom Stereo Microscope; Leica MeF3 Inverted Metallographic Microscope, Zeiss Axio Imager M2m, Nikon A1R Confocal Microscope, Nikon Eclipse Ti Inverted Microscope. We are still working out the ideal set up and arrangement for some of this equipment (**Figure 2**).

The EEBS Plant Sciences laboratory (M block, Level 5) is where most of the plant structure research is conducted. Part of the lab is set up for freehand sectioning, staining, chromosome squash and resin embedding. We use the rotary microtome at CARF to cut thin sections, and bring slides with resin or paraffin-embedded samples to the Plant Sciences lab for staining. This lab has two Nikon microscopes (Nikon SMZ 800 Stereo, Nikon eclipse 50i compound) with the full NIS Elemental digital image analysis. The stereoscope has a drawing tube attachment that can be used for illustration.

The EEBS Ecology laboratory (R block, Level 1) includes ample bench space for sorting out bulky and messy samples and room for storing our field gear. We also have ~10 large growth cabinets that are used for a variety of experiments (e.g., seed germination, plant drought stress), an insectary and a temperature and humidity controlled walk in room that houses our local QUT herbarium. Additional microscopes, scanners for biological samples (seeds, leaves) and photography resources (such as time lapse video) are available in this lab.

Plant diversity garden (R block courtyard): Since 2008 we have been building up a living collection of plants that are required for practicals. Whilst this may not sound interesting enough to even warrant a mention, what we have accomplished in an urban, space-limited campus, is to establish a wide variety, both taxonomically and ecologically, of plants that we use for plant diversity units. Some of the trees are now big enough for students to use keys to develop skills in plant identification. A rainwater tank and automated irrigation system keeps the pots watered. The first couple of years of starting this garden saw the pots being used as cigarette and trash receptacles (amongst other less desirable usages) but we hardly see any rubbish in the pots anymore (**Figure 3**).

Plant researchers and research themes

Prof. Sagadevan Mundree and other researchers based at the Centre for Tropical Crops and Biocommodities (CTCB) are using innovative biotechnology solutions to improve our understanding of the way plants adapt to extreme environments. Every year, drought and salinity stress has a severe impact on agriculture across the world, resulting in significant yield and economic losses. Using a native Australian resurrection plant as a model system and Next Generation Sequencing technologies, in parallel with physiological analyses, Sagadevan Mundree and his team of researchers (Dr Brett Williams, Dr Sudipta Das Bhowmik, Mr Hao Long, Mr Alam Cheng, Ms My linh Hoang, Mr Isaac Njaci and Mr Peraj Karbachi) are dissecting the molecular pathways and physiological mechanisms used by extremophiles for adaptation to extreme environments. Advancing our knowledge of plant adaptive mechanisms is essential for the continued security of agriculture and will pave the way for the development of crops that are more resilient to environmental stresses.

Dr Jennifer Firm is a theoretical and applied ecologist who specializes in linking ecological theory to practical management. Jennifer's research focuses on identifying the mechanisms that facilitate opportunities for invasive plant species. She investigates both bottom-up (soil nutrients) and top-down (herbivory) controls on plant species diversity in grassland communities (Firm 2007, 2009; Han *et al.* 2012). She is involved in quantifying the complex role between biodiversity and ecosystem function, and the population level significance of plant phenotypic plasticity in response to disturbance (Firm *et al.* 2012).

Dr Peter Prentis uses a combination of high throughput genomics, bioinformatics and ecological experiments to examine the relative influence of the landscape and environmental conditions on gene flow and local adaptation in plant species. Pete's research has led to the development of new theory for understanding the evolution of plant invasiveness. He has led efforts to test theory about the adaptation of invasive plants to novel habitats. Research questions that Pete is currently investigating include the genomics of speciation in island plants, the role of artificial selection on genome architecture and gene expression variation, and whether similar or different genes are involved in adaptation to novel environments.

Tanya Scharaschkin's plant systematics group has been growing steadily (see student projects below) since she first joined ASBS. Tanya is leading the establishment and development of research capacity to investigate plant structure (anatomy and morphology) at QUT. Along with plant systematics, Tanya is interested in investigating the potential link between ecophysiological performance and resource utilisation with plant structure. Some of this research is being conducted on weeds, in collaboration with Dr S. Osunkoya and Dr. K. Dhileepan (Biosecurity Queensland-DAFF), and has involved a number of honours students (Richard Boyne and Karina Pyle), and a current Masters student (Joshua Buru). Tanya is collaborating with Dr Hervé Sauquet and others on the eFLOWER project (<http://eflower.myspecies.info/>) involved in answering key questions on the evolution of flowers. Tanya continues to be involved with Annonaceae, mainly in projects involving pollination biology (Pang *et al.* 2013), in collaboration with Prof Richard Saunders (Univ. of Hong Kong). Non-plant systematics research has involved collaborations with Dr Andrew Geering and Dr Roger Shivas (Plant Pathology-DAFF), joint supervision of a PhD student (Alistair McTaggart) and publications on smuts and viruses (Geering *et al.* 2010; McTaggart *et al.* 2012a; McTaggart *et al.* 2012c, 2012b).

Research students: past and present

Karma Wangchuck (supervised by Dr. Tanya Scharaschkin, Dr. Matthew Gray and Dr David G. Long at the Royal Botanic Garden, Edinburgh) is working on the phylogeny of the Sino-Himalayan Pterobryaceae Kindb. (Bryophyta: Hypnales, Bryopsida) using morphological and molecular data. Pterobryaceae is a family of pleurocarpous mosses distributed throughout tropical and warm temperate regions of the world. The placement and number of genera within the family in Sino-Himalayan region is not clear. The systematic treatment of Sino-Himalayan Pterobryaceae is aimed to 1) develop well-resolved phylogeny using both molecular and morphological data, 2) address phylogenetic issues, such as distinctness and monophyly of *Calypothecium* and *Pterobryopsis* and 3) undertake detailed taxonomic revision of Sino-Himalayan Pterobryaceae. Karma will be presenting some

of his results at the International Association of Bryologists (IAB) Congress in London in July 2013. Karma holds Royal Government of Bhutan scholarship and QUT fee waiver scholarship for 4 years (June 2010-April 2014). After completion, he plans on returning to Sherubtse College to continue teaching and working on Bhutanese bryophytes (**Figure 4**).

Melodina “Melody” Fabillo (supervised by Tanya Scharaschkin, Dr Peter Prentis and Mr John Thompson-BRI) commenced her PhD in March 2011. She is working on the systematics of *Tripogon* (Poaceae: Chloridoideae). *Tripogon* is a genus of grasses with ca. 40 species distributed in Africa, America, Asia and Australia. The sole, but widespread Australian species, *Tripogon loliiformis*, is a morphologically variable resurrection plant, and it has been suggested that it could be more than one species. Melody is using DNA sequence data and morphological data (through stereomicroscopy, light microscopy and scanning electron microscopy) to obtain a robust, well-supported phylogeny of the genus, including multiple accessions of *Tripogon loliiformis* from across Australia, along with representatives of the genus occurring on other continents. She aims to determine the monophyly of the genus *Tripogon*, the relationships of the different species to each other and the monophyly and placement of the Australian *Tripogon*. Her study will try to identify unambiguous synapomorphies that could be of value for subsequent taxonomic revisions. She presented preliminary results at the 2012 ASBS Conference in Perth and will be presenting more recent results at the Monocot Conference (New York) and Botany Conference (New Orleans) in July 2013. Melody holds a tuition fee waiver scholarship from QUT and is employed as a sessional academic at the same university. She was a recipient of the 2012 and 2013 ABRIS Student Bursary. She is on leave as a lecturer in animal developmental biology at the University of the Philippines (**Figure 5**).

Hernán Retamales (supervised by Tanya Scharaschkin, Dr Steven Cameron and Dr Rosa Scherson at the Univ. of Chile) is working on the anatomy, character evolution and phylogenetic position of the Chilean Myrtaceae. Myrteae is the largest of the 17 recognised tribes in Myrtaceae (c. 2500 species) and it is mainly distributed in rainforest areas of South America and Australasia. The Chilean Myrtaceae are in the tribe Myrteae. Chile is rich in genera but has few representatives per genus, most of which are endemic. This distribution pattern has been attributed to the geographic and historic isolation of the country since the Pliocene uplift of the Andes and the formation of the arid diagonal zone during the Miocene. Hernán’s research will make extensive use of anatomy, morphology and micromorphology, in combination with molecular data. Hernán have been awarded a Chilean scholarship to undertake his PhD in Australia (**Figure 6**).

Joshua Buru (supervised by Tanya Scharaschkin, Dr Peter Prentis, and Dr S. Osunkoya and Dr K. Dhilepan at Biosecurity Queensland-DAFF) is studying the biology of cat’s claw creeper, *Dolichandra* (syn. *Macfadyena*) *unguis-cati*. There are two distinct forms of cat’s claw creeper in eastern Australia and Joshua will attempt to determine if the variations are significant enough to warrant different biological control strategies, as indicated by a pilot study (Boyne *et al.* in review). He will study the morphology, anatomy, germination rates and growth response of these two forms to different levels of water and light. Joshua is currently enrolled in a research Masters but hopes to articulate to PhD and plans to extend his project to include host-

specificity tests and molecular assessment of genotypic diversity of both forms of the weed. Joshua was nominated by the Government of Botswana for a scholarship to study at QUT, which he commenced in January 2013. Prior to starting his PhD at QUT, Joshua worked as an aquatic weed biologist in the Aquatic Vegetation Control Unit (AVCU in Maun, a town in the north-western part of Botswana, that is a gateway into the Okavango Delta. At least he won't have to keep an eye out for crocodiles or hippos while working on cat's claw creeper (**Figure 7**).

John Thompson (supervised by Tanya Scharaschkin, Dr. Matthew Gray, Dr Gordon Guymer-BRI and Mr Byran Simon-BRI) began a PhD in January 2013 on a systematic study of the Australian cleistogamous panicoid grasses. John retired in 2012 after 21 years as a botanist at the Queensland Herbarium (BRI) where his main duties were survey and mapping of Queensland and curator of Poaceae, Boraginaceae and **Polygaceae**. He maintains connection with BRI as an honorary associate. John's PhD research focuses on species in three genera (*Calypochloa*, *Cleistochloa* and *Dimorphochloa*) all of which have a unique reproductive system (Thompson and Simon 2012). These plants have two types of inflorescences with different pollination strategy in any given individual: terminal inflorescence with chasmogamous spikelets and axillary inflorescence with cleistogamous spikelets. In grass taxonomy, terminal inflorescences and spikelets are used extensively to provide most of the morphological data, while axillary inflorescences have been used sparingly. The morphology of the axillary cleistogamous spikelets varies across the genera and could provide useful distinguishing characters. Phenetic analysis of morphological data together with phylogenetic analysis of morphological and molecular data will be used to delimit new taxa and determine evolutionary relationships of the group (**Figure 8**).

Cristina Latorre is a volunteer in the plant systematics group under the supervision of Tanya Scharaschkin. She graduated as a forester from the University of Chile. She has been involved in an investigation of the reproductive biology of *Alstroemeria pallida* Graham (supervised by Dr Paulette Naulin, University of Chile). Her undergraduate thesis was on the floristic evaluation for conservation purposes in the Santuario de la Naturaleza (Nature Sanctuary) Cerro El Roble, Región Metropolitana, Chile (supervised Dr Gustavo Cruz, Univ. of Chile). She also has IT skills regarding GIS and cartographic management. Cristina is currently assisting with projects on the Australian resurrection grass, *Tripogon loliiformis*, and has been helping Tanya update the database on the publications of the Proceedings of the Royal Society of Queensland (**Figure 9**).

Richard Boyne (supervised by Tanya Scharaschkin, and Dr. O. Osunkoya at Biosecurity Queensland-DAFF) completed his honours project in June 2011. His honours thesis was on the "Comparative leaf anatomy of invasive and non-invasive climbers under different light levels: implications for ecophysiological performance and phenotypic plasticity", one small aspect of which has recently been accepted for publication (Boyne *et al.* in press) and it is hoped more papers will follow. After completing his honours, Richard undertook an internship at the Australian National herbarium, Canberra and worked as an experimentalist at the Centre for Wet Tropics Agriculture, South Johnstone, Queensland. Richard is currently in the United Kingdom visiting plant researchers from the Natural History Museum, the Royal

Botanic Gardens at Kew and Edinburgh, and the CABI labs in Surrey. He has been working as a volunteer at the herbaria at Kew and Edinburgh, and has recently been offered a position at Kew to digitise herbarium specimens (**Figure 10**).

Karina Pyle (supervised by Tanya Scharaschkin, and Dr. K. Dhileepan at Biosecurity Queensland-DAFF) completed her honours in 2008 and recently joined the technical team at EEBS. Karina's project focussed on simulated herbivory trials on bellyache bush (*Jatropha gossypifolia*). Prior to honours, she completed a summer research internship investigating the subterranean tuber abundance of cat's claw creeper (*Dolichandra* (syn. *Macfadyena*) *unguis-cati*) which indicated the need for seed-feeding biocontrol agents along with other approaches (Osunkoya *et al.* 2009). Karina plans on undertaking a PhD in the near future.

Other activities of the Scharaschkin research group: Our research activities have been discussed above, but we are interested in lots of other things as well. Most of us are planning on attending ASBS 2013 in Sydney, so you'll be able to ask us more about some of these academic and non-academic activities. A number of us are avid gardeners (Karma, John, Tanya), many of us like hiking (Hernán, Christi, Tanya), at least one is a good chess player (Joshua), another a taekwondo expert (Hernán) and an experienced jewellery maker (Melody). Some of our non-academic activities led to the formation of a group called "Crafty Scientists" so that we can learn from each other's artistic skills. Melody has shared her passion for jewellery making and Tanya her interest in crocheting and hopes to start a botanical art group. Melody also runs workshops at The Edge (State Library of Queensland) some of which have involved using plant anatomy to provide the inspiration for fabric design (**Figure 11**). A number of us also participate monthly walks with Naturalists Anonymous, a group organized by Tanya and now in its 5th year, with the aim to learn about the natural history of places near Brisbane (**Figure 12**). We are all participating in the 2013 Global Corporate Challenge and have formed a team called "Botanical Buddies", although as one of the figures clearly shows, we probably won't be in the top 20 teams at QUT! (**Figure 13**).

Acknowledgements

This article has been a team effort with individual contributions from researchers and students along with input from technicians regarding equipment and resources (a special thanks goes to Mark Crase and Rachel Hancock). As compiler of the content and instigator of this article, I take responsibility for any mistakes. Complaints can come to me; compliments should go directly to the relevant person.

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