fostering research into
the biology and cultivation
of the Australian flora

Newsletter

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No. 18 New Series

Let the planting begin!

By Professor Corey J. A. Bradshaw, The Environment Institute and School of Earth and Environmental Sciences, The University of Adelaide

A tough little *Eucalyptus porosus* – one day soon this entire ex-paddock will be filled with carbon-guzzling natives. Note the plot markers in the background.

I had a great morning today checking out the progress of our carbon-biodiversity planting experiment out at Monarto Zoo. What a fantastic effort! Briony Horner and her team have made some amazing progress.

If you haven't read about what we're up to, here's a brief re-cap:

Late last year we were awarded an Australian Research Council (ARC) Linkage Project grant in which we proposed to examine experimentally the cost-benefit trade-off between biodiversity and carbon using a replicated planting regime. The approach is quite simple, but it will take many years to pay off. What we are asking is: how many different species and in what densities are required to restore a native woodland from an over-grazed paddock that provide the biggest long-term biodiversity *and* carbon benefits simultaneously for the lowest costs?

Our basic approach is to apply a few biodiversity (native monoculture, medium diversity, high diversity) and planting density treatments (low and high spacing) to plots within blocks repeated across a landscape. We want to test whether the time-consuming and expensive high-density, high-diversity plots end up sequestering more carbon and housing more species once the forest has matured than the other treatments. However, if we can get away with (i.e., end up with the similar carbon sequestration and biodiversity) lower tree densities when planting, and fewer species planted, then our costs will go down.

Briony invited me out this morning to see the progress, and I was blown away! To date we have slashed the grass & weeds, set up and marked out the 80 25 × 25 m experimental plots in 10 blocks, begun digging the reptile pitfall traps, plotted out the bee & invertebrate trapping grids, and taken initial soil cores for carbon analysis. A few photos are included here to demonstrate.

The soil-core drilling rig

Freshly dug soil cores for carbon analysis

Digging the pitfall traps

Next week, co-investigator Margie Mayfield is coming down from UQ to help with the baseline biodiversity monitoring. In May, the entire site will be burnt and treated with herbicide to kill the weeds, and then planting begins in June! I can't wait to see all the plants in the ground.

Briony and her babies ready for planting

What was merely an idea only 6 months ago is turning into a fully fledged, 20-ha experiment thanks to Briony and her amazing project management.

Many thanks as well to the ARC, Zoos South Australia, David Chittleborough and his soil team, the South Australia Department of Environment, Water and Natural Resources (DEWNR) and the Australian Flora Foundation for co-investment.

CJA Bradshaw 3rd April 2013

Seeds without sex – some racy findings on the cloning of plants

Reproduced from http://theconversation.edu.au/

By John Bowman, Professor of Genetics at Monash University


New research suggests that seeds could now be formed without the biological process of fertilisation.

Sex without seed. Seed without sex. It's been said that the greatest gift of science to humankind would be achieving those two goals. Effective contraceptives such as the pill have pretty much nailed the first goal. Our findings, published on Friday in Science (Science 1 March 2013: Vol. 339 no. 6123 pp. 1045-1046), could be significant pieces of the puzzle for the second.

That's because by helping solve one of the fundamental questions in the evolution of plants, we may also have brought closer the possibility of cloning a plant with good traits through easy-to-distribute seeds, rather than cuttings.

This so-called "apomixis" is one of the holy grails of agriculture because it would make new crop varieties – ones that are resistant to drought, say – both cheaper, and more widely available.
What we — my post-doc Keiko Sakakibara and myself – have done is identify a molecular gate-keeper between the two life stages that make up plant life cycles.

Us and them
Plant life cycles are very different from our own. The "us" we are most familiar with is complex and multicellular. Our body is composed of cells that are diploid, containing two copies of each chromosome. But we also have haploid cells, containing only one copy of each chromosome: the single-celled egg and sperm. Those haploid cells are generated from special diploid cells via a process

called meiosis; conversely, fertilisation – basically a union of two haploid cells – gives rise to the diploid us.

In contrast, plants alternate between haploid and diploid generations, both of which have complex multicellular bodies.

If this happened in us, it would be as if our sperm and eggs left our bodies, grew into multicellular organisms, went to the pub, met, and mated, eventually creating the next diploid generation.

So seemingly disconnected and dissimilar are the haploid and diploid bodies of many plants that for centuries they were sometimes mistaken for different species.

That changed in the mid-1800s with the findings of the incomparable German biologist and botanist Wilhelm Hofmeister. Making use of some recent technological innovation – better microscopes – Hofmeister spent a decade or more observing the life-cycles of a huge variety of plant species, concluding that so-called "alternation of generations" was a universal property of land plants.

We now know that in most plants, such as mosses and liverworts, the haploid body is the complex, impressive one; while in flowering plants and ferns, the diploid body takes centre stage.
Rolling stones …

Which brings us back to our work on moss – the sort you see around the edge of ponds, or on the cracks in damp sidewalks. The moss most people would recognise as moss is the haploid body.

It spawns haploid sperm and egg, which fuse to produce the relatively unimpressive diploid version – the little stalks with brown caps.
The brown caps eventually burst, releasing haploid spores, which float off to colour another path or sidewalk.

In a piece of curiosity-driven research, we removed a gene called KNOX2 from this moss.

What we found was that the cells that normally produced the diploid body, instead behaved like the haploid generation and grew into those familiar moss mats. KNOX2, it seems, functions as the molecular brake that prevents diploid moss body from generating the haploid moss body.

Feed the world

So why does this matter? For several reasons. First, we've gone a good way to revealing how the alternation of generations in plants is controlled at the molecular level – and provided genetic support for the favoured theory about its evolution.

Our findings strongly support the idea that the common ancestor of all plants was haploid – each cell having only one set of genes — with the diploid generation evolving later.

There could also one day be a practical ramification. If a single gene can control conversion from the diploid to the haploid life-form, it raises the possibility of altering that gene in flowering plants – specifically crop plants — to skip the haploid stage.

Rather than have cells undergo meiosis, and mixing their genetic contents to create new plants via pollen and ovule, seeds could be produced with the same genes as the parent – and apomixis would be possible.

This is far from a done deal: plant biologists have been trying to achieve that goal through various means for decades, and no doubt need to put years more work in. But if it were achieved it would be a truly transformative form of technology.

Modern, highly productive farming relies on crossing crop variants to produce crops with superior qualities to either parent. This carefully orchestrated "hybrid vigour" is lost if the crop is allowed to do its own thing, mixing and matching genes to create the next generation.

Apomixis would allow traits such as yield and drought-resistance to be preserved generation after generation, potentially reducing the cost of producing hybrid seeds, and the farmer's need to purchase seeds anew each planting season.

Thus, the seeds without sex could help feed the planet in the coming century.

Summaries of Final Reports

Each year the Australian Flora Foundation funds a number of grants for research into the biology and cultivation of the Australian flora. While the grants are not usually large, they are often vital in enabling such projects to be undertaken. Many of the projects are conducted by honours or postgraduate students, hopefully stimulating their interest in researching Australia's unique and diverse plants. This work is only made possible by the generous support of donors and benefactors.

Presented here are brief summaries of completed projects. Full reports of these and other projects can be viewed on the Foundation's website http://www.aff.org.au/

Determining the pollinators of rare and endangered Epacris species: implications for conservation

Karen Johnson and Peter McQuillan, University of Tasmania


Australian admiral butterfly (*Vanessa itea*) visits *Epacris graniticola*

There is little information available on the pollinators of Tasmania's threatened *Epacris*. Our main objective was to determine the pollinators of eight *Epacris* species, and explore for relationships between pollinators, floral morphology, flowering time and habitat.

In completing the objectives we undertook breeding system experiments, quantitatively documented pollinators, collated flowering time and habitat information, and assessed for the

Red-bottomed bee (*Exoneura* sp.) visits E. *barbarta*

potential impact of introduced insects on the native *Epacris* pollinator mutualisms.

During our study of pollinators, over 85 hours of observations were made on the animal visitors during peak flowering time, and a total of 4,896 animal visits to *Epacris* flowers were documented.

While *Epacris* species set very little seed in the absence of animals, seed set as a result of animal pollination was successful with up to 30% of capsules containing numerous viable seeds.

Epacris species have generalised pollination systems attracting at least 33 different pollinators, including flies, bees and butterflies. Four introduced species also visited *Epacris*: honey bee, bumble bee, drone fly and cabbage white butterfly. The introduced drone fly and cabbage white butterfly have not previously been recorded as pollinators of the native flora of Tasmania.

No statistically significant relationship was found between pollinators, floral attributes, flowering time or habitat.

Although further information is necessary to establish whether *Epacris* floral resources are plentiful enough to accommodate the needs of both native pollinators and honey bees, the current high frequency of honey bee visitation is enough to cause concern. Over half of all visits to *Epacris* flowers during this study were undertaken by honey bees.

“Green Caviar” and “Seagrapes”: Targeted cultivation of high value seaweeds from the genus *Caulerpa*

Nicholas A. Paul[1], Symon A. Dworjanyn[2], Rocky de Nys[1]
1. School of Marine and Tropical Biology, James Cook University
2. National Marine Science Centre, Southern Cross University

This research project describes the first detailed and simultaneous examination of the aquaculture production and nutritional values of edible seaweeds in Australia.

Sea grape production showing growth after 6 weeks with harvested section (front right)

“Sea grapes” is a collective term for the edible varieties of the green seaweed genus *Caulerpa* that are harvested and consumed fresh in nations throughout the Pacific. These species are also present throughout Australia. However, only one species (*Caulerpa lentillifera*) is in aquaculture production in Japan and SE Asia, and it is unclear, to date, whether other sea grapes can also be domesticated or have comparable nutritional value.

We conducted comparative analyses of biomass productivity and nutritional composition of *C. lentillifera* (“green caviar”) and *C. racemosa* var. *laetevirens* from tropical Australia. We focused exclusively on these species for the empirical components as we found that other common varieties of sea grapes from the tropics (*C. racemosa var. racemosa*, Townsville) and sub-tropics (*C. geminate* and *C. sedoides*, Coffs Harbour) were not suited to aquaculture production via vegetative propagation.

We demonstrated that the most important traits for aquaculture production of sea grapes are the ability to grow rapidly from vegetative fragments which are stocked at high stocking densities in land-based facilities. The culture system must importantly be controlled to deliver water motion that facilitates the above-tray growth of the biomass for harvest. These features are critical for the successful commercial production of sea grapes.
Mass cultivation of seaweeds faces numerous challenges in scalability of productivity and quality (Lüning & Pang 2003). However, aquaculture also provides the opportunity to create a uniform product under controlled conditions, with the added benefit of sustainable production by reducing the reliance on wild harvests.

We demonstrated that aquaculture can be used to manage the production cycles to consistently produce and harvest fronds of shorter length that maximise the nutritional profiles.

Links between variation in morphology and biochemical composition have, until now, been overlooked – yet the ability to manipulate these traits could enable any future industry to diversify products and enhance marketability of the product for health and lifestyle.

Overall *C. lentillifera* had high production rates and therefore warrants commercialisation as a new aquaculture product in Australia. On the other hand *C. racemosa* has many nutritional traits and some growth traits (e.g. frond length) that indicate potential for commercial production or alternatively for aquaculture ranching using wild harvests as a seedstock.

The two species are both viable options for the establishment of a high-value, edible seaweed industry in Australia, which may be complimented by other sea grapes from the diverse genus of *Caulerpa* that can be found on all coastlines.

Close up of fronds of *C. lentillifera* showing the horizontal runners (stolons) wrapping over the top of the aquaculture tray and young fronds with "lentil"-like branchlets on opposite sides of the axis (white arrows).

Cassia Read, School of Botany, University of Melbourne, received the Australian Flora Foundation Young Scientist Award for her talk at the Ecological Society of Australia Conference on 3-7 December, 2012 in Melbourne:
Using biological soil crusts to assess condition of semi-arid ecosystems

Biological soil crusts (BSCs) are the community of lichens, bryophytes, cyanobacteria and algae that commonly exist on the top few millimetres of soil in arid and semi-arid ecosystems. Total BSC cover is used as an indicator of ecosystem condition, due to the sensitivity of BSCs to livestock trampling and their functional importance in ecological processes such as soil stability and vascular plant recruitment.

Despite recognition that BSC composition mediates BSC function, species are rarely included in site assessments, due to the challenge of confidently identifying these cryptic organisms. In response to this issue, David Eldridge and Roger Rosentretter devised a simple classification of species into morphological groups for use in rapid assessments of BSCs.

We used Multivariate Regression Trees (MRT) to analyse two independent datasets from north western Victoria, to evaluate the utility of morphological groups as indicators of site condition* compared to species composition and total BSC cover.

Our study shows BSC species within morphological groups respond more similarly to ecological degradation than species across groups. Our results provide support for using morphological groups in rapid assessments of ecosystem condition, because they allow us to generalise about species responses to degradation, are easier to assess in the field than species and are more informative about ecosystem function than total BSC cover.

*Because BSCs are important for a range of ecological functions they are relevant to a range of specific definitions of ecological condition (e.g. capacity of a site to retain soil and nutrients rather than lose them through wind and water erosion).

Thank you to our donors

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By the way, we have recently inserted new donations and bequests pages on our website http://www.aff.org.au/

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