A charity fostering scientific research into the biology and cultivation of the Australian flora

Research Matters

Newsletter of the Australian Flora Foundation

January 2017

Inside

President's Report 2016

Delivered by Dr Peter Goodwin at the AGM on 21 November 2016

New Councillors

Carolyn Gillard and Associate Professor Jennifer Firn became Councillors in December 2015, and have already made valuable contributions, Carolyn by producing a new brochure describing the activities of the Foundation, and encouraging people to join us, and Jennifer by taking over the work of managing the Foundation website. Her draft version of the new website is currently at http://aff.antl.com.au/.

New grants

Four grants were awarded for work to begin in 2017:

1. Kerryn Chia, Kings Park and Botanic Gardens, Germination of *Persoonia* species $19,324

Persoonia has long been recognized for its potential as a garden ornamental but the entire genus has proven difficult to propagate. Kerryn's research into *Persoonia longifolia* has been highly successful with some very exciting results of direct relevance to the mining, floriculture and horticultural industries. The aim of this project is to see if germination in this species can be further speeded, and if the techniques work with other members of this genus.

2. Laura Skates, School of Plant Biology, University of Western Australia, How hungry are carnivorous plants? $13,750
Laura aims to enable us to better understand the nutrition (how much of their nutrients come from animals?) and ecology (how do they interact with the plants and animals around them?) of carnivorous plants, focussing on the highly diversified carnivorous plants of Western Australia.

3. William Fowler, School of Veterinary and Life Sciences, Murdoch University, Effects of urbanization on *Banksia* woodland communities $15,000

William aims to quantify vegetation change in the *Banksia* woodlands of Perth over the last 20–25 years, to identify causes of species loss and gain, identify features that lead species or fragments to be vulnerable to such loss or gain, and provide information to help management of the woodlands for plant biodiversity conservation.

4. Ed Biffin, State Herbarium of South Australia, The evolutionary significance of range disjuncts among South Australian eucalypts $20,000

The woodland communities of the Flinders-Lofty region of South Australia contain many isolated eucalypt populations, far from the extensive populations of these species in eastern Australia. Ed will determine whether the isolated populations are ancient remnants of once continuous populations which have survived in this region, or are recent arrivals. This will influence the management priorities of the South Australian populations.

Final reports

Two final reports were received this year and are available on the Foundation website:

1. Corey JA Bradshaw and Briony Horner, The University of Adelaide and Succession Ecology Pty Ltd.
Identifying cost-effective reforestation approaches for biodiversity conservation and carbon sequestration in southern Australia

This project has been initiated with Foundation funding. Of a total cost of $257,000, only $18,182 has come from the Foundation. The remainder of the funding has come from the Australian Research Council, as a Linkage Grant, the University of Adelaide, the South Australian Department of Sustainability, Environment and Conservation, and Zoos SA. The report covers only the setting up of the project, which will continue to be evaluated for the next 10 to 20 years.

2. Alexandra S Bowman and José M Facelli, School of Earth and Environmental Sciences, University of Adelaide.
The dynamics of formation and dissipation of patches associated with fallen logs in a chenopod shrubland of southern Australia

Finally I should like to thank you for your contributions over the year, whether as members of the executive, members of the Finance Subcommittee, of the Scientific Committee, and/or members of Council. A special thank you to all donors and benefactors of the Foundation; without you the Australian Flora Foundation could not function. Particularly noteworthy is a donation of $1,000 from APS Newcastle.

Peter Goodwin, President
21 November 2016

Young Scientist Awards

The Australian Flora Foundation awards prizes annually to encourage young scientists to continue studying the flora of Australia.

At the annual conference of the Ecological Society of Australia held in Fremantle in December 2016 the Foundation's prizes were presented to:

Outstanding student spoken paper on the biology or cultivation of an Australian plant

Berin Mackenzie, PhD candidate, University of New South Wales
Title: Advancing our understanding of fire driven recruitment in species with physiological dormancy

Outstanding student poster presentation on the biology or cultivation of an Australian plant

Maia Raymundo, PhD candidate, University of Queensland
Title: Mechanisms limiting seed recruitment in a novel ecosystem

The details of the recipients of the two annual prizes are available at http://www.ecolsoc.org.au/news/2016/12/esa-2016-conference-student-prize-winners

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Smoke Germination of Australian Plants

Kingsley Dixon*

Introduction

Fire has played a significant role in the ecology of the Australian flora at least since the arrival of arid conditions in the mid-Tertiary. In fire-prone floras, particularly those of mediterranean zones, fire has been shown to be crucial for the recruitment from seed of a wide variety of taxa. For seeder or fire-sensitive species and fire ephemerals, fire is the single most important cue for triggering germination of the dormant soil seed bank. For many fire-responsive taxa, germination of viable seed under controlled conditions has been difficult or impossible using conventional treatments other than in vitro excised embryo culture or complex and often difficult to apply pre-treatments including hormonal applications. However, my research has now shown that smoke responsive species occur throughout the world's plants from fire-prone to non-fire-prone floras.

The role of smoke in germination

Smoke is a key principal in breaking seed dormancy in a wide variety of native Australian species. Many studies over the years since the discovery for Australian species in 1993 of the action of smoke in germination have found that smoke:

- Promotes faster and more uniform germination under controlled greenhouse and laboratory conditions.

- Enables germination in species previously thought difficult or impossible to germinate by conventional means e.g. *Geleznowia* and *Eriostemon* (Rutaceae); *Hibbertia* (Dilleniaceae); *Stirlingia* and *Conospermum*, *Grevillea* and *Hakea* (Proteaceae); *Verticordia* and *Calytrix* (Myrtaceae); *Pimelea* (Thymeleaceae); *Blancoa* (Haemodoraceae); *Stylidium* (Stylidiaceae).

- Promotes germination in species with low levels of germination e.g. *Anigozanthos* and *Conostylis* (Haemodoraceae); *Thysanotus* and *Burchardia* (Liliaceae); *Patersonia* (Iridaceae); *Lechenaultia* (Goodeniaceae); *Gyrostemon* and *Codonocarpus* (Gyrostemonaceae); *Stackhousia* (Stackhousiaceae); *Hybanthus* (Violaceae).

- The promotive effect is independent of seed size and shape; plant life form i.e. whether annual, perennial, herbaceous, seeder (fire-sensitive) or resprouter (fire-tolerant).

- Aerosol smoke, smoke dissolved in water or direct smoked solids (activated clays, sand particles) or direct-smoked seeds are effective methods for delivery of smoke for seed germination.

- High doses of smoked water can inhibit germination of many species e.g. paper daisies (Asteraceae).

- As seed ages it can change in its ability to respond to smoke such as in *Conostylis* which has cyclical dormancy – seed dormancy cycles in and out of smoke responsiveness each 6 months or so.

- Ageing seed in soil for 1–2 years and repeat smoke application will result in high germination of smoke ‘recalcitrant’ species in the Ericaceae, Proteaceae, Cyperaceae, Restionaceae, Rutaceae and others.

Smoke methods (see figure below)

Sown seed trays or seed are placed on an open mesh, two tiered frame in a sealed, plastic tent approximately 2 x 2 m and 1.4 m high. Smoke is generated by slow, controlled combustion of a mixture of fresh and dry leaf and twig material from a range of plants avoiding too much myrtaceous material due to the high level of oils in the leaf material that can be ‘distilled’ over onto the seed trays. The drum is fitted with an inlet through which air is pumped at the rate of 60–100 litres per minute, and an outlet connected to a 1.5 m long pipe. A 2 m length of flexible stainless steel exhaust piping approximately 50 mm in diameter is connected to the plastic enclosure ensuring that smoke is injected towards the roof of the tent. This ensures that there is adequate spread of smoke inside the tent.

After smoking for 60 minutes, trays are transferred to the glasshouse and watered carefully for the first 6–10 days to ensure that the soluble promoter in smoke comes in contact with the seeds but not washed through the mix before reacting with the seed. Watering is then continued as for normal germination.

Seeds can also be direct smoked. In this instance, air-dried seed is laid out in a single layer in trays. The trays are smoked for 60 minutes in the fumigation tent (as described above) and seed is then sown or stored dry until required. Unlike smoke applied to soil containing sown seeds, smoked seeds can watered as for normal seed trays.

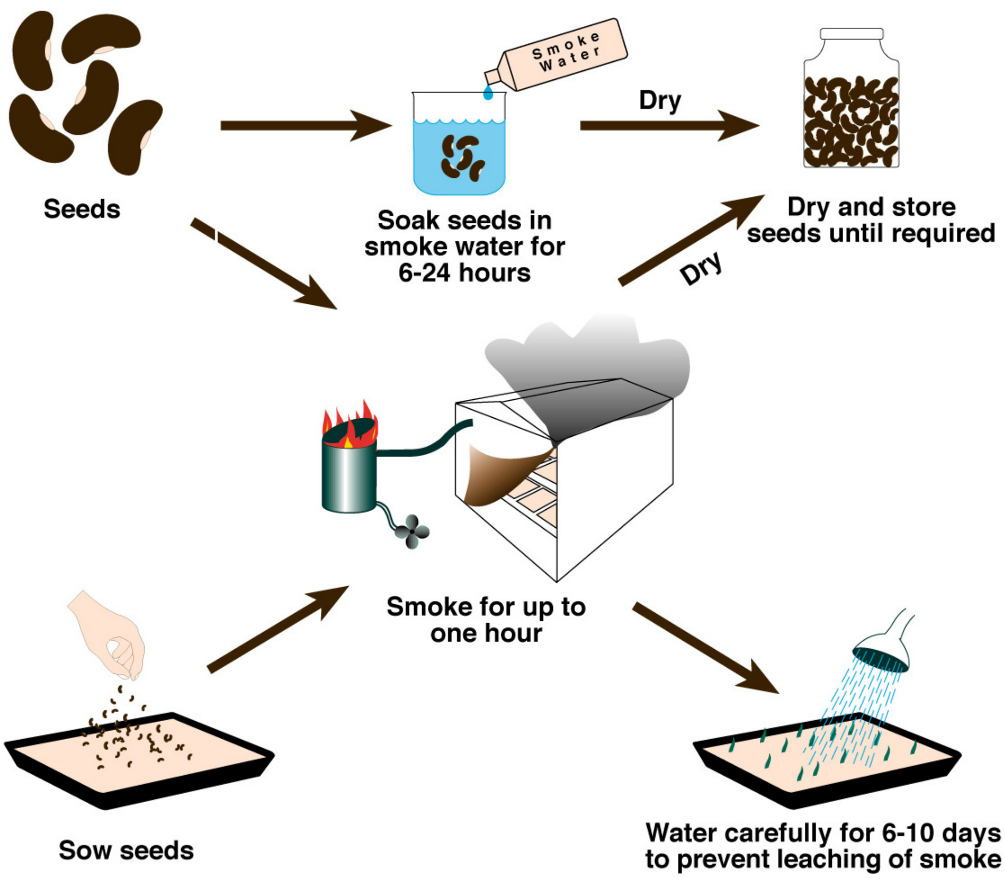

Fig 1. Schematic of how to use smoke for germination of native Australian seeds.

Smoke water

Smoke water can be useful for direct priming or pre-germination of seeds prior to sowing. Smoke water-treated seeds have the advantage of not requiring the use of the smoke tent and the convenience of priming seeds at will. Smoke water-treated seeds may germinate better than smoked seedling trays with the process applicable to handling potentially large quantities of seed such as for land restoration or automated seed sowing devices.

Smoke water is produced by drawing smoke produced from the combustion drum operating as for aerosol smoke, through a 20 litre container of water. Smoke bubbling is done for approximately 60 minutes and the resultant solution is frozen till required. It is important to note that commercial smoke water products are available but if they are derived from wood this smoke water can be highly suppressive of germination.

Seed to be treated with smoked water is soaked for 12 hours in a 10% solution of the neat solution and then sown or dried then sown as required. Seed treated with smoked water can be watered normally after smoking. Although this method has been shown to be useful for a number of native species, caution is recommended as seed of some species can degenerate if soaked in water for prolonged periods. Pre-germination as a horticultural practise for seed of Australian native plants requires some experimentation to ensure the process is applicable.

In situ habitat germination studies

Smoke fumigation treatments can be applied directly to habitat sites and for a range of species germination will happen in 6–8 weeks after treatment. This technique is particularly useful for soil seed bank auditing (determining how large a native soil seed bank is) and for patch stimulation of rare species. The benefit is that the process is defined rather than the use of prescribed fire which can result in highly patchy germination.

Smoke is generated as above and applied to sites where excess leaf litter and larger plants have been removed to prevent ‘shadowing’ of the soil from smoke. Tents are erected over the sites, usually 5 x 1 m and 40 cm high, and smoke is pumped into the tent for 60 minutes. In temperate regions of Australia, the best results are achieved if smoking is done in summer to early autumn so that leaching of the smoke products coincides with the onset of the first rains. Smoking undertaken at other times of the year appears to yield less germination for taxa which respond to summer/autumn smoking.

Summary

Smoke derived from the combustion of plant material enhances seed germination in a wide range of native species that will not germinate under normal nursery conditions. Species in the families Rutaceae, Restionaceae, Ericaceae, Thymeleaceae, Proteaceae and Dilleniaceae and many other species in other families have improved germination in response to the application of smoke, smoke water or the key germination promoting agent in smoke, karrikinolide. Genera known to be highly recalcitrant to conventional seed propagation which respond to smoke include *Stylidium* (Stylidiaceae), *Geleznowia* (Rutaceae), *Hibbertia* (Dilleniaceae), *Stirlingia* (Proteaceae), *Verticordia* (Myrtaceae), *Actinostrobus* (Cupressaceae) and *Pimelea* (Thymeleaceae). Germination percentages of species which normally germinate in small numbers are positively influenced by smoke treatment. Seed size varied amongst all positively responding taxa. Within the Ericaceae, small-seeded (*Lysinema* and *Sphenotoma*) but not larger, woody-fruited species respond to smoke however both seed types respond under field stored seed. Significant applications now exist for the use of smoke in germinating a wide range of species for horticulture and land restoration.

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About the author

Professor Kingsley Dixon is an academic in the Department of Environment and Agriculture at Curtin University and at the University of Western Australia and is a Visiting Professor at Kings Park and Botanic

Garden. In addition, he is a valued member of the Scientific Committee of the Australian Flora Foundation. His research areas are in conservation science, restoration ecology and plant science. Professor Dixon was named Western Australian Scientist of the Year in 2016.

AFF-Funded Project: How does smoke-promoted germination in SE Australian flora vary among plant lineages, vegetation types and fire strategies?

Alex Carthey*

Background

We have known since the 1990s that exposure to smoke promotes seed germination in some species. Smoke has been shown to affect timing and success of germination, as well as seedling vigour, in native, weed and commercial species, but can also inhibit germination in some species. Most of the research on germination responses to smoke has been conducted in Western Australian, South African fynbos, Californian chaparral and Mediterranean matorral ecosystems. In comparison, very little is known about germination responses to smoke for eastern Australian species. Also, we know almost nothing about patterns of smoke-promoted germination in relation to phylogeny, growth form, vegetation type and fire response strategies (obligate seeders compared to resprouters). Understanding some of these broad-scale patterns in germination responses to smoke would enable conservationists to incorporate this knowledge into their management practice. This project investigates patterns of smoke-promoted germination both internationally and with a focus on eastern Australian flora, to examine relationships between smoke response and phylogeny, growth form, fire response strategies and vegetation type.

Methods

Seed banks associated with Botanic Gardens are untapped resources of germination trial data that often include smoke treatments. Working together with the Australian Seed Bank at the Australian Botanic Garden Mount Annan, we accessed, compiled and digitised their hard copy germination trial data to inform our study. We have also obtained data on smoke-responsive germination from a recent review of the global smoke germination literature (Jefferson *et al*. 2014). A subset of this global dataset pertaining to south eastern Australia has been created and combined with the Seed Bank data. This larger dataset will be used to investigate how smoke-promoted germination relates to the variables previously mentioned, with a south eastern Australian focus. At a later stage we will also investigate patterns of smoke-responsive germination in the global flora.

Results

The south eastern Australia dataset contains 377 entries from 46 sources (journal articles, or seed bank germination trial data), comprising 298 species from 60 families and 173 genera. Of the 298 species in the dataset, 138 have more than one entry, meaning that it will be possible to investigate different factors that might result in a positive or negative response to smoke (e.g. different types of smoke treatment). Of the different types of smoke treatment, 132 entries record responses to smoke water, 220 to aerosol smoke, 11 to karrikinolide, and 5 to ash/charate. No studies in this dataset used glyceronitrile. The majority of the dataset comprises entries from woody (169 entries) and herbaceous (116 entries) species, followed by graminoids (77 entries), with one succulent and one climber. The best represented habitats in the dataset are “Woodland/forest/shrubland/heath” with 250 entries, followed by “Aquatic/wet” with 31 entries, “Rainforest” with 18 entries, “Arid/dry/rocky/sandy” with 11 entries, “Diverse/widespread” with 7 entries, and “Grassland/herbfield” with 3 entries. Of the 377 entries, 181 record a germination response to smoke treatment. Of these, 13 entries recorded reduced germination in response to smoke and 168 entries recorded a positive germination response to smoke. Detailed data analysis aimed at answering our research questions and looking for the patterns that best predict smoke-responsive germination in eastern Australian flora is currently underway.

Outputs and outcomes

We will publish our findings in scientific journals, and the dataset associated with this project will be made freely available to the public through a web-based portal at https://pirel.wordpress.com/datasets/ so that anyone interested in conservation and management of natural areas can use this dataset to inform their work. We hope that our research helps to incorporate smoke-promoted regeneration into vegetation management in eastern Australia and helps to promote the cultivation of eastern Australian plants.

Reference

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*About the author

Alex Carthey is a Research Fellow at Macquarie University in New South Wales. She works with Professor Michelle Leishman in the Plant Invasion and Restoration Ecology Lab. This article reports on the progress made on a project funded by the Foundation in 2015: ‘How does smoke-promoted germination in SE Australian flora vary among plant lineages, vegetation types and fire strategies?’

Collecting, Cultivating and Competing Carnivores

Renee Smith*

Collecting carnivorous plants

No other part of my life's work and hobbies quite grabs the attention of a broad range of people than my carnivorous plant (CP) collection does. Whether it's customers at my parent's wholesale nursery, visitors to the family property, my photographs on different social media platforms, bringing up the topic in idle conversation, or engaging with strangers as I compete my plants at local agricultural shows – the interest and fascination is always there. Maybe it's their menacing design, the horror factor, or revenge-like way that they have flipped the food chain on the animal world?

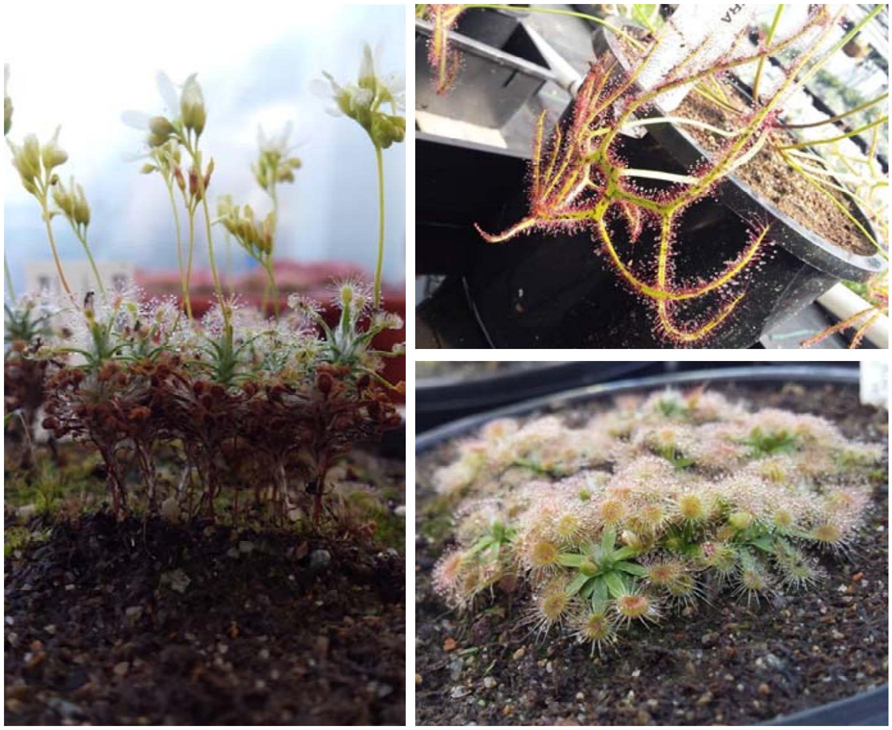
A friend and fellow member of the Australasian Carnivorous Plant Society (AUSCPS) recently told me about a market he was selling plants at that shared the grounds with a large car show and swap meet. He watched as a group of burley men left the cars and walked towards his store. He laughed as he recounted that he began to get really nervous and wasn't sure what they were going to say to him – all they wanted to do was check out the cool killer plants, and after a chat, they left with a few pots of Venus Flytraps. Carnivorous plants certainly do not fit the opinion that botany is dull and that plants are boring!

Top left: *Drosera burmannii*; top right: *Drosera paleacea* ssp. *trichocaulis*; bottom: trapped prey on *Drosera*.

The earliest CP experience I can recall was as a young child, when I found some strange glistening and sticky plants growing amongst a bed of moss, alongside the seasonal rock pool where I loved to look for tadpoles. I remember my father telling me that these were a special type of plant that trapped and ate insects. My father in particular helped spark my growing interest in the Australian environment and hiking in the wilderness. I loved all different types of native flora and fauna, but nothing ever quite grabbed my fascination like that very strange insect-eating plant. Growing up surrounded by my parent's wholesale production nursery and my interest in plants in general, it made sense that sooner or later, one day I'd begin a CP collection of my own.

Surprisingly, the first plants in my collection were not *Dionaea muscipula* (Venus Flytrap) – arguably the most recognised CP, that's relatively easy to obtain and grow, and has had a presence in a number of movies and video games. While their trapping mechanism fascinates me, my first CPs belonged to the same genus as the one I found as a child – the genus *Drosera*. These glistening carnivores captivated Charles Darwin as well. So much so he wrote that he cared "more about *Drosera* than the origin of all the species in the world". He spent a great deal of time collecting specimens, growing them in glasshouses at his home, and investigating the strange morphology and adaptations of the leaves. Darwin was the first person to conclusively demonstrate that these sticky-leaved plants were able to distinguish between organic and inorganic substances, nitrogenised and non-nitrogenised substances, and had the ability to digest and absorb nourishment from insects trapped in its sticky mucilage.

Australia is home to over 240 species of CP – roughly 30% of the world's total – of which the genus *Drosera* makes up the largest proportion. This genus not only caught my childhood interest, but it has flowed through into my collection and I aim to eventually have all species native to Australia. Of the 161 species, I currently have 36. I have quite a way to go yet, and I have set myself quite a challenge to source plant or seed specimens, as well as successfully keep them in cultivation. Collecting and cultivating CPs has taught me the virtue of patience. With many CP genera, slow growth is normal, and seeds can take months to germinate and years until the plants reach maturity.



Left: *Drosera stelliflora*; top right: *Drosera binata* var. *multifida*; bottom right: *Drosera pulchella*.

Growing carnivorous plants

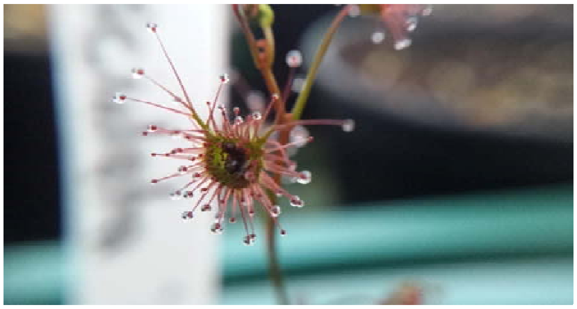
Cultivating CPs in general has posed the greatest challenges on my horticultural skills. Textbooks offer different methods and media recipes, fellow growers have differing advice, and one collector's secret for success produces no result for another. I accepted very early in my experience that I would lose plants as I experimented with methods. Researching into the natural distribution and habitat of a soon to be acquired species has saved a number of plants from disaster by being placed in the wrong environment. One of my most used set of books is Allen Lowrie's 'Carnivorous Plants of Australia Magnum Opus' – in my opinion, an essential resource for the collector of Australian CPs. After research, the second factor to the success of my growing collection is that I live on-site at my parent's wholesale production nursery. I'm very fortunate and the envy of some of my CP growing friends, as it gives me access to different growing environments, production equipment, industry suppliers, as well as keen customers who readily snap up plants that I occasionally release for sale.

I have many personal CP stories that adhere to the principle of having not failed 10,000 times, but instead successfully finding 10,000 ways that will not work. To be brief but informative, I will list some of the important lessons and key points for how the Australian native genera are currently housed. The most devastating lesson I learnt was to check over a delivery invoice before using the growing media. Unfortunately I recently lost over 2,500 plants, thousands of tubes of sown seed, and set back the growth of re-potted adult plants, when the non-descript bags of growing media I used at the beginning of the new growing season contained buffered peat, instead of unbuffered peat. Buffered peat is less acidic, but more importantly, it also contains fertilisers which are generally harmful to CPs.

As my father generously sets aside pockets of space in his glasshouses, shade houses, poly tunnel and uncovered growing areas, I am able to choose prime locations for different groups of plants. The exotic and beautiful *Sarracenia* thrive in the hot, humid and high light poly tunnel, whereas the exotic *Nepenthes* would suffer there, and instead produce many lovely hanging pitchers in their spot in the shaded glasshouse. I keep my *Cephalotus follicularis* (Albany Pitcher Plant) outdoors in full sun and the lightest shade house where they are rarely disturbed in their deep pots, which sit in a 2 cm shallow tray of water, instead preferring overhead irrigation. The terrestrial *Utricularia* (Bladderwort) are kept in water dishes in the partly shaded poly tunnel; they are periodically inundated with water to the soil surface, which is then allowed to naturally decrease but never dry out. The aquatic *Utricularia* are kept in a pond that has been planted out with natives, in the sunny corner of a glasshouse; they are generally left to their own devices, now that the destructive fish have been relocated. Depending on the species, my *Drosera* can be found growing in the full sun in the poly tunnel, the shaded but warm and humid section of the glasshouse or spending their dormancy period in the protected glasshouse. Understanding each of the hundreds of plants I own, and using research and skill to determine the cultivation methods to help them thrive is a horticultural challenge that I very much enjoy.

Top: *Utricularia gibba*; bottom left: bladders for catching insect prey; bottom right: *Utricularia bisquamata*.





Left and top right: native population of *Drosera auriculata* in bushland near my home; bottom right: *Drosera auriculata* in cultivation in my collection.

Showing carnivorous plants

Growing CPs for my own personal interest is satisfying. However, I really enjoy being able to make plants interesting for those who wouldn't normally look twice. I entered a beautifully patterned exotic *Sarracenia* (North American Pitcher Plant) hybrid in the foliage plant class of my local agricultural show, where it was awarded a "First Place", followed by "Champion Miscellaneous Plant", "Grand Champion Potted Plant" and "Most Successful Exhibit". I was able to spend time in the pavilion demonstrating and talking about CPs to a surprisingly large number of people who came through – as opposed to just passing by the perceivably dull horticulture section. At the more prestigious Sydney Royal Easter Show, the Royal Agricultural Society has recently added a CP section to the flower and garden show. This has really opened up a great opportunity to display CPs to the general public. I entered my plants into three of the CP classes in the 2016 Show and was placed first in each. My *Sarracenia* hybrid went on to be awarded "Champion Carnivorous Plant" – a wonderful achievement for me.

Last year's CP competition was particularly well attended, which has opened the way for new judging classes for this year – one in particular being a class for Australian native CPs – as well as the AUSCPS being invited to hold an information stall in the pavilion to engage with the public about CPs. This is set to be an excellent opportunity to further teach the public about these strange but fascinating plants.

Left: Renee Smith; top right and bottom: the award winning *Sarracenia* (North American Pitcher Plant) hybrid.

One species in my collection, the non-native *Sarracenia oreophila*, is listed as critically endangered, with very few populations left in its natural range of the hilly central and northern parts of Alabama in the United States. While it is nice to hold specimens in cultivation, it saddens me to look at this plant contained to a pot and know that CP wild sites worldwide are under threat. Their fragile habitats are increasingly degraded, destroyed, fragmented and poached, and the risk that species may eventually be lost in the wild is a very real possibility. Land is cleared, wetlands drained, fires suppressed, local hydrology changed, urban areas expand, invasive species are introduced, fertilizers contaminate and kill, and demand by enthusiasts and horticulturists fuels illegal plant poaching.

Maintaining collections of plants in cultivation can represent an important safeguard against total extinction of a particular species, however it is also important that collection goals for the private collector like myself need to respect and protect native populations. For instance, new pieces to my collection must only come from responsible and ethical sources. If that means that I will not be able to one day see my goal of having all Australian native *Drosera* species growing in my collection then that is perfectly fine. Wild populations of plants should not be depleted or threatened in order to support cultivation and collections. After all, the real joy and satisfaction from botanists should be to see a species growing safely in its natural environment today and into the future.

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Recently updated and republished as:
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*About the Author
Renee Smith is a Senior Technical Officer (Physiological Plant Ecology) at the Hawkesbury Institute for the Environment, Western Sydney University. The research of the lab group she serves is mostly focused on plant response to changes in global climate factors (e.g. temperature, carbon dioxide, water and extreme weather events). Renee works with woody species – in particular, species of *Eucalyptus*, native gymnosperms, Wollemi pine, waratah, and cotton. She enjoys a broad range of plant physiology research interests, with structure-function relationships being a prominent favourite. Outside of her research work, her main interests include carnivorous plants, kayaking, and competing successfully as a disabled athlete in para-equestrian. Her dream is to be able to rehabilitate enough from a spinal cord injury to visit wild sites of carnivorous plants in southwest Western Australia.

You can find Renee's profile at:
http://scholar.google.com.au/citations?hl=en&user=FKMuzN8AAAAJ

How to propagate native carnivorous plants at home – *Drosera* and *Utricularia*

Alexander Tran*

When it comes to growing native carnivorous plants, many people that I have come across have been daunted by their unusual morphologies and believe that they are "too exotic" to grow in their own backyard, requiring a professional setup such as proper greenhouses and highly specific conditions to grow them in. However, this is not the case for many of the species that are commonly available in local nurseries.

The following growing and propagation practices focuses on two of five of the main groups of carnivorous plants and are based on my experience with plants that I have grown through lots of trial and error. Mine may not be the flashiest of methods compared to a commercial-scale production line but these methods are simple and efficient for me and my backyard.

Left and right: A sample of Alex Tran’s backyard collection of carnivorous plants.

Drosera (Sundews)

Species in the genus *Drosera*, collectively and commonly known as Sundews, are a group of sticky-leaved carnivorous plants that occur in a wide variety of ecosystems. As their common name suggests, these plants glisten brightly when a beam of sunlight passes over their reflective and sticky mucilage borne on the ends of delicate tentacles which cover majority of the leaf surface.

Sundews are usually grown in mixes of wet sphagnum peat moss and river sand. Some species found growing naturally in cooler environments, such as the Australian native *Drosera adelae*, appreciate growing mixes comprising of only sphagnum moss. Light levels can vary depending on the species and the way you want to grow your plants, ranging from full sun to shade.

Most species of *Drosera* are highly totipotent and can be propagated in several ways while other species, such as the fast moving *Drosera burmanii* and *Drosera glanduligera*, are only able to be propagated from seed.

The most common and easiest method of propagation of *Drosera* is from seed. This is likely to occur in any collection as the majority of species can self-pollinate their flowers. Seeds can be sown on the surface of their respective mixtures and germination times will vary. Many of the smaller species can reach maturity within a year. Because some species, such as *Drosera capensis* from South Africa, are very easy to grow from seed they can easily become weeds within a collection and there is a risk of them escaping into natural freshwater ecosystems. There have been reports that this has happened in a few areas in NSW.

Drosera can also be propagated easily from leaf or root cuttings however, this is not the case for all species. Leaves can be cut or ‘pulled’ and placed face up on their respective growing mixes and bagged. As the leaves of *Drosera* curl to engulf their prey, it is important to anchor pulled leaves down with small stones or pins. Roots can be treated the same way without the anchoring. Within a few weeks, depending on the species, buds will develop along the leaf or root surface from which where new plants are formed.

Details of *Drosera adelae*. Left: mature plant; middle: flower; right: unfurling leaf.

There are two distinct but common groups of *Drosera* endemic to Australia; Tuberous and Pygmy Drosera. Within the tuber-forming group there are three subgroups based on the way that they grow, being rosetted, fan-leaved or erect and scrambling. Tuberous *Drosera* can be propagated from seed or brightly coloured tubers which can be gathered during the summer dormancy period. Seeds can be more difficult to grow and may require smoke or heat stratification for germination. In addition, seeds can take an extremely long time to germinate, with some species taking up to a year. In my experience, this group of species cannot be multiplied through leaf or root cuttings.

Pygmy Droseras are a group of highly collectable *Drosera* which rarely exceed 2 cm in diameter. Flowers are produced freely when plants mature and are often as large as the plant themselves. Flowers can be brightly coloured in different shades of white, yellow, orange, red and pink. Although pretty, seeds are rarely produced from these flowers and when they are their germination can be extremely difficult. In addition, Pygmy Droseras cannot be multiplied via leaf cuttings and root disturbance often results in death. Forgivingly, they do have a unique and extremely easy method of propagation. After summer dormancy, growth resumes in autumn with the production of gemmae from the centre of the plant. These small, bulb-like growths are modified leaves which can develop into new plants after being detached from the parent plant. The gemmae are often so densely packed that old leaves are pushed away from the centre of the plant, essentially acting as trigger. When the pressured cluster of gemmae is disturbed from as little as a single raindrop, the leaves bend back to their original positions resulting in an eruption of gemmae which can send them flying a few metres away. With this explosive dispersal mechanism, Pygmy Drosera will be able to easily colonise and spread within an extensive collection! Before this happens though, gemmae can easily be collected during the fall with a wet cotton bud and sown directly on the surface of prepared medium.

Details of leaf variation in *Drosera*. Top right: *D. capensis*; top middle: *D. filiformis* var. *filiformis*; top right: *D. dielsiana*, single plant; bottom far left: *D. binata* var. *multifida*; bottom left: *D. pulchella*; bottom right: *D. binata* var. *dichotoma*; bottom far right: *D. dielsiana*, cluster of young plants.

Utricularia (Bladderworts)

Utricularia, commonly known as bladderworts, are another cosmopolitan group of carnivorous plants with a number of groups that grow in aquatic (living only in water), rheophytic (living in fast moving water), epiphytic (living on other plants), lithophytic (living in or on rocks) or terrestrial environments. Many species are found in Australia and can be very easy to grow.

Bladderworts are the largest genus of carnivorous plants and their common name refers to their distinct bladder-shaped traps which act as powerful vacuum, sucking in their prey in under a millisecond when triggered. Unfortunately, these traps are tiny and subterranean for majority of species, and are only slightly more obvious in floating aquatic species which have traps that are a few millimetres long. With traps this small, this group commonly prey on soil microfauna and microorganisms, with larger traps of aquatic species being capable of trapping mosquito larvae. Bladderworts are grown mainly for their orchid-like flowers which come in an array of different shapes and colours.

Flowers of Pygmy Drosera. Top left: *Drosera binata* var. *dichotoma*; top right: *D. glanduligera*; bottom left: *D. peltata*; bottom right: *D. pulchella*.

As for *Drosera*, there are a range of growing conditions for these plants, with aquatic species being more difficult to grow due to stricter water chemistry needs. Other species can grow in shade to bright sun. Thus far, I have only had successful experiences growing terrestrial and epiphytic species and will elaborate on these species.

Small terrestrial species can easily be grown in a sphagnum peat moss-based mix. I have found that larger terrestrial species with fleshier leaves, such as *Utricularia livida*, prefer to grow in sphagnum moss-based mixes. Non-native epiphytic species that are restricted to Central and South America and are somewhat more sensitive and difficult to grow. From my experience with *Utricularia reniformis*, they appear to appreciate mixes with a high percentage of sphagnum moss and some perlite.

Terrestrial *Utricularia* are highly totipotent, being able to propagate and regenerate from self-pollinated seeds, leaves, roots and flower spikes. With high totipotency, some non-native species including *Utricularia bisquamata* and *U. subulata* can become very invasive within collections. Epiphytic species on the other hand are only able to be propagated from seed or by rhizome division.

Flowers of Bladderworts. Left: *Utricularia bisquamata*; middle: *U. livida*; right: *U. subulata*.

Summary

Experience is the best teacher when it comes to growing any plant and there are no universal methods for growing and propagating them. Some methods may work marvellously in the backyards of some growers while, for others, it simply may not work at all. I have had growers tell me that my conditions are horrendous for my plants and they should have been dead long ago. If some plants cannot grow for you, never fret about it for it has been said that even Charles Darwin could not grow Venus Flytraps successfully.

About the author*

Alex Tran is a PhD candidate in the Faculty of Agriculture and Environment at the University of Sydney. When he is not propagating carnivorous plants he is studying how interactions between arbuscular mycorrhizal fungi and bacteria can be used to control phosphatase diversity and activity in crop rhizospheres. Part 2 of his article will appear in the July edition of the Australian Flora Foundation newsletter.

You can find Alex's profile at:
http://sydney.edu.au/agriculture/academic_staff/alexander.tran.301.php
https://www.linkedin.com/in/alexander-tran-990161b8

Financial Report

These statements are summarised from the Foundation's audited accounts for the year ended 30 June 2016:

Income	**$**
Donations	5,847
Membership fees	1,914
Interest, investment income and change in value of investments	45,943
Imputation credit refunds	7,646
Total Income	**61,350**
Expenses	
Grants	70,261
Accounting and audit fees	4,740
Postage, printing, general expenses	761
Total Expenses	**75,762**
Deficit for year	**14,412**
Assets	
Investments and bank accounts	872,704
Debtors	47,864
Total Assets	**920,568**
Liabilities	
Grant commitments	42,835
Net Assets	**877,733**
Accumulated funds	
Balance 1st July 2015	**892,145**
Deficit for year	14,412
Balance 30th June 2016	**877,733**

About the Australian Flora Foundation

The Australian Flora Foundation is an Australian not-for-profit charity dedicated to fostering scientific research into Australia's flora. It is totally independent. All members of the Council and the Scientific Committee give their time freely as volunteers.

Each year the Australian Flora Foundation provides funding for 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 researchers are honours or postgraduate students, and their success with an Australian

Flora Foundation grant hopefully stimulates their interest in researching Australia's unique and diverse plants throughout their careers.

This work is only made possible by the generous support of donors and benefactors.

The AFF is currently calling for applications for projects to commence in December 2017. The Foundation expects to support between two and four projects at $5,000–$15,000 per year each in 2018 with possible extension into 2019. See the AFF website for application details (http://aff.antl.com.au/).

Email Contacts

Peter Goodwin, President: petergoodwin@internode.on.net
Ian Cox, Secretary: itcox@bigpond.com
Tina Bell, Newsletter Editor: tina.bell@sydney.edu.au

Australian Flora Foundation Inc.
ABN 14 758 725 506
PO Box 846
Willoughby NSW 2068
http://www.aff.org.au/