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Summary of talks delivered at the 10th International Carnivorous Plant Society (ICPS) Conference: 18-20th July 2014

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Introduction

The ICPS conference was held over three days at the Cairns Botanic Gardens. About 60 carnivorous plant enthusiasts attended. Eighteen presentations were delivered; summaries of which, based on the notes I took, are presented below:

Greg Bourke – A photographic journey through Australia's fragile habitats.

Greg presented a photographic tour across Australia using a selection of his wonderful photos. The tour started in Perth Hills where carnivorous plant habitats are often treated as wastelands, e.g. with vehicle burnouts over *Drosera glanduligera* plants. However, they are often beautiful places, such as around Esperance. The Western Australian Wheatbelt includes many granite outcrops which are often excellent carnivorous plant habitat, e.g. *D. rupicola* and *D. lowriei* (Figure 1). Surprisingly, the margins of salt lakes in this region also include carnivorous plant habitat, e.g. *D. salina* and *D. zigzagia*.


Figure 1. *Drosera lowriei.*

The tour then moved to Tasmania where temperate and subalpine bogs support such plants as *D. arcturi* and *D. binata*. The persistence of these habitats may now be threatened by climate change.

Moving to Victoria, to The Grampians area where the large, beautiful and variable *Utricularia beaugleholei* grows and flowers en-masse.

Then moved onto the sandstone plateau and escarpments of central eastern New South Wales where seeping cliffs colonized by *Drosera binata* form a spectacular sight. In contrast lakes in coastal sand dunes support plants like *Aldrovanda vesiculosa* and *Utricularia biloba*. On the New South North Coast and into Queensland impressive plants of *D. binata* var. *multifida* occur, (Figure 2) some with leaves with up to 63 terminal lobes. Many coastal wetlands supporting carnivorous plant have been destroyed by clearing and development — and the development pressures continue.

Rainforest habitat of the Wet Tropics of Far North Queensland support the three rainforest sundews (*D. adelae*, *D. prolifera* and *D. schizandra*) where they remain rare and grow in isolated subpopulations.

The tip of Cape York includes seepages and freshwater wetlands in

Figure 2. *Drosera binata* var. *multifida*.

sandstone country of the Jardine River. It is home to *Nepenthes mirabilis*, *N. rowanae* and *N. tenax* (Figure 3), as well as an array of species of *Byblis*, *Drosera* and *Utricularia*..

The floodplains of the Kimberley Region of Western Australia support a wonderful array of carnivorous plants. Fire is a frequent event in this habitat, to the benefit of many smaller species. However, the spread of exotic pasture grasses create more biomass which results in hotter fires. These hot fires are now changing the woodland – grassland boundary and reducing the local seed bank, and adversely affecting many local populations of carnivorous plant.

Figure 3. *Nepenthes tenax.*

Seasonal wetlands of the Top End of the Northern Territory support a wonderful array of carnivorous plants, many of which are protected by Salt Water Crocodiles! Old sand and gravel quarries around Darwin provide excellent habitats for a diverse array of carnivorous plants – perhaps at the expense of the general area through changed hydrology. The western Top End is a centre of diversity of the *Drosera petiolaris* complex, where putting a name to a plant in the wild can still be a challenge. It is also a centre of diversity of the *D. indica* complex which includes many attractive taxa, including *D. serpens*. The Kakadu escarpment to the south east of Darwin provides habitat for a different range of carnivorous plants, particularly *Utricularia*, and still appears to support undescribed taxa.

Dr Adam Cross – Little left to lose: habitat loss and the global challenge of returning to a carnivorous plant inhabited landscape (Figure 4).

Mounting evidence from multiple sources suggests that we are now in the 6th Age of Extinction (e.g. Barnowsky *et al*., 2011). Habitat loss is the main cause of species' loss, and is found widely from the coastal plain of the SE United States of America, on and around inselbergs, in wetlands across the globe, and the loss of tropical rainforests.

On the positive note, ecosystem rehabilitation and restoration is now being widely practiced, however in relation to carnivorous plant habitat results have so far not been so good. This is due to such things as the intrinsically different nature of the modified (often post-mined) landscape; skeletal soils of ridgelines, for example, replaced by more porous moulded mine spoil with different hydrology and nutrient levels. Unfortunately it appears that the more specialized species have limited resilience to a modified environment. Additonally there are few carnivorous plant taxa that have been included in revegetation or rehabilitation projects anywhere in the world.

Figure 4. Adam Cross delivering his talk.

South Western Australia is a global biodiversity hotspot. Of the ca. 12,000 plant species that occur there about 70% are endemic. About 97% of this region has been cleared; mostly for agriculture (Figure 5). About 90% of the carnivorous plant taxa of this region are also endemic; most of which have small ranges. However there has been no International Union for the Conservation of Nature (IUCN [http://www.iucn.org/]) list compiled for this region, nor are there any management plants yet for any of the *Drosera* taxa.

Land clearing has resulted in additional threatening processes in the region, including salinity, erosion, weeds and canopy dieback due to exotic pathogens. However, most of the damage has already been done. Thus it is important to protect and enhance what is left.

Mining has been and remains one of the main causes of land clearing (Figure 6). There are currently about 300, 000 open pits in Western Australia, which suggests how large the cumulative impact of mining on biodiversity has been. Mining is still expanding, such as proposed coal mines near Esperance, and expanding bauxite mining in the Darling Range. It is perhaps the new and expanding Iron Ore mines that pose the greatest risk to biodiversity due to its occurrence in areas of high degrees of plant endemism, such as the Pilbara, which are botanically still poorly known. Thus we are losing species before we even know about them, including potentially additional members of the *Drosera macrantha* complex.

Rehabilitation and restoration of cleared and damaged landscapes in the region is not so simple. Tens of thousands of square kilometres have already

Figure 5. Wheatfield with remnant Eucalypts, Wongan Hills.

been affected. There are so many unknowns, such as the ecology of various plant species, their breeding systems, and their relationships. Even such basic things of how to germinate seed are not known for many of these plants. Thankfully several research institutions, such as Kings Park and Botanic Gardens and the University of Western Australia (currently focusing on Integrated Restoration Science) have been conducting research to help fill this knowledge gap.

Different microhabitats, with different hydrology, soil chemistry, profile, and microbial activity etc. are essential for accommodating a greater range of biodiversity. This can be difficult to achieve on rehabilitated mine tailings that may be 25% Iron Oxide and 75% Quartz. Rehabilitation of tailings is now a State Government requirement but there may be problems with the wording of consent conditions and how they may be interpreted and implemented, e.g. what does "...70% of species returned in 5 years..." mean in an ecological sense? Geophytes, such as tuberous *Drosera* and orchids, and annuals are often missing. Fire is often ignored.

There have been some exceptions. For example on the Alcoa bauxite mining leases in the Darling Range SE of Perth. Under the guidance of Dr. David Williams they have raised large numbers of *Drosera erythrorhiza* (5,300 plants) (Figure 7) and *D. stolonifera* (52,000 plants) in tissue culture and added them to post-mine rehabilitated land. Many of these plants have survived and flowered, and recruitment has occurred. The success with these species has been helped by such steps as X-raying seed to test viability before using them in tissue culture. There is still work to do, for example

Figure 6. Land cleared for mining.

determining seed longevity, reproductive ecology, and biology of a range of sundews, including the *Drosera macrantha* complex, and how they may be used in rehabilitation. The main limitation to gaining greater understanding of these species usually comes down to that of cost. Consent conditions for recently-approved mines now often include a funding requirement for research to assist with rehabilitation.

Older developments in the over-cleared Wheatbelt, in contrast typically have no rehabilitation requirements. However, there are some revegetation projects in that region, of which the Gondwana Link Project [http://www.gondwanalink.org/], run largely by volunteers and donations is the largest single project in the region.

In conclusion, the current mining boom in Western Australia is leading to the loss of more areas of remnant native vegetation and its associated biodiversity. However, it is also now associated with active research and implementation of rehabilitation. The region has lost an unknown and unknowable amount of its biodiversity but the best time to do something positive about that, to help know and preserve what is left is now.

Figure 7. *Drosera erythrorhiza* subsp. *collina*, Darling Range.

Dr Katja Rembold – Diversity and conservation of the genus *Nepenthes* (Figure 8).

Nepenthes diversity and conservation were tested using spatial analysis of currently available information in a Geographic Information System (GIS) environment. There are currently about 120 accepted species which are conventionally classified as ‘Lowland’ or ‘Highland’ species, of which highland species are often highly restricted in disjunct locations separated by unsuitable habitat.

This project aimed to identify *Nepenthes* biodiversity hotspots for preferential conservation in order to preserve the most number of species. The available data was first assessed for its veracity, and in several cases locational detail was too vague to be useful for this project. The remaining data was analysed to identify hotspots of *Nepenthes* diversity where multiple species grow together. These hotspots included Gunung Mulu and G. Murud (with 17 species), the Hose Mountains (14 species), and Mount Kinabalu (16 species) in Borneo, and peaks in the Barisan Mountains along the western edge of Sumatra. It was noted that while the Philippines have 17 species of *Nepenthes* most taxa did not grow together.

This work showed that different species varied greatly in their densities and distributions. For example, 32 species were found to have ranges of less than 400 km^2. And not all of these species occur in National Parks. This means

Figure 8. Greg introduces Dr Katja Rembold.

that in order to achieve tangible conservation results requires networking with a range of people and organisations on the ground, particularly in South East Asia; such as the Southeast Asian *Nepenthes* Study and Research Foundation [http://www.savenepenthes.org/].

Land clearing, particularly for Oil Palm plantations, has occurred rapidly over many parts of South East Asia It is a threat to biodiversity, especially outside National Parks.

The work also showed a link of *Nepenthes* distribution to areas of ultramafic lithology. Satellite imagery has been useful in refining plant distribution range estimations, but in areas of poor data, such as in Kalimantan where access to areas is often limited, there is a risk of over-estimation or under-estimating the ranges of different species of *Nepenthes,* but it is a start.

Rob Cantley – Conservation – The IUCN Carnivorous Plant Specialist Group (Figure 9).

The International Union for the Conservation of Nature (IUCN) plays a pivotal role in providing advice for planning, implementation, monitoring and evaluation of conservation work around the World. It works is done with and on behalf of IUCN members.

One of the key tasks of the IUCN is the generation of 'The IUCN Red List of Threatened Species' [http://www.iucnredlist.org/]; the first and most comprehensive effort to categorise the conservation status of all taxa of all life on the planet. This is an enormous task. It is therefore not surprising that many details on the Red List are incorrect, or out of date; due to such things

IUCN SSC Species Survival Commission
Carnivorous Plant Specialist Group

Figure 9. Rob Cantley photo from the IUCN-CPSG webpage.

as taxonomic changes. This is where Thematic Specialist Groups can make a big difference. It was one of the main reasons why the IUCN Carnivorous Plant Specialist Group was formed in 2012 [http://www.iucn-cpsg.org/]. The patron of this group is Sir David Attenborough with Rob Cantley as its chair.

Charles Clarke and Ch'ien Lee have made a great start updating the assessment on the genus *Nepenthes*. They put together an updated list of recognized taxa in the genus which included identified threats, ecological details, and specific conservation efforts required; they established a baseline of required information; they assessed the conservation level of each taxon (i.e. Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX); from which they estimated the extinction risk for each taxon. This work also involved many expert workshops.

Achievements of this group in 2013 included:

- Nominating *Nepenthes attenboroughii* as a 'breaking point project' species;
- Nominating Stewart McPherson for an 'Excellence in Plant Conservation' Award; and
- Completing a Red List Assessment of 15% of all recognized *Nepenthes* species [http://www.iucn-cpsg.org/Red%20List%20Activity%20Report%202013%20-%20abridged.pdf].

Plans for 2014 include:

- Establishing a website for this group;
- Recruiting new members – please keep in mind that you know more than you think you do;
- Producing a Quarterly Newsletter;
- Establishing a presence on social media, such as FaceBook; and
- Reviewing at least another 60 species of *Nepenthes* as well as taxa in the Droseraceae.

So, this is how can you help:

- Join the group;
- Spread the word about this group;
- The more members the group has shows more universal support, and this has a direct correlation to funding that this group may attract;

You may consider being a specialist member for this group to help with such tasks as:

- Contributing to Red List assessment;
- Editing the newsletter;
- Maintaining the webpage and social media (the aim is 1 person per genus); and
- Red List administration and mapping (ArcGIS and GeoCAD).

Aims for this group include:

- Developing conservation initiatives; and
- Endorsement of funding opportunities, assistance with government spending (e.g. collection permits) and developing a network of experts.

So in conclusion, the IUCN Carnivorous Plant Specialist Group exists and is doing exciting and important work to understand and preserve carnivorous plants. Please consider joining it.

Figure 10. Jan Schlauer delivering his talk.

Jan Schlauer – Field Notes from Andalucía, Spain (Figure 10).

Dr Schlauer presented a summary of a fieldtrip to Andalucia, in southern Spain, near Gibraltar, for the study of *Drosophyllum lusitanicum* and several species of *Pinguicula.*

Drosophyllum lusitanicum was observed growing at one site in a small area of low open shrubland around sandstone outcrops. The plants grew in very limited areas of wetland vegetation centred on small seepage zones.

The *Pinguicula* species studied grew on either sandstone ('S') or limestone ('L') mountains, and were *P. nevadensis* (S), *P. vallisnerifolia* (L & S), *P. mundi* (L & S), *P. dertosensis* (L & S) and *P. grandiflora* (S). They often occurred in very small, locally humid locations that were frequently associated with waterfall and the banks of streams. This snapshot of the local assemblage of species suggests that dispersal of *Pinguicula* is a rare event, and that plants probably persisted at suitable sites for long periods of time.

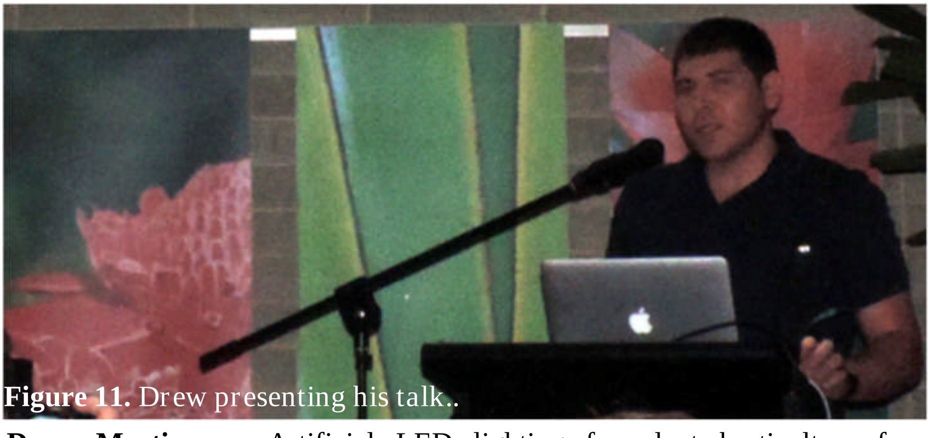


Figure 11. Drew presenting his talk..

Drew Martinez – Artificial LED lighting for plant horticulture for carnivorous plant growers (Figure 11).

Drew completed a Master of Science (MSc) degree at the University of Arizona in which he studied the effectiveness of Light Emitting Diode (LED) lights in growing carnivorous plants. The project included a comparative study of the unit cost of purchase, the running costs, the light output (measured in lumens/ watt), and the Photosynthetic Active Radiation

(PAR) (measured as Watts (W)/m^2) between a number of fluorescent and LED lights. Drew's results are summarized in Table 1 (below):

Table 1. Comparative summary of the fluorescent and LED lights in Drew's study. Irradiance measured 30 cm from the light.

Light Type	**Unit Cost ($US)**	**Power requirement (Watts)**	**Light Output (lumens/Watt)**	**Bulb life**	**Notes**
T8 Fluorescent	$25 for 2 bulbs; $8-12 for replacement bulbs	32	8-100	20K hours	Output degrades well before end of bulb life
T5 Fluorescent	$65-120 for 2-4 bulbs; replacement bulbs $10	54	8-105	10-20k hours	
LED			4.5-150		
T8 LED	$22-80 per bulb	22		5 years (43.8k hours)	Minimal output in decline
LED Strips	$4-25/ metre	12-18		1-2 years	Must have well-maintained heat sink
High Performance LED	$400+ per bulb (custom designed)	90-400		5 years	Minimal output in decline

Unit cost in Table 1 includes the cost of mountings. This explains why the cost of replacement bulbs is less than the initial outlay. Running costs were based on lights about 1.2 metres long that were on for 14 hours per day.

Theoretically LED lights could produce up to 300 lumens per watt, but they are not there yet. LED lights are proving very useful for in-vitro plants, particularly in shelves, and for those grown indoors.

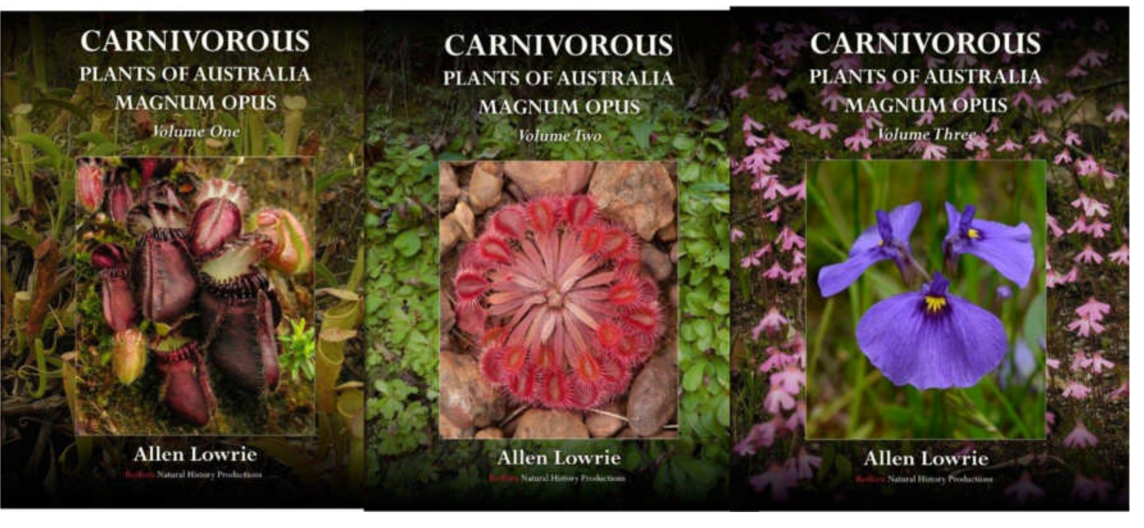
LED lights produce a lot of heat (especially white light); they require a good quality power supply (typically 12 Volts) and are 25-40% efficient compared to current fluorescent lights. However, they generally have a longer life than comparable fluorescence globes. There is the need to match the LED output more carefully than with fluorescent globes, for example use red LED lights for *Heliamphora* and *Nepenthes*, and red and blue LED lights for *Dionaea.*

Allen Lowrie – launch of 'Carnivorous Plants of Australia – Magnum Opus'

This large, three volume book set is published by Redfern Natural History Productions [e.g.http://www.redfernnaturalhistory.com/books/carnivorous-plants-of-australia-magnum-opus-vol-1/]. Collectively they cover 242 different species in six genera. They synthesize five decades of research into these plants, with much having study taken place of the plants in the wild. Some plants required 20 site visits in order to get a better understanding of their biology and ecology. This study came at much personal cost to the author, but this enabled comprehensive and well-documented accounts of each species to be produced.

The book set includes dichotomous keys and descriptions that are intended to enable anyone to be able to find a name for a plant they see in the wild. It also includes biographies of all botanists who have described carnivorous plants native to Australia. It provides an excellent background to these people and conveniently places much disparate information in one accessible source.

This book set is an impressive piece of work.



Jeremiah Harris – Cultivating Finicky Carnivorous Plants (Figure 12).

Jeremiah provided a synthesis of his experience in successfully growing a number of hard-to-grow carnivorous plants and provided tips on cultivating these plants.

What makes a plant fussy?

- Light – insufficient to what the plant requires;
- Slow growth rate, so they are unforgiving of any ‘accidents’;
- Temperature range (heating is easy; cooling is difficult);
- Large size (they outgrow their terrarium/ freezer/ growing chamber);
- Water quality;
- Humidity (this is relatively easy to address); and
- Growing medium (this is often the least important factor of this list).

There are number of different cultivation methods available for such plants:

- Window sill with a few hours of direct sunlight per day;
- Outdoors – this works well for many carnivorous plants;
- Terrarium – excellent for those starting this hobby; and
- Greenhouses – invariably they are never big enough.

Figure 12. Jeremiah presenting his talk.

Where to start?

Get to know how fellow growers grow their plants;

Research your target plants – where they grow, their ecology, other people's experience in growing them;

Be discerning of bad information (just because it is on the internet does not mean it is true);

Spend about as much on the growing set up as on the plants themselves; and

Keep good records, e.g. well-labeled plants, when they flower, gender....

General comments on growing environments:

Window sills – generally not so good for fussy carnivorous plants with a low success rate; but worth trying if you have excess plants;

Terrariums – you can use a daily insertion of frozen water bottles into them to keep them cool, but this is a lot of effort. Converted freezers can work well, especially for ultra-highland *Nepenthes*, for example in such a set up Jeremiah had a *N. rajah* plant grow from 8 cm diameter to 50 cm diameter in 14 months;

Greenhouse – is your only long-term option however cooling them is still a major problem. Solutions include evaporative air cooling, air conditioning, shading (but some fussy plants require full sunlight), and misting systems, but be careful not to over-mist. It is possible to set up different microclimates in a greenhouse, e.g. highland section in front of the mister/cooler. The door is kept open at times to bring in clean air. Pots have a cover of live sphagnum moss to slow the degradation of peat moss. The greenhouse floor comprises a weed mat set on about 5-8 cm of pea gravel which in turns sits of bare earth.

Comments on some fussy plants grown by Jeremiah in Boulder, Colorado, USA (40°01'39"N, 105°15'07"W, 1655 metres altitude):

Roridula dentata (Figure 13)

Needs lots of light;

They grow best in terracotta pots, but do okay in plastic pots;

They need good air flow around them;

Keep drier than most other carnivorous plants, water by drip irrigation rather than having the pot sitting permanently in water; and

They are highly susceptible to growth tip rot.

Figure 13. *Roridula dentata* in the wild in South Africa.

Cephalotus follicularis

Use very pure water;
Don't over-mist;
Watering: don't over or under-water, drip irrigate rather than use a water tray;
They require good drainage; and
Light levels – not a big deal.

Heliamphora follicularis

Use pure water only (from Reverse Osmosis);
Leaves require near constant misting;
Plants require good drainage – use a mix of sphagnum moss + chunky perlite ± charcoal;
Needs very bright light; and
Needs cool temperatures.

Darlingtonia californica (Figure 14)

- Grows in a large pot buried beside the greenhouse;
- Use pure water only;
- Loves misting;
- Requires good drainage;
- Brightest light for good colour development; and
- Requires cool temperatures, particularly around the roots. This is achieved by the installation of a temperature controlled drip system on a repeat cycle which is linked to the greenhouse thermometer (set to around 16°C)

Figure 14. Darlingtonia grown at Bathurst, N.S.W.

Drosera regia (Figure 15)

- Use pure water;
- Don't over-mist;
- Give plenty of light; and
- Grows best in large pots.

Figure 15. *D. regia*

Drosera graomogolensis

- Use pure water;
- Don't over-mist;
- Grow in large pots (30-55 cm. diameter);
- Grown under fluorescent lights; and
- Keep cool (grown with Highland *Nepenthes*)

Utricularia* section *Orchioides

- Require a well-drained mix (grown in net pots with live sphagnum moss);
- Use pure water;
- Keep pots isolated (these species are avid 'pot jumpers'); and
- Grow best under diffused light, such as under benches.

Nepenthes northiana

Struggles when small;
Very slow growing when young;
Keep temperature and humidity stable;
Requires high light levels; and
Requires a light and airy potting mix, e.g. live sphagnum moss + chunky perlite + charcoal.

Nepenthes jacquelinae

Some clones are very fast growing.

Nepenthes edwardsiana

Easy once established; and
Requires high light and humidity levels.

Nepenthes macrophylla

Very slow growing.

Nepenthes villosa

Slowest growing of all *Nepenthes*;
Difficult to maintain in the long term; and
Requires cool days and cooler nights.

Nepenthes rajah (Figure 16)

Plant started in a modified freezer;
Notoriously difficult to cultivate, but can be grown outdoors in Hawaii;
Ultimately forms a massive plant and requires a greenhouse;
The main stem frequently dies off and is replaced by basal shoots;
Grown in a mix of 95% long fibre sphagnum moss + 5% perlite;
Requires high light and humidity > 70%;
Mist – always; and
It took 6 years for a seedling to mature and flower.

Please note these observations are specific to Jeremiah's local conditions which may not exactly match your conditions, so the text here is intended as a guide only.

Figure 16. *Nepenthes rajah* at Mesilau.

Ch’ien C. Lee – Recent Discoveries in Nutrient Acquisition Strategies in *Nepenthes* (Figure 17).

We are currently in a renaissance of new *Nepenthes* discoveries with many new taxa discovered and named, e.g. the spectacular *N. attenboroughii*. Until recently *Nepenthes* were thought to only be carnivorous, that was despite much variation in pitcher form which suggests specialization for different

Figure 17. Ch’ien Lee starting his presentation.

types of prey, e.g. white hairs under the mouth opening for *N. albo-marginata*; a termite specialist and *N. lingulata* which appears to be a wasp/ fly specialist. This renaissance has been largely driven by greater access to the region where the genus grows, so that now is better than ever to study these plants in the wild.

It is important to note that whilst some species have evolved for specific prey and habitats, e.g. ultramafic rock outcrops, most species are still considered to be generalists.

Some of the current areas of interest in the genus include:

- Evaluation of pitcher morphology and function – the basic form is archetypal for nutrient accumulation and assimilation, therefore minor changes in pitcher form can lead to very different trap function by way of prey type;
- Some species are detritivores. The best known is *N. ampullaria* which obtains 30-50% of its Nitrogen from leaf litter. This species is well-known for its relatively long-lived pitchers (leaf breakdown is usually a slow process). Its pitcher fluid is not very acidic which also helps leaf tissue breakdown, and they have an abundant and complex in-fauna assemblage (Figure 18). *Nepenthes lowii* also appears to be a facultative detritivore too;

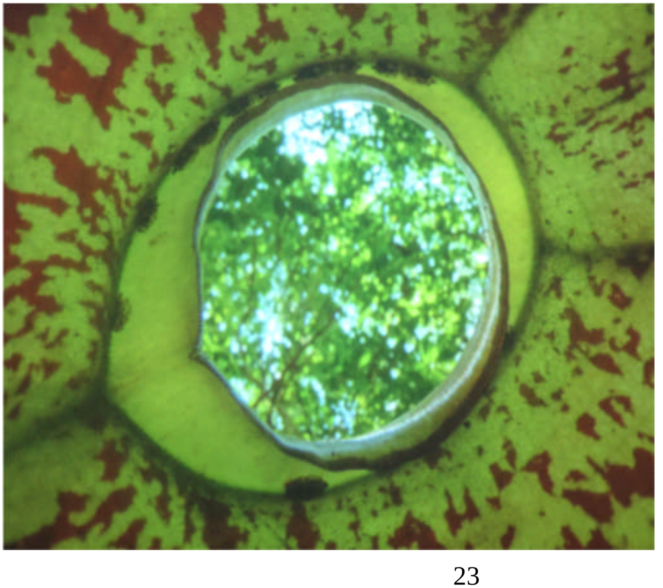


Figure 18. Small flies on the protected inside rim of a *Nepenthes ampullaria* pitcher. Photo by Ch'ien Lee.

Some species obtain nutrients from mammal droppings – *N. lowii* plants have been recently found to have obtained 50-100% of their Nitrogen from Tree Shrew droppings. These hyperactive small mammals eat just about anything and have been observed pooping in *N. lowii* pitchers. *Nepenthes rajah* and *N. macrophylla* may also benefit the same way, and have similarly large pitchers with broad openings. It is possible that the Summit Rat, endemic to Mt Kinabalu and Mt Tambayukon may also behave in a similar way with some local *Nepenthes*;

Several different vertebrates have been recently found to have a commensal relationship with some species of *Nepenthes*, e.g. Hardwicke's Woolly Bat *Kerivoula hardwickii* use *N. rafflesiana* var. *elongata* (= *N. hemslyana*) for roosting (see pages 26-28); *Microhyla borneensis*, a newly described species of frog with adults to 1 cm long lays its eggs in the pitchers of *N. ampullaria*. Each egg contains sufficient yolk for the tadpole to grow to maturity without the need to eat, but perhaps their presence adds Nitrogen to the pitcher? An undescribed species of Bush Frog *Phalotus* sp. uses pitchers of *N. hurrelliana* in the same way;

Other observed animal – pitcher interactions include:

An unidentified rat or mouse using pitchers of *N. rajah*;

Tree Shrews *Tupaia montana* using pitchers of *N.* x *kinabaluensis*. This is subject to a current study project. *Nepenthes. ephippiata* is a prime candidate for a similar study project;

N. lowii pitchers emit a distinct yeast-like smell and thus may have an interaction with fruit flies?

N. ampullaria pitchers have many invertebrate associates, few of which have been studied;

Snails have been observed feeding on the underside of lids of *N. lowii* and *N.* x *trusmadiensis*;

Sugar Gliders *Petaurus breviceps* have been observed ripping cultivated *Nepenthes* pitchers apart in the quest for food;

Metallic skinks *Niveoscincus metallicus* sit at the entrance of some cultivated *Sarracenia* pitchers licking nectar from the plants; and

Blue Jays *Cyanocitta cristata* rip *Sarracenia* pitchers apart to obtain insects for food.

Allen Lowrie – *Stylidium* (Triggerplants), are they carnivores?

Stylidium is a genus of about 360 species, all of which have glandular hairs present to various degrees on plant parts; some have a few glands, others are densely glandular hairy (Figure 19). Herbarium specimens with insects stuck to leaves have been known for decades, and cultivated plants of *Stylidium daphne* have been observed with insects getting stuck in glandular hairs on the leaves.

There is anecdotal evidence of the breakdown of trapped insects. It is worth noting that *Stylidium* often grow with *Drosera* and other carnivorous plants in nutrient-poor soil, and often support Sundew bugs (genus *Setocoris*) on them. Some *Stylidium* have been considered to be protocarnivorous (e.g. Darwnowski *et al.*, 2006), but Allen suggests that perhaps all species could be considered to be carnivorous. Further study is required.

Figure 19. *Stylidium adenophorum*; from near Musgrave, Cape York with glandular hairy leaves, scapes and many parts of the flowers.

Michael G. Schoner – The Bornean pitcher plant *Nepenthes hemsleyana* - its natural history and interaction with a bat mutualist

Animal-plant interactions may be of three broad types:

Mutualism (symbiosis) where all parties benefit;

Commensalism where one party benefits, with nil effect on the other; or

Parasitism where one party benefits at the expense of the other.

In practice it can be difficult to tell these interactions apart.

Nepenthes rafflesiana sens. lat. occurs in at least two different forms: var. *typica* and var. *elongata*. They have pitchers of different shape and function and have different strategies for trapping different prey. *hemslyana* (see Table 2, below):

Table 2. Key differences between *N. hemslyana* and *N. rafflesiana*.

Character	*N. rafflesiana* var. *typica*	*N. rafflesiana* var. *elongata* (=*N. hemslyana*)
Pitcher opening	Wide	Narrow
Location of hip	Low	High
Digestive fluid level	High	Low
Exterior pigment pattern	Bright and complex	Simple and low key
Insect prey capture	High	Low
Use by roosting bats	No	Yes

Nepenthes hemslyana was first collected by Frederick Burbidge in 1877 and described by Macfarlane in 1908. However, Danser reduced it to synonymy with *N. rafflesiana* in 1928. It was informally referred to as *N. rafflesiana* var. elongata until being described (erroneously) as *N. baramensis* by Clarke *et al*. (2011) on the basis of its morphology and ecology. Scharmann and Grafe (2013) recognised that this *Nepenthes* had been formally described more than 100 years ago and reinstated *N. hemslyana.*

During bat tracking studies in Brunei it was found that all Hardwicke's Woolly Bat *Kerivoula hardwickii* occurred in Peat Swamp Forest in which a number of *Nepenthes* occurred. The studies revealed that these bats roosted almost exclusively in pitchers of *N. hemslyana* (Figure 20). These forests grow in soils that are very deficient in Nitrogen. Bat poo however, is rich in Nitrogen and Phosphorus. This led to a brief study in which it was found that the plants observed had obtained on average 33.8% of their Nitrogen from bat droppings.

This led to another question of how the bats used echolocation in dense vegetation in which to find the pitchers to roost in. Consequently the acoustic properties of *Nepenthes* pitchers were studied. It was discovered that *N. hemslyana* pitchers had strong reflectance of frequencies between 40 and 160 kHz from the back of the mouth of the pitcher, about from 20 cm from the pitcher (in a study area of about 1.3 m^2). It was also found that individual bats had strong fidelity to particular pitchers, but that towards the end of the 2-4 month life of an individual pitcher that the bats moved to a new pitcher when their current home started to wilt.

Figure 20. Bat flying into *N. hemslyana* pitcher. Photo by M. Schoner.

Caroline R. Schoner – Interactions between carnivorous plants and animals – what's in it for the plants?

Nepenthes pitchers can contain and maintain entire ecosystems. They are home to a whole range of bacteria, rotifers, mosquitoes, crabs, frogs etc. Ants are known to inhabit the tendrils of *N. bicalcarata.* Interactions with mammals (aside from humans) are rare, but include Hardwicke's Woolly Bat *Kerivoula hardwickii*. This bat species is known to roost in pitchers of *N. ampullaria*¸ *N. bicalcarata* and *N. hemslyana*, however they only use the old or damaged pitchers of the first two listed species.

Nepenthes pitchers were found to be about 1°C cooler than the outside ambient air temperature. Humidity levels also varied. The interior of *N. bicalcarata* pitchers were generally less humid than their exterior, however those of *N. hemslyana* were always found to be consistently more humid than the exterior ambient levels.

Bat roosts are often homes to bat parasites too, many of which provide resources that these invertebrates need. However, *N. hemslyana* pitchers used by bats were free of these bat roost parasites; perhaps they had become plant food?

Analysis of bat utilization of *N. bicalcarata* and *N. hemslyana* pitchers in the wild showed that the latter were a preferred roost site (used for up to 11 days, rather than up to 5 days for *N. bicalcarata* pitchers).

A study of *N. hemslyana* plants showed that plants caught about 35 mg of arthropods per week, on average 0.6 days per week. Pitchers used by roosting bats had on average 40 mg of bat poo in them. This lead to a controlled feeding experiment where pitchers were fed once a week with one or more of a combination of the following: flies, bat faeces, flies & faeces, or nothing over an 18 week period. Plant growth, Nitrogen, Phosphorus and Potassium were measured during this time. At the end of this experiment it was found that plants did best on a diet of flies & faeces, as measured by photosynthesis rates and the quality of chlorophyll in the study plants.

In conclusion the bat–plant interactions are an example of mutualism, where both parties benefit from the activities of the other. This study has produced wonderful insight into this interaction, but has also raised a whole lot more questions.

Dr Andrej Pavlovic – Costs and benefits of electrical signaling in carnivorous plant Venus Flytrap (*Dionaea muscipula* Ellis) (Figure 21)

Insects are about 10% Nitrogen, but plants, such as *Brocchinia* are generally between about 1-2%. By trapping and assimilating insect prey carnivorous plants are able to increase their rate of photosynthesis and thus their growth rate. The cellular structure of traps of carnivorous plants more closely resemble those of roots than typical plant leaves. Therefore it is perhaps not surprising that carnivorous plant traps often have a lower rate of photosynthesis than typical plant leaves; which is the 'cost of carnivory'. However, it has been found that this cost is reduced at higher light levels.

Dionaea muscipula has an active trap in which trap closure is triggered by physical stimulation of sensitive trichomes ('trigger hairs'). This is translated by the release of Calcium ions into electrical signaling. However, this is very costly for *Dionaea* plants, by way of reduced photosynthetic rates. *Dionaea* plays a balancing act in seeking to optimize its available resources to produce traps, trap insects and grow in nutrient poor environments.

Figure 21. Venus Flytrap plant in the wild in North Carolina.

Naoki Tanabe and **Koji Kondo** – Habitats of *Pinguicula* Native to Japan

Two species of *Pinguicula* are native to Japan: *P. ramosa*, which is a rare endemic species; and the more widespread but morphologically variable *P. macroceras*. This talk described the habitats where these species occur.

Pinguicula ramosa is endemic to the Mt Nantai and Unryu Valley area of central Honshu Island. It is characterized by scapes that regularly bifurcate near the base so that they produce two flowers per scape, which is unique in the genus. This species is known from three locations, at least two of which are locally humid cliff-base habitats where they are often exposed to frequent mists. Both cliff habitats comprise a few square metres and support at most a few hundred plants. As if the state of this species in the wild was not precarious enough, one of these two sites was destroyed by a mud and rock slide, that may have been triggered by the Great East Japan Earthquake of 2011. The two other sites may also be at risk of landslide.

Pinguicula macroceras was described from nine different habitats. These varied from a moist grassland on an open rocky slope on Mt Shibutsu, where plants flower in July and grow with *Drosera rotundifolia*; to the Ayamedaira peat bog; to dry grassland on Mt Akagi; to short alpine grassland on Happo-one Ridge; to a waterfall at Neo; and to the base of a moist cliff at Iidalia. These sites supported between 20 and several hundred plants, and occurred at different elevations. Plants varied in size, flower morphology and flower colour between sites. In addition plants from lower altitude sites tended to be easier to maintain in cultivation.

Figure 22. Alastair Robinson starts his

Alastair Robinson – Palawan: A Microcosm for *Nepenthes* Taxonomy (Figure 22).

The island of Palawan in the Philippines has an area of about 12,000 km^2 of which about 45% is composed of mountains. This island has low levels of development which also means that access to the mountainous interior is often difficult. About 1,530 plant species ae native to Palawan of which about 20% are endemic Many species are also shared with Borneo which occurs to its south west.

There is a strong correlation to the flora with the underlying lithology. This reflects the geological origins and history of the island, which started forming about 35 million years ago. It has been above sea-level for about 10 million years. The northern third of the island is comprised of sandstone and limestone, but the remainder is composed of ultramafic ricks which form the isolated large mountain peaks.

The flora of Palawan includes nine recognized species of *Nepenthes* which have been described over the last 106 years (See Table 3, below):

Table 3. Summary of *Nepenthes* in Palawan.

Year	*Nepenthes*	Notes
1908	*N. deaniana*	Type lost during World War 2. Rediscovered on the topmost 100 metres of Thumb Peak in 2007. Closely related to *N. villosa*.
	N. philippinensis	Very variable; sometimes considered as a variant of *N. alata*; flowers are pollinated by the Wasp Moth *Amata huebneri* (Figure 23).
1998	*N. mira*	Related to *N. villosa* (about 300 km to the SSW).
2007	*N. mantalingajanensis*	Close to *N. villosa*, and related to *N. mira* and *N. deaniana*.
	N. attenboroughii	Only on the summit ridge of Mt. Victoria at about 1,700 m. altitude.
2010	*N. palawanensis*	Produces amongst the largest pitchers in the genus. Occurs only on Sultan Peak at a lower altitude than Victoria Peak.
	N. gantungensis	Endemic to Mt. Gantung.
	N. leonardoi	Endemic to Schom-carp Peak. Closely related to *N. deaniana* and *N. mira*.
2013	*N. campanulata*	Plants of *N. campanulata* discovered in limestone cliffs in the Saint Paul Karst in far north of Palawan. This was surprising and represents a large range extension, and a very isolated population.

Palawan's montane *Nepenthes* appear to all be closely related, so much so that five of these species are morphologically almost identical (*N. deaniana*, *N. gantungensis*, *N. mantalingajanensis*, *N. mira*, and *N. leonardoi*). This raises the question of whether they are 'good' species. Which in turn raises the question of 'what is a species? There are different species' concepts applied by different botanists and this has implications for how many species of *Nepenthes* there may be (between 33 and about 138).

Figure 23. Wasp Moth (*Amata* sp.)

A solution to this problem may be the recognition of subspecies, or even varieties. Danser (1928) in his benchmark work on the genus did not recognize subspecies. Perhaps it is time to revisit this idea? It also helps working in collaboration with other people, to raise and consider more data and ideas and also to better place new work in context of other work on the genus.

It is suggested that species criteria for *Nepenthes* must include:

Clear and consistent morphological differences;
An identifiable molecular signature;
Ecological differences; and
Non-geographic reproductive isolation.

The suggested criteria for subspecies (and variety) are:

Morphological similarities, e.g. Palawan, Indochina species complexes;
Cover a broad range of apparent phenotypes, e.g. *N. philippinensis*; and
No apparent reproductive isolation in the absence of allopatry (i.e. occuring in separate, non-overlapping ranges).

The *Nepenthes* flora of Palawan raise many interesting questions about *Nepenthes* evolution, ecology, taxonomy and classification. It appears time to have a discussion on the application of species concepts to the genus, consensus on the categorization of morphological features and how they are measured and defined, and the use of subspecific and varietal rank in a revised classification of the genus.

Figure 24. Andreas Fleischmann delivers his talk.

Andreas Fleischmann – Evolution of carnivory in the plant kingdom (Figure 24)

When mapped on the phylogeny of seed plants (angiosperms) carnivory has evolved at least 7 times. It currently occurs in 11 plant families, 18 genera and comprises about 800 species. Geographic centres of diversity occur in SW Australia, SW Africa and SE Brazil.

A phylogenetic breakdown of carnivory by order or phylogenetic group is given below.

POALES: *Catopsis* (1 of 2 species)
Brocchnina (2 of 30 species).
These pitcher plants are considered primitive, and use ultra violet reflectance patterns to attract prey. In addition *Brocchinia* leaves include false nectaries at the tips of their leaves to further attract prey.

CARYOPHYLLALES:
Dioncophyllaceae (1 species)
Drosophyllaceae (1 species)
Nepenthaceae (129 species)
Droseraceae (213 species in 3 genera)
Carnivory is often developed in monotypic genera in this order.

The development of different types of traps in this Order is becoming clearer: secretory gland evolves (e.g. *Plumbago*) > glands becomes vascularized (e.g. *Drosophyllum*) > trichome and leaf mobility develops (e.g. *Drosera*) > leaf shape is modified into a snap trap (*Aldrovanda* and *Dionaea*) OR sticky trap is housed inside the leaf to form a pitcher (*Nepenthes*). Sticky traps do not work well underwater, but snap-traps do; this suggests that *Dionaea* may be best considered as 'dryland *Aldrovanda*'.

OXALIDALES:
Cephalotus follicularis
It is hard to say how this species evolved. Despite superficial similarity to some *Nepenthes* pitchers the pitchers of *Cephalotus* develop in a different way.

ERICALES:
Sarraceniaceae (ca. 9 species)
Roridulaceae (2 species)

Roridula are palaeoendemic species in South West Africa that use resin to trap insectsIt ha. It has a digestive mutualism with invertebrates to obtain nutrients from trapped prey.

Sarraceniaceae comprise three genera: *Darlingtonia*, *Heliamphora* and *Sarracenia*; of which molecular and morphological studies suggest *Darlingtonia* is now considered to closest to the basal lineage of this family (Figure 25).

LAMIALES:
Byblis (ancestral trap);
Philcoxia (Gratiolaceae) – traps nematodes;
Lentibulariaceae (*Genlisea*, *Pinguicula* and *Utricularia*);

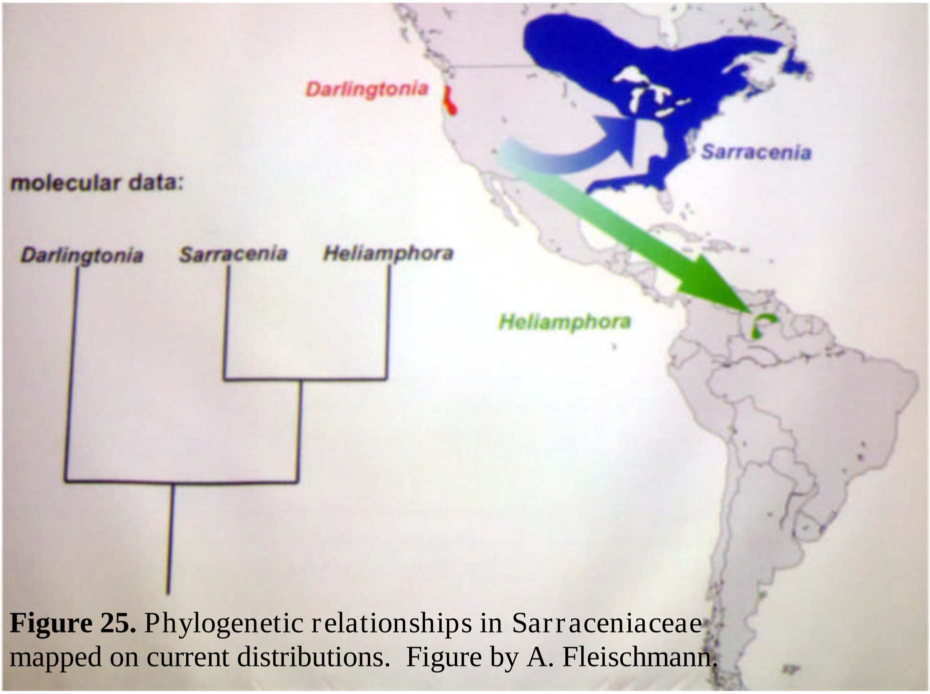


Figure 25. Phylogenetic relationships in Sarraceniaceae mapped on current distributions. Figure by A. Fleischmann.

Many members of the Lamiales have glandular hairs (e.g. *Orobanche*, *Salvia*), however not all stalked glands are vascularized.

The pathway to the development of carnivory in the Lamiales appears to have occurred as follows: Secretory glands > gland dimorphism > leaf margin movement > leaf margins fuse (tubular leaves are known from *Pinguicula*) > leaf dimorphism (= *Genlisea*) OR leaf bends through 180° (*Polypomphoyx* > *Biovularia* > *Utricularia*).

Strangely some species appear to be devolving from carnivory: e.g. *Drosera caduca* and *Utricularia neottioides*.

Gary Wilson – Studies of *Nepenthes* pitcher plants in Austro-Papua

Gary works at James Cook University at Cairns which has a herbarium (code is ‘CNS’). CNS has over 170,000 collections, a molecular lab for DNA sequencing, and staff and students with expertise in the study of ecology. Gary’s studies includes the phylogenetic, biogeographic and ecological study of *Nepenthes* in northern Australia and the adjacent part of southern New Guinea (‘the Trans Fly’). The deepest part of the Torres Strait that separates Australia from New Guinea is only 11 metres deep, making this current water barrier of about 150 km between both landmasses a very transient feature. Thus there are many ecological similarities between northern Australia and The Trans Fly, however because travel in the area is often dangerous it has been under-collected.

Nepenthes in Australia have a messy history. In 1905 there were 11 recognised native species. However between 1928 and 2005 this was reduced to one species, *N. mirabilis*. Currently there are three species recognized: *N. rowanae* (see front cover), *N. mirabilis* and *N. tenax* (Figure 3 on page 5). Presently neither *N. rowanae* nor *N. tenax* are known from New Guinea, but is this really the case? Similar habitat certainly occurs in that region. Have they simply not been collected?

Similarly, why is there no *N. ampullaria* in Australia? Suitable habitat seems to occur, e.g. in the Lockerby Scrub in Cape York? This species occurs in New Guinea about 350 kilometres from the tip of Cape York.

Current work at James Cook University is looking at the phylogeny of *Nepenthes* in Austro-Papua, which also extends to taxa in the rest of the genus. These studies include looking at morphology, pollination ecology, niche occupation and resource partitioning. From studies to date a new taxon, is proposed to be described based on a multi-faceted approach, such as its preference for very wet habitats.. It has been informally referred to as ‘mini tenax’ and has yet to be formally described.

Studies have found that Australian *Nepenthes* have a simpler food web in their pitchers compared to taxa in other parts of the range. This this may be due to the monsoonal climate in Australia which is perhaps marginally suitable to the genus.

The isolated, southern-most population of *Nepenthes mirabilis* in the Wet Tropics is currently classed as Endangered. There are problems with illegal collection, pig damage and wanton destruction of its habitat by land managers.

Mason McNair – *Sarracenia*: A Nomenclature Nightmare (Figure 26)

A study of the classification of the genus *Sarracenia* was undertaken using strict application of different taxonomic rank and an understanding of gene flow in wild populations.

In this study the following taxonomic definitions were applied:
‘Species’ = interbreed, fertile offspring, allopatric;
‘Subspecies’ = can interbreed but often don’t in the wild;
‘Variety’ = breed true; and
‘Form’ = based on a single trait.

Consistency of rank was applied in this study. This creates some problems, for example, if *S. rosea* is recognized then by extension *S. alata* variants, *S. purpurea* subsp. *montana*, and *S. rubra* subsp. *gulfensis* would all need to also be recognized at specific rank.

Identification of plants in the wild is often a fraught exercise. It is made worse if you have a fixed idea of what a particular plant ‘should’ look like. It pays to remember that hemember hybridization is rife in the genus, as increasingly being identified by recent papers on *Sarracenia* genetics. With that in mind is there really such a thing as a ‘pure species’ in such a genus?

Figure 26. Mason McNair presenting his talk.

The end result of this study was a dichotomous key (see below). This represents a hypothesis and is intended to stimulate further discussion and study on the genus.

Dichotomous key to *Sarracenia* Species, Subspecies, and Varieties
by Mason C. McNair

1. Flowers have white, yellow, or green petals→2
2. Pitchers have areoles flight windows)→3
3. Pitchers up to 30cm tall) *S. minor* var. *minor*
3'. Pitchers 70-80cm tall) *S. minor* var. *okefenokeensis*
2'. Pitchers do not have areoles→4
4. Pitchers have 6 structural ribs including the ala; Plants can have pubescence; Plants typically have more linear than reticulate venation; Plants have a prominent ala; Plants found from Alabama west to Texas→5
5. Plant from east of the Mississippi River (*S. alata* ssp. alata)→6
6. Pitcher is primarily veined with no pigmentation→7
7. Pitcher is lightly veined) *S. alata* ssp. *alata* var. *alata*
7'. Pitcher is heavily veined) *S. alata* ssp. *alata* var. *ornata*
6'. Pitcher is veined and also pigmented→8
8. Pitcher tube is veined but has no pigmentation→ *S. alata* ssp. *alata* var. *rubrioperculata*
8'. Pitcher tube has pigmentation→9
9. Pitcher lid, inner tube, and outer tube have pigmentation→10
9'. Only the pitcher lid has pigmentation→*S. alata* ssp. *alata* var. *cuprea*
10. Pigmentation is primarily dark red to black→*S. alata* ssp. *alata* var. *nigropurpurea*
10'. Pigmentation is primarily red→*S. alata* ssp. alata var. *atrorubra*
5'. Plant from west of the Mississippi River **(***S. alata* ssp. *mississippiensis*) →11
11. Pitcher has areolation→*S. alata* ssp. *mississippiensis* var. *areolata*
11'. Pitcher does not have areolation→12
12. Pitcher is lightly veined→*S. alata* ssp. *mississippiensis* var. *alata*
12'. Pitcher is heavily veined→*S. alata* ssp. *mississippiensis* var. *ornata*
4'. Pitchers have 8 structural ribs including the ala; Plants do not have pubescence or a prominent ala; Plants found from Virginia south to Florida and west to northeastern Alabama→13

13. Pitcher lid is convex and does not have a tendril and has recurved phyllodia→14
14. Pitcher heavily veined→*S. oreophila* var. *ornata*
14'. Pitcher has light or no venation→*S. oreophila* var. *oreophila*
13'. Pitcher lid is typically concave with an extended tendril at the tip and rarely has phyllodia (when they occur they are long and straight)→15
15. Pitcher lacking venation and/ or pigmentation→*S. flava* var. *maxima*
15'. Pitcher veined or pigmented→16
16. Pitcher has venation but little or no pigmentation→17
16'. Pitcher has venation and pigmentation→18
17. Pitcher throat and lid heavily veined→*S. flava* var. *ornata*
17'. Pitcher throat heavily veined→19
19. Venation densely clustered at the throat into a single splotch with no other venation anywhere on the pitcher→*S. flava* var. *rugellii*
19'. Venation lightly clustered at the throat and extending down the pitcher tube slightly and up onto the bottom of the lid→*5. flava* var. *flava*
18. The pitcher lid has coppery pigmentation→*S. flava* var. *cuprea*
18'. The pitcher tube has red pigmentation→20
20. The entire pitcher tube, lid, and throat are red pigmented→*S. flava* var. *atropurpurea*
20'. Only the pitcher tube is red pigmented, the lid and throat are primarily yellow with venation→*S. flava* var. *rubricorpa*

1'. Flowers have red, orange, or pink petals→21
21. Pitchers are decumbent→22
22. Pitcher has areoles→23
23. Pitchers predominantly 30cm long or larger, have little areolation, and have large, bulbous heads→*S. psittacina* var. *okefenokeensis*
23'. Pitchers predominantly less than 30cm long and contain prominent areolation→*S. psittacina* var. *psittacina*
22'. Pitcher lacks areoles→24
24. Pitchers large and robust; Interior of pitcher hood has long hairs; Pitcher hood is very broad with a small indentation at the tip; Pitcher body is squat, often possessing tan-red coloration; Pitcher has a very thick nectar roll (lip); flowers have pink petals→*S. purpurea* ssp. *burkii*
24'. Pitchers often compact and clustered; Interior of pitcher hood has short hairs; flowers have red to maroon petals→25

25. Plants found north of Maryland; Hood contains a prominent indentation at the hood apex; Pitcher body is thin and narrow; Pitcher hood does not or barely exceeds lip margin when pinched together→*S. purpurea* ssp. *purpurea*
25'. Plants found between Virginia and Georgia; Pitcher hood exceeds lip margin when pinched together→26
26. Pitcher body fat and robust→*S. purpurea* ssp. *venosa*
26'. Pitcher hoods are noticeably taller than the stout pitcher bodies. Pitchers are usually very brightly colored→*S. purpurea* ssp. *montana*
21'. Pitchers are erect→27
27. Pitchers have areoles→28
28. Pitchers have little to no venation on the lid, throat, and upper tube→*S leucophylla* var. *alba*
28'. Pitchers have prominent venation on the lid, throat, and upper tube→*S leucophylla* var. *leucophylla*
27'. Pitchers do not have areoles→29
29. Pitchers have a noticeable bulge at the throat just below the pitcher opening→*S. jonesii*
29'. Pitchers do not have a bulge at the throat just below the pitcher mouth→30
30. Pitchers are thin and linear in shape→*S. rubra* ssp. *rubra*
30'. Pitchers are not thin and linear in shape→31
31. Pitcher prominently funnel shaped and a sharply 'V'-shaped mouth→*S rubra* ssp. *gulfensis*
31'. Pitcher is broad with a curved 'V'-shaped mouth→32
32. Pitcher lid is undulate and has coppery pigmentation→*S. alabamensis* ssp. *wherryi*
32'. Pitcher lid is undulate and does not have coppery pigmentation on pitchers produced in the late summer and fall. Spring pitchers may have coppery pigmentation. Fall pitchers bright yellow→*S. alabamensis* ssp. *alabamensis*

Charles Clarke – Why are there so many species of *Nepenthes*? (Figure 27)

Nepenthes is a diverse genus, in which, naturally, the number of recognized taxa in it has increased over time, from 33 in 1873 to now about 157 taxa in 2014.

Figure 27. Charles Clarke delivering his talk.

It is important to note 'taxon' rather than 'species' are more robust units of a classification This is due to the different interpretation of what is or is not a 'species' between different people and over time.

There are other ways of measuring diversity, e.g.:

Ecological interactions; Trap structure;
Nutrient acquisition strategies; Molecular and chemical attributes; and
Habitat and geography.

A case can be made to take a stab at assessing a putative entity that is new to science, and working out the minutiae later, for documenting diversity is important. However, this approach makes the job of preparing a synopsis of the genus more challenging later on.

Why are *Nepenthes* so diverse? It is known that they have wide and diverse interactions with a range of different animals and this appears to go some way to answering this question.

What is a 'typical' *Nepenthes* pitcher? It is easy to recognize the 'weirdoes', such as *N. aristolochioides*, *N. inermis*, *N. attenboroughii* and even *N. ventricosa*. It seems the two main drivers of these weird pitchers are peristome morphology and the location of the hip. The driving factors for weird pitchers appear to be geographic isolation (in space and time) and complex interactions with animals. In contrast the periphyral species in the genus appear to be fairly generic in form.

Specialised Nitrogen specialization is confined to NW Borneo, Sumatra and the Sunda Shelf Lowlands (*N. albomarginata*). Lowland *Nepenthes* all capture ants in abundance, but ants are rare on tropical mountains so plants have to trap something else. In addition, insect abundance and diversity decrease with altitude on these mountains. The montane *Nepenthes* in NW Borneo and Sumatra display a diverse range of pitcher form, including where several species grow together. This suggests prey partitioning between taxa; but this has yet to be tested. It is known that some montane species in NW Borneo appear to specifically trap flies and mammal faeces.

Peristome structure is the primary character of many taxa of *Nepenthes*, and has been found to be a very effective trapping mechanism when wet, particularly in peri-humid areas such as NW Borneo and Sumatra. In contrast the waxy zone works everywhere, all the time. Wax is expensive for the plant to produce. This may explain why there are no *Nepenthes* taxa outside the peri-humid regions that have broad peristomes and small waxy zones.

Nepenthes distribution appears to be constrained by climate, e.g. no species is native to the strongly monsoonal 'Top End' or Kimberley regions of northern Australia; the Dry Season is simply too long to support them.

Nepenthes pitchers are very plastic in evolutionary time. They have the ability to respond quickly to minor climate variability. This has implications for the recognition of stable, 'good' morphological characters to use in the taxonomic study of the genus.

Future areas for study in the genus appear to be how they interact with local insect populations. It is not in the plants interest to catch all available insects.

Charles' talk was the last of the conference. Greg Bourke then closed the conference (Figure 28).

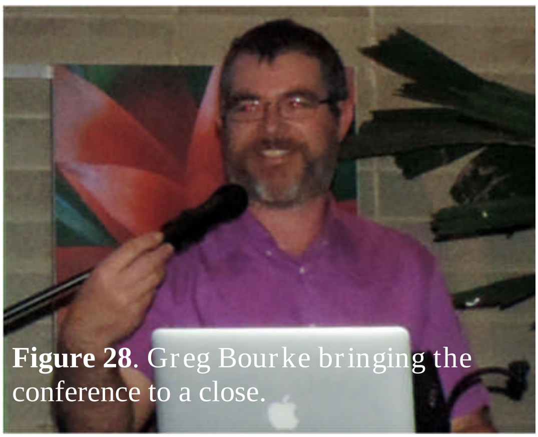


Figure 28. Greg Bourke bringing the conference to a close.

Notes to contributors

Contributions including articles, letters, photographs and drawings to the journal are greatly appreciated and may be forwarded to the Society's postal address or on-line. The views expressed in this journal are of the authors not necessarily those of the Australasian Carnivorous Plant Society Inc.

Contributions to the journal may be submitted on CD, DVD, pen drive or by email. Use Microsoft Word whenever possible. For instructions on submitting photographs and diagrams please contact the editor (auscps@gmail.com). Contact details are preferred for publication but may be excluded by author request.

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Dedicated to Conservation and Education

Following the last talk on July 19th was a cruise of Trinity Inlet at sunset. This was followed by the formal dinner during which Noaki Tanabe impressed those present, once again, with a display of magic tricks (Figure 29).

Overall the 10th ICPS was a wonderful success.

Figure 29. Naoki Tanabe Inspires and entertains the crowd with his famous magic tricks.


FM: LENTIBULARIACEAE
FM: DROSERACEAE
Drosera heterophylla
Western Australia
FM: DROSERACEAE
Drosera spatulata
Spoon-leaf Sundew
FM: DROSERACEAE
Drosera filiformis
Threadleaf Sundew
U.S.A. East Coast & S.East
FM: DROSERACEAE
FM: CEPHALOTACEAE
Cephalotus follicularis
Albany Pitcher Plant
FM: DROSERACEAE
FM: DROSERACEAE
FM: DROSERACEAE