The impact of soil type on Pygmy *Drosera* distribution

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Introduction

There are currently 52 species of Pygmy *Drosera* known to science (Lowrie 2014), many of which have only been described in the past few decades. Most of these are endemic to south-west Western Australia with one species, *Drosera pygmaea*, also found in South Australia, Victoria, Tasmania, New South Wales, Queensland, and New Zealand.

Pygmy *Drosera* species differentiate themselves from other members of the *Drosera* genus in two ways; firstly, they reproduce asexually via gemmae, small buds produced in the center of the plant that are an exact clone of the parent. Secondly, they produce stipules at the base of each mature leaf, and these stipules form a tight bud that protects the plant during summer dormancy. The growth cycle of Pygmy *Drosera* species revolves around the arrival of the first autumn rains; most species spend the harsh summer in dormancy and with the arrival of rain send down fresh roots and start producing carnivorous leaves to replenish the plant with nutrients. As winter arrives, and with it cooler temperatures, the plant begins to form gemmae, which are dispersed by the rain. These gemmae in turn send out roots and form an identical clone of the parent plant. As spring arrives, gemmae production ceases and the plants produce flowers, many of which are spectacular and large for the size of the plants. Seed serves as another means of reproduction, ensuring the survival of the plants.

The soils in south-western Australia are severely phosphorus-impoverished and Pygmy *Drosera* species have evolved to survive in these conditions. That there is such a density of species in south-west Western Australia is in itself extraordinary when one compares this with other parts of the world where *Drosera* occurs. The aim of this paper is to introduce the connection between soil type, age, and nutrient level with the evolution and species density of Pygmy *Drosera* species.

Soil types in south-west Western Australia

The landscapes of much of south-west Western Australia have developed on the Archaean granitic basement rocks of the Yilgarn Craton which have undergone little mountain building since the Permian glaciations. This area has largely been above sea level since that time, and as a result, has undergone an extended period of weathering. The resulting subdued landscape of the Darling Plateau is mantled by Tertiary-Quaternary laterites and sandplains on the upland, and duplex soils in the broad valleys (Gibson *et al*. 2004). It is on these laterites and sandplains that Pygmy *Drosera* species have evolved and speciated to the greatest degree, with relatively fewer species found in peat based soils in swampy areas. Some have subsequently moved to the coastal plains that resulted from the accumulation of marine deposit on the west (Swan coastal plain) and south coast (Scott coastal plain), after Gondwana broke up (Wyrwoll *et al*. 2014).

In the Northern Hemisphere, ice-sheets removed much of the pre-Quaternary regolith cover. In contrast, south-west Western Australia has not experienced glacial events since the Early Permian, *ca.* 260 million years ago. The absence of glaciation, coupled to the tectonic stability of south-west Western Australia, has allowed the weathering products to be retained in the landscape (Wyrwoll *et*

Table 1. Pygmy *Drosera* species and the predominant soil type in which they grow. Some species can grow in multiple soil types. Table constructed using Bourke & Nunn (2012), Erickson (1968), and Lowrie (1987, 1989, 1998, 2014).

Species	Soil type preference	notes
Drosera allantostigma	pale sand	
Drosera androsacea	pale sand	
Drosera australis	pale sand, laterite or peat	
Drosera barbigera	laterite, yellow sand over laterite	
Drosera bindoon	laterite	
Drosera callistos	laterite, pale sand over laterite	
Drosera citrina	yellow sand	
Drosera closterostigma	pale sand	
Drosera coalara	pale sand, pale sand over laterite	
Drosera coomallo	laterite	
Drosera depauperata	peat	Peat-based soil also contains pale sand
Drosera dichrosepala	laterite	
Drosera echinoblastus	pale sand	
Drosera eneabba	pale sand	
Drosera enodes	peat	peat based soil also contains pale sand
Drosera gibsonii	laterite	
Drosera grievei	yellow sand over laterite	
Drosera helodes	pale sand	
Drosera hyperostigma	laterite	
Drosera lasiantha	laterite	
Drosera leioblastus	pale sand	
Drosera leucoblasta	pale sand	soils often have organic matter and peat content
Drosera leucostigma	pale sand	tends to grow in the wetter areas and soils have more organic matter
Drosera mannii	peat	can grow in laterite as well at some locations
Drosera micra	peat	sand is present in the soil
Drosera micrantha	pale sand	
Drosera microscapa	peat	sand is present in the soil
Drosera miniata	laterite	clay under laterite
Drosera minutiflora	pale sand	

Table 1. Continued.		
Species	Soil type preference	notes
Drosera nitidula	yellow sand	clay mixed in with soil
Drosera nivea	yellow sand	
Drosera occidentalis	peat	
Drosera omissa	pale sand	
Drosera oreopodion	pale sand over laterite	
Drosera paleacea	peat	sand mixed in with soil
Drosera patens	pale sand	
Drosera pedicellaris	pale sand	
Drosera platystigma	laterite over sand	high clay content in sand
Drosera pulchella	peat	can grow in sand and laterite
Drosera pycnoblasta	pale sand	
Drosera pygmaea	peat	
Drosera rechingeri	pale sand	
Drosera roseana	peat	sand is present in soil
Drosera sargentii	pale sand	
Drosera scorpioides	laterite over pale sand	
Drosera sewelliae	laterite	
Drosera silvicola	laterite	
Drosera spilos	laterite	can grow in yellow sand
Drosera stelliflora	laterite	
Drosera trichocaulis	pale sand	occasionally in laterite
Drosera verrucata	pale sand	high clay content
Drosera walyunga	laterite over pale sand	

al. 2014). It is thought that in these landscapes natural selection has favored limited seed dispersal, resulting in elevated persistence of lineages and high numbers of localized rare endemics (Hopper 2009).

There are two types of sandplain in this region. Coastal sandplains, where the pale sand is of a marine origin, deposited as dunes as long as 2 million years ago until the present. Over time, the original nutrients eroded away and the soil pH declined. Inland sandplains originated from the ancient continent towards the east, and extend in a broad belt from Shark Bay to west of Esperance. The soils of inland sandplains are typically yellow deep sands, pale deep sands, and yellow sandy earths (Wyrwoll *et al.* 2014) and profiles often contain ferricrete or ferruginous gravels.

Plant life in south-west Western Australia has evolved on some of the world's oldest and most nutrient-impoverished sandy soils. The availability of phosphorus (P) is particularly low on these sandy soils, but soil nitrogen (N), potassium (K), and micronutrients are also notoriously scarce (McArthur 1991). The extreme infertility of these soils is primarily due to the low nutrient content

Drosera nivea only grows in yellow sands in a small area south of Coorow, WA. All photos in this article are by Richard Nunn.

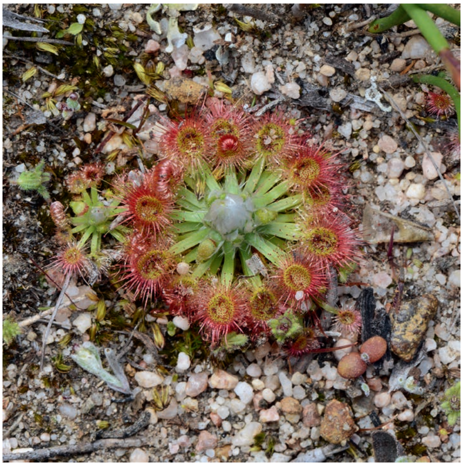
Drosera citrina growing in yellow sand near Moora, WA. This is the only yellow flowered species in the Pygmy *Drosera* complex.

A recently described species, *Drosera coomallo* favors laterite soils. Photo taken along the Brand Highway, WA

Drosera hyperostigma is a commonly occurring species of Pygmy *Drosera*, that grows in laterite. Photo taken near Bridgetown, WA.

of the parent material that gave rise to the sand and to their old age and strong degree of weathering. Over time, weathering leads to the loss of key rock-derived nutrients (*e.g.*, P) in the absence of major soil-rejuvenating processes (*e.g.*, glaciations, volcanic eruptions) (Walker & Syers 1976; Laliberté *et al.* 2012). On the other hand, N, a nutrient derived from the atmosphere, is continuously lost from the system, predominantly as a result of fire, when most N is volatilized (Orians & Milewski 2007). Nitrogen fixation is therefore crucially important to compensate for these losses.

Drosera sewelliae growing in heavy laterite. Photo taken near Muchea, WA.



An example of mixed soil types, *Drosera leucoblasta* prefers pale sand based soils with a high peat and organic matter content. Photo taken at Cranbrook, WA.

The ubiquitous *Drosera pygmaea*, is the only Pygmy *Drosera* species found outside of WA, this species prefers peat based soils.

Drosera roseana growing in peat based soil near Northcliffe, WA.

Given that extreme soil infertility imposes a severe constraint to plant growth, one might expect the sandplain flora to show low diversity, comprising only a restricted number of plant species that evolved the necessary adaption(s) to successfully grow on these soils. Yet, the exact opposite is actually found, and a key feature of sandplains are their exceptionally high degree of floristic and functional diversity (Lambers *et al.* 2010). Interestingly, the greatest plant diversity on the sandplains is found on the most severely P-impoverished soils (Laliberté *et al*. 2014; Lambers *et al.* 2014; Zemu-

Drosera minutilfora specializes in growing in pale sand. Photo taken near Cataby, WA.

Drosera closterostigma is another pale sand growing species endemic to the sandplains north of Perth. Photo taken at the type location near Cataby, WA.

nik *et al.* 2015). Pygmy *Drosera* species are no exception and have developed an extensive roster of endemic species in this harsh low-nutrient environment.

Carnivory in south-west Western Australian flora

One particular nutrient-acquisition strategy displayed by species in nutrient deficient soils is carnivory. This strategy is far more common in south-west Western Australia and particularly in *Drosera*, than it is in the rest of the world. Based on the total number of species in the Southwest Australian Biodiversity Hotspot, one can calculate how many carnivorous species one might expect, based on global averages. However, there are in excess of four times more carnivorous species than expected (Lambers *et al.* 2014). Carnivorous species have diversified tremendously during the course of evolution in south-western Australia, and the Pygmy *Drosera* species are an excellent example of this diversification in action. The low fertility of the region and tens of millions of years of climatic stability and a lack of major disturbances such as glaciation and volcanic activity have allowed diversification of a range of species and nutrient-acquisition strategies, including carnivory.

Pygmy *Drosera* soil type preferences

Pygmy *Drosera* species have evolved on sands and ironstone and it can be observed that some species are endemic to pale (white) sands, some species to yellow sand, and others to laterite/ironstone gravel (Table 1). A few species have evolved on peat-based soils in the coastal swamps found in the region, but there is nowhere near the species density that can be found on sand and laterite. The occasional species has formed the ability to populate multiple soil types.

Conclusion

The rich diversity of Pygmy *Drosera* species on the nutrient impoverished soils of south-western Australia is a result of the age and long-term climatic and tectonic stability of this region and the ability of the genus to evolve carnivory as a strategy to acquire nutrients. The greatest diversity and evolution of Pygmy *Drosera* species can be seen on the sandplains and laterite gravel outcrops, which are both low in P availability. Fewer species occur on younger, higher-nutrient peat and loambased soils in the swamps of the region or on the youngest dunes formed over the past 7,000 years since the last glacial maximum.

References

Bourke, G., and Nunn, R. 2012. Australian Carnivorous Plants. Redfern Natural History Productions, Poole, Dorset, England.

Erickson, R. 1968. Plants of Prey. University of Western Australia Press, Nedlands, Western Australia.

Gibson, N., Keighery, G.J., Lyons, M.N., and Webb, A. 2004. Terrestrial flora and vegetation of the Western Australian wheatbelt. Records of the Western Australian Museum Supplement No. 67: 139-189.

Hopper, S.D. 2009. OCBIL theory: towards an integrated understanding of the evolution, ecology and conservation of biodiversity on old, climatically buffered, infertile landscapes. Plant and Soil 322: 49-86.

Laliberté, E., Turner, B.L., Costes, T., Pearse, S.J., Wyrwolll, K-H., Zemunik, G., and Lambers, H. 2012. Experimental assessment of nutrient limitation along a 2-million year dune chronosequence in the south-western Australia biodiversity hotspot. Journal of Ecology 100: 631-642.

Laliberté, E., Zemunik, G., and Turner, B.L. 2014. Environmental filtering explains variation in plant diversity along resource gradients. Science 345: 1602-1605.

Lambers, H., Brundrett, M.C., Raven, J.A., and Hopper, S.D. 2010. Plant mineral nutrition in ancient landscapes: high plant species diversity on infertile soils is linked to functional diversity for nutritional strategies. Plant and Soil 334: 11-31.

Lambers, H., Shane, M.W., Laliberté, E., Swarts, N.D., Teste, F.P., and Zemunik, G. 2014. Plant mineral nutrition. Plant Life on the Sandplains in Southwest Australia, a Global Biodiversity Hotspot (ed. H. Lambers), pp. 101-127. UWA Publishing, Crawley.

Lowrie, A. 1987. Carnivorous plants of Australia. Volume 1. University of Western Australia Press, Nedlands, Western Australia.

Lowrie, A. 1989. Carnivorous plants of Australia. Volume 2. University of Western Australia Press, Nedlands, Western Australia.

Lowrie, A. 1998. Carnivorous plants of Australia. Volume 3. University of Western Australia Press, Nedlands, Western Australia.

Lowrie, A. 2014. Carnivorous Plants of Australia Magnum Opus. Volume 1-3. Redfern Natural History Productions, Poole, Dorset, England

McArthur, W.M. 1991. Reference soils of south-western Australia. Department of Agriculture Western Australia, South Perth.

Orians, G.H., and Milewski, A.V. 2007. Ecology of Australia: The effects of nutrient-poor soils and intense fires. Biological Reviews 82: 393-423.

Walker, T.W., and Syers, J.K. 1976. The fate of phosphorus during pedogenesis. Geoderma 15: 1-9.

Wyrwoll, K-H., Turner, B.L., and Findlater, P. 2014. On the origins, geomorphology and soils of the sandplains of south-western Australia. Plant Life on the Sandplains in Southwest Australia, a Global Biodiversity Hotspot. (ed. H. Lambers), pp. 3-22. UWA Publishing, Crawley.

Zemunik, G., Turner, B.L., Lambers, H., and Laliberté, E. 2015. Diversity of plant nutrient-acquisition strategies increases during long-term ecosystem development. Nature Plants 1, 10.1038/nplants.2015.1050.

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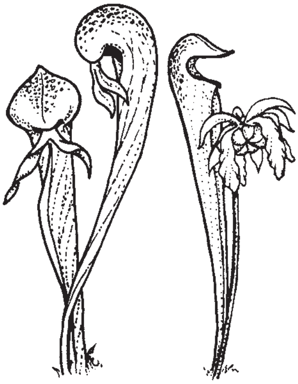

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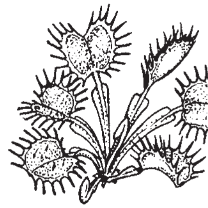

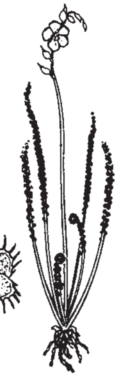

Front Cover: There has been much confusion around the identity of the true *Drosera paleacea*, this had recently been resolved with populations matching the type sheet and description found in the Albany area. This species grows in peaty swamps. Photo taken at Frenchman Bay, Western Australia by Richard Nunn. Article on page 13.

Back Cover: Another newly described species, *Drosera bindoon* is endemic to a few small patches of laterite soil north of Perth. Photo taken at the type location near Muchea, Western Australia by Richard Nunn. Article on page 13.

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