Quillworts – *Isoetes*

Isoetes australis: Kevin Thiele from Perth, Australia, CC BY 2.0 via Wikimedia Commons

The granite outcrops of south-western Western Australia are significant landscape features throughout the Wheatbelt, emerging like ancient dinosaurs from the surrounding plain; some of you will have seen Wave Rock (pictured). These extraordinary weathered rock structures are of major importance to the Noongar people of Western Australia and are home to an extraordinary range of animals and plants, many of them endemic.

The environment of these exposed granite outcrops is very harsh with even higher temperatures and lower moisture levels than the surrounding country. Over 230 species of plants have been recorded on these granite outcrops, some surviving in shallow ephemeral rock pools, others rooted into sediments at the base of gnammas or occurring naturally in waterholes atop the outcrops. Quillworts are known from both gnammas and shallow rock pools.

Gnamma, naturally occurring rock waterholes. These have long been an important source of water for the Noongar people. Gnamma were often covered to reduce water loss by evaporation.

Quillwort, *Isoetes australis* in a shallow rock pool on granite in south-western Australia. Pederson et al. 2011.

Western Australia has nine species of Quillworts (*Isoetes*), plants that belong to a relatively small, ancient group of plants that also includes Club Mosses (*Lycopodium* etc.) and Spike Mosses (*Selaginella* spp.), all collectively referred to as *Fern Allies* in spite of the fact that, even though they *reproduce by spores*, they're *definitely not ferns*. Worldwide, there are about 150 Quillwort species, Australia has ~ 15, all but one being endemic. They have a grass-like appearance, rather like sedges or rushes, with slender leaves that widen at the bulb-like corm at the base.

Quillworts are really quite remarkable, and can be totally aquatic or semi-aquatic but some live in waterways that can be seasonally dry. They can be evergreen, or deciduous during the cold months of winter, or deciduous in the heat and drought of summer. Simple or primitive they are not! In Australia, they are present in a wide range of environments, from alpine pools of the Snowy Mountains, to the tropical landscapes of the Kimberley, and in a range of habitats, including shallow rock pools and gnammas of granite outcrops of south-western Western Australia.

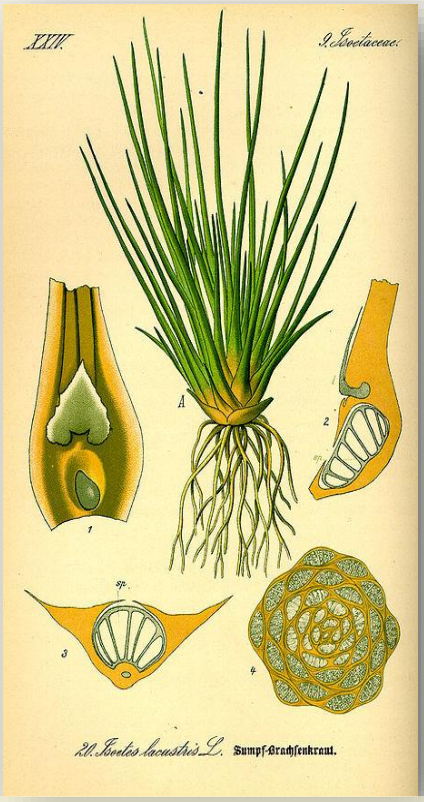
However, life in shallow, ephemeral pools comes with costs, particularly low levels of CO_2 and high levels of photorespiration. Botanists from Universities of Western Australia and Copenhagen studied one Quillwort, *Isoetes australis*, in intermittently wet, shallow rock pools on granite outcrops, in particular the way in which the plants utilise the CAM (Crassulacean Acid metabolism) photosynthetic pathway to overcome the challenge of such a harsh, variable niche. In CAM photosynthesis, stomates in the leaves open at night to absorb carbon dioxide rather than during the day in order to minimise water loss.

Shallow, ephemeral rock pools on granite outcrops in south-western Australia. Pederson et al. 2011.

We usually recognise CAM as a means of survival for plants of arid and semi-arid regions, where stomates in leaves close during the heat of the day to reduce water loss by evaporation, and open at night to accumulate and store malate that can then be used the following day for photosynthesis. Quillworts have short, stiff leaves with thick cuticles but *no*

stomates to let CO_2 enter. In the absence of stomates, how do they absorb CO_2? Seemingly the hollow roots absorb CO_2 from the sediment of the pool in which they grow. Each leaf has four longitudinal air canals (lacunae) surrounded by green tissue and these provide a low resistance pathway for gas diffusion from the roots to the green photosynthetic tissue of the leaves.

Curiously, the opposite occurs when leaves of some *Isoetes* species emerge above water; those produced *in air* develop stomates and utilise atmospheric CO_2 in C3 photosynthesis. This is not a luxury that *Isoetes australis* growing in ephemeral pools can afford – it always relies on its internal ventilation system to garner CO_2.



Isoetes lacustris: Otto Wilhelm Thomé *Flora von Deutschland, Österreich und der Schweiz* 1885, Gera, Germany

Pederson O, Rich S M, Pulido C, Cawthray G R, Colmer T D. 2011. Crassulacean acid metabolism enhances underwater photosynthesis and diminishes photorespiration in the aquatic plant *Isoetes australis*. *New Phytologist*: 190: 332–339.

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