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What the Ancestors Knew and the Limits of European Nomenclature

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Abstract

All over the world, people working in the biological sciences use the European system of nomenclature that classifies living things into collections of phylum, order, family, species and so on. In pre-settlement Australia, trees were either male or female and part one's totem group. The Linnaean system of taxonomy creates a hierarchy of plants when grouping them according to their similar characteristics, but which characteristics should take precedence? Accidental woody Epiphytes have a commensal relationship with their hosts living in the soil-holding crotches available in older trees. Parasites, however, extract nutrients from their hosts by accessing their vascular system. When Grafted plants fuse together the vascular tissues join to form a bridge between the 2 species as well. What if a deliberately planted and nurtured woody epiphyte forms a parasitic connection with its host or is grafted onto the tree trunk and receives saprotrophic nutrition via fungi? This scenario is beyond the known plant classification systems but may account for one how a semi-nomadic people grew fully mature trees inside other trees in a semi-arid outback Australia.

Keywords: Arboreal soil; Facultative epiparasites; Haustoria; Mycorrhizae fungi; Obligate parasites; Santalales; Sapindaceae, Semi-arid

Introduction

I am a 5th generation farmer in far northwest NSW, Australia. I have been interested in the Culturally Modified Trees (CMTs) of my area for many years now and have a website devoted to them https://scartrees.com.au/ One particular type of modification, restricted to this area, is the practice of growing a variety of scrub tree species inside old hollow eucalypts. In European terminology, these scrub trees, which I refer to as 'guests', would be known as accidental woody epiphytes. "Their association with Culturally Modified Trees and the relatively low density of epiphytes elsewhere suggest that Aboriginal people have played a direct role in creating this landscape, to which they remain deeply connected" [1].

From my research online it appears that most accidental epiphytes around the world are found in the crowns of forests in tropical regions and are less than 1 meter tall. Some of the guests here have a DBH circumference of over 1 meter and grow from the trunk in a semi-arid zone with 16-18" (400-450mm) ave. rainfall per annum. Studies involving tree ferns in New Zealand found over thirty species of accidental woody epiphytes living on them with 4% greater than 1.35m tall [2]. Water availability, however, is the critical difference between semi-arid inland Australia and temperate maritime N.Z, and the most decisive factor for epiphytic plant growth. The Indigenous tribes whose ancestors we believe grew trees in other trees (TinTs) are the Gamilaroi/ Yuwaalayaay & Wailwun people of the Ngiyampaa language group. I wrote about this cultural practice last year in the journal of plant signalling and behaviour [3]. Most 'host' trees here are the common eucalypts of the area and half of the endemic non-eucalypt native tree species can be found as guests. Geijera parviflora or Ehretia saligna growing in Eucalyptus populnea account for almost 50% of the TinTs here (Figure 1).

These popular combinations could have cultural explanations, but I think the reason the two most frequently occurring guests live in the most numerous hosts is their tolerance of lower soil PH levels. The red soils out in far Nth West NSW are quite acidic, often below 5.5. The most common guests and the most common host live in red phosphorus deficient soils. The ancestors would have been aware of the compatibility between host and guest. Other plant species found living on old eucalypts here are the black orchid - garrii (Cymbidium canaliculatum) and mistletoe – baan (Amyema miquelii, Lysiana subfalcata & Amyema lucasii) Ive seen

Amyema miquelii parasitised by Lysiana subfalcata which makes Lysiana subfalcata an obligate hemi-parasite but an incidental facultative epiparasite. Even the former director of the Australian National Herbarium thinks the boundary between facultative and obligate epiparasitism has become obscure [4]. It is difficult to imagine how solid, non-eucalypt species could epiphytically host other native trees in a semi-arid climate without some form of anthropological intervention. There is a small subset of TinTs here where the guest does not grow in a hollow eucalypt but rather in ironwoods – dhan.gayaan.gan (Acacia excelsa), belahs – bilaarr/murrgu (Casuarina cristata) a leopardwood – bagala (Flindersia maculata) and a whitewood – birraa (Atalaya hemiglauca) (Figure 2).

Figure 1: Old wilga (Geijera parviflora) living in and outcompeting a very old bimblebox (Eucalyptus populnea). Both trees are still alive.

Figure 2: Wilga and mistletoe (Amyema lucasii) living on a solid leopardwood. Only the mistletoe is considered a parasite and now 3 years after this photo was taken only the wilga is still alive).

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Dr David Watson, the foremost Australian expert on Mistletoe, said this in a recent email to me on the topic of parasites, epiphytes, and grafting. "Just to be clear, there is a discrete and well-defined group of plants capable of establishing vascular connections with other species. This is quite distinct from various kinds of grafting, where the vascular tissues of conspecifics (or the same individual) merge. Within Australia, there are many families with parasitic taxa, but all the woody plants known to be parasitic are within the Santalales" [5]. I am not questioning what is 'known' but interested in what is 'unknown' to European science yet understood by the Indigenous ancestors. If fully mature, fully grown scrub trees have been living in old eucalypts unnoticed, unprotected, and unstudied for at least 230 years then how would we know if the guests are epiphytic, grafted, or parasitic?

Unlike animals, plants continue organogenesis throughout their lives in an ongoing evolution. Meristematic growth can be adapted to suit unusual environmental situations. Ecophysiological research shows "there are striking similarities in the processes that accommodate pathogens between plants and animals, some of which could possibly have originated from the ancestral eukaryotic cell" [6]. Investigations into Phenotypic plasticity have found "Under certain ecological conditions, a previously free-living organism exhibits a novel phenotype and opportunistically exploits a host. Pre-adaptations may make such novel inductions more likely, but the initial production of the parasitic phenotype requires particular environmental conditions" [7]. I think the ancestors may have manipulated the roots of suckering rosewood - bunbarr /boonery (Alectryon oleifolius) seedlings to allow them to survive in the minimal deposits of arboreal soil contained in the crotches of solid non eucalypts (Figure 3). Mistletoe is classified as obligate stem hemiparasites as they photosynthesis as well as steal carbon from their hosts via haustoria. Just how much nutrition mistletoes can extract from their hosts depends on how specialized or developed these haustoria are. The origin of the aerial habit from root parasitism is not known or how the root zone of the embryo became modified into a haustorium [8]. Sometimes haustorial strands grow inside the host as well and mistletoe foliage may emerge from the trunk away from the original attachment. I have seen this here with Leafless cherry/ ballart - mirrii (Exocarpus aphyllus), a root hemiparasite, that has broken with tradition and is living as an aerial hemiparasite. The roots of these mirrii guests must travel down inside the hollow eucalypt trunks before attaching to their roots in the usual terrestrial hemiparasitic manner (Figure 4).

Figure 3: Rosewood possibly killed its ironwood host.

Another connection between trees comes from the mutualistic association of their roots with mycorrhizal fungi found in the soil. In our phosphorus deficient soils west of Walgett in outback NSW, ectomycorrhizal links promote greater nutrient cycling. Many Australian eucalypt species rely on root fungi to enhance their ability source nutrients and water. These specialised fungi can also manipulate the genetic development of the tree roots by releasing tiny amounts of RNA. Fungi hyphae also have an ectosymbiotic association with termites breaking down the dead wood inside old eucalypts, but this has not been fully investigated [8] (Figure 5).

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Figure 4: Exocarpus aphyllus in dead coolabah & live bimble box.

Figure 5: Different fungi living beside or on native trees here in semi-arid Nth West NSW Australia.

Eucalypts have an ability to naturally form ectomycorrhizae and these fungi would also be found in soil inside the aged hollow trunks. Saprotrophic wood fungi facilitate the extraction of nutrients such as nitrogen and phosphorus from organic waste and may explain why water and nutrient availability were higher in crotches filled with arboreal soil. This suggests conditions for growth, if there is sufficient moisture, may be better epiphytically than conventionally. "Our findings highlight that vascular epiphytism in the study area is not necessarily limited by abiotic conditions but at least partly by the availability of old

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and structurally diverse trees providing suitable microhabitats" [9]. There are thousands of old hollow eucalypts here but only those around Aboriginal camps contain mature or multiple guests (Figure 6).

The exceptions away from the old camps are those TinTs found along the ancient pathway's aka songlines that connect the gathering places and reliable water. This extract from Ted Fields Snr in Yundiboo Vol. 2 published over 20 years ago by the local Elders group Dharriwaa, explains how the old songline, now Gingie road, came to be. "Gali guranaa lived at what they call the deep hole at Gingie reserve (village). He dug an underground river then from the Barwon and created a spring at Murru-manaarr (Gingie Station now) and another which is called Gali-guranaa (now known as Cumborah spring) Ever since he created these 2 springs, people – Gabilaraay, Ngiyambaa, Gamilaraay and the Yuwaalaraay – when they are walking to Dharriwaa (Narran Lake) for their big meetings, can walk everywhere even in dry times now because there's waterholes all the way. People could go from the Barwon to Murru-manaarr, to Gali-guranaa then on to Gurrawin (Grawin waterhole) where there was a big camp then on to Mil Maliyan (eagles' eyes) and Dharriwaa (Figure 7).

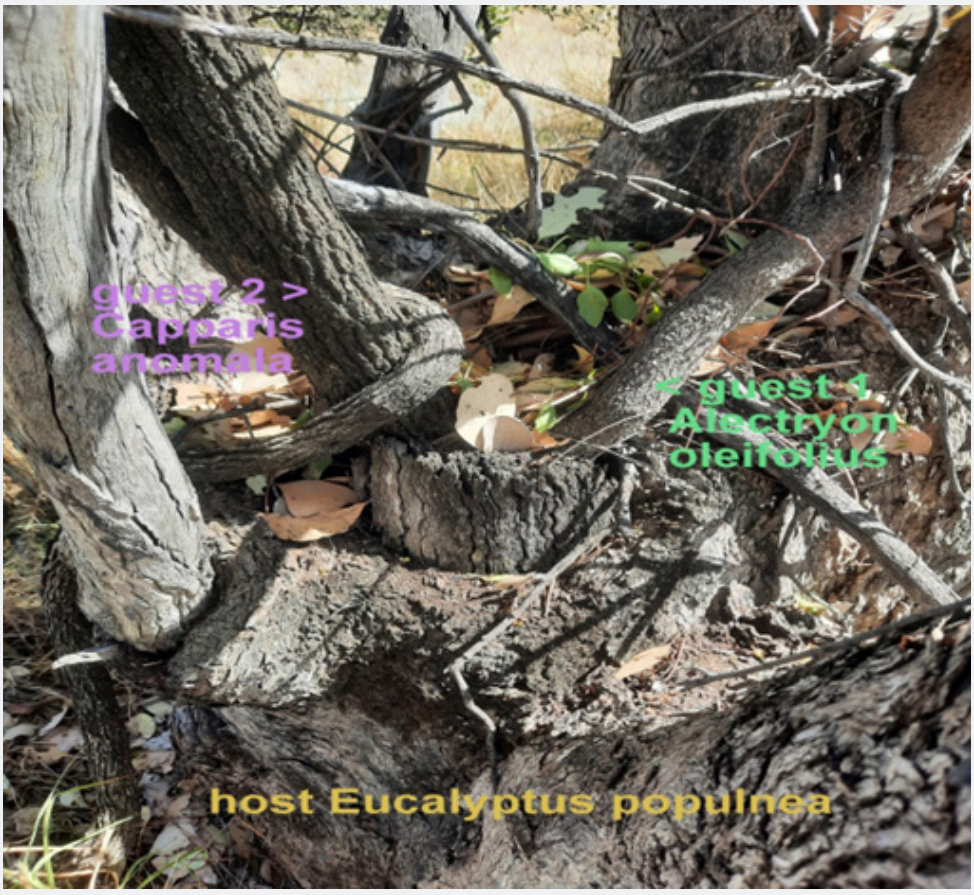

Figure 6: Double guests in one crotch – Alectryon oleifolius and Capparis anomala.

There are many similarities between parasitism and grafting, where two different plants are cut and joined together. This age-old practice makes plants fuse, and their vascular tissues connect so different species grow together on one stem or trunk. "How people discovered grafting remains unknown, though they were likely inspired by natural tissue fusions seen when branches attach or when parasitic plants grow on their host plants. By the fourth century BCE, grafting was practiced in the Mediterranean region and in China and the Middle East" [10]. Aboriginal cultural traditions were passed down verbally, so we do not know how long they have been forcing tree branches and trunks to inosculate here. We do know they merged various species into rings by tying their branches together when they were younger and more flexible. A stone was sometimes inserted to prevent

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the rings closing over time. There have been rare occasions when I have thought I have found eucalypts living epiphytically in other eucalypts but on closer inspection they have turned out to be reshoots of the parent. Eucalypts that have been poisoned, rung (ringbarking/ girdling) or severely burnt many years ago sometimes attempt to regenerate. Eucalypt seeds are small and lack aerodynamic features so do not fall far from the parent tree. If there was no interaction between host and guest, then this should be the commonest TinT combination given their proximity. Propagules from the old eucalypts would regularly fall into their own crotches and grow there. Eucalypts sometimes hybridise or crossbreed within their locality to produce progeny that may become new sub-species, but they do not seem to grow as epiphytic guests. By late 2019 I had stopped believing the available Australian institutional advice about accidental woody epiphytes and was approaching academics that would help me. I had been told repeatedly that trees growing in other trees were the result of natural seed dispersion by bird guano or wind. I started describing the TinTs as 'chimeras' and by mid-March 2020 and had found a range land ecologist Dr Jennifer Silcock to help investigate the phenomena. I have found during my research for this paper that the term chimera crops up frequently. The biological meaning of the Greek mythological chimera is an organism containing a mixture of genetically different tissues, whether by parasitism, grafting, mutation or anastomosis. Anastomosis is a recombination of evolutionary lineages as species branch out into novel forms [11,12]. Just what, if any, vascular connections are made inside these TinT chimeras may never be established because there is no research planned (Figure 8). It has been suggested in the literature that a typical epiphytic strategy enables the more palatable scrub trees to escape terrestrial herbivores. Livestock regularly browse young non eucalypt seedlings especially in drought conditions. However, some of the guest species are unpalatable to both sheep and cattle – Pimelea microcephala, Eremophila mitchellii, Callitris glaucaphylla and Myoporum montanum [13]. Epiphytes are also thought to use hosts to gain access to more sunlight but that would only be applicable in dense forests. The vast majority of guests here grow in the forks of eucalypts not the crowns and most are far away from any daylight limiting canopies.

Figure 7: Branch bow tree in Avon & double ring in Nardoo.

Discussion of Accidental Woody Epiphytes

So, let us substitute the word "accidental" with "deliberate" and "epiphytes" with "grafts" and revisit European plant taxonomy. Once a seed has germinated or a seedling has been planted in the rich humus inside old eucalypts, it would need watering in this dry climate. At least until the roots reach the ground or close enough to draw up moisture through the capillary action gardener's call 'wicking'. Unless of course, the seedling became partially parasitic

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under certain nurturing circumstances and tapped into the vascular system of its host. Some guests live 10 – 15 "(3-4.5mts) up the eucalypt trunk but are not classified in the order Santalales containing Australia's only woody parasites. There is enough light coming through holes in the trunk for these guests to sucker up internally through the arboreal soil. 99.9% of scrub trees grow in hollow eucalypts but there are rare instances where they are growing in solid non eucalypts as well. How this is even possible in a semi-arid environment is beyond me.

Figure 8: Eucalyptus populnea crotch containing an epiphytic wilga and bimblebox reshoot.

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