

AUSTRALIA'S ICONIC TREES – THE EUCALYPTS

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Eucalypts (family Myrtaceae) are very special to Australians because of their immense utility, and economic and ecological importance. They have been described as the universal Australian. They dominate most Australian landscapes, ranging from the moist tropics in the north, cool forests and mountains of south-eastern Australia to the edges of the arid interior of Australia. The biodiversity benefits of eucalypts are immeasurable as they are critical to the survival of animals and soil organisms, and thus they are key to the healthy functioning of the ecosystems that they dominate.



DISCOVERY AND NAMING OF THE EUCALYPTS

It is likely that the early Portuguese and Dutch explorers noted eucalypts, with a record made by Abel Tasman in 1642. However, no collections were made until the eighteenth century, when Joseph Banks and Daniel Solander collected in Botany Bay in 1770, on Cook's first voyage. However, it was in 1777, on Cook's third voyage, that ships surgeon William Anderson, on the *Resolution*, and gardener and collector David Nelson on the *Discovery*, collected an historically important specimen from Adventure Bay, Bruny island, Tasmania. This specimen was taken back to London and formally named *Eucalyptus obliqua* by the French botanist Charles Louis L'Héritier de Brutelle in 1788. This is the type species for the genus *Eucalyptus*, the name meaning "well (*eu*) covered (*calyptos*)", referring to the distinctive cap that covers the young flowers of this and other eucalypt species. Other early, important collections of eucalypts were made by the French botanist Labillardière, on the D'Entrecasteaux expedition, 1792, 1793.

DIVERSITY OF THE EUCALYPTS

Two centuries later, more than 700 species have been named and described, and discovery of their phylogenetic relationships has been based on combining studies of morphological characters with the sequencing of DNA. DNA comparisons between species have identified major lines of evolution. Accumulated evidence indicates that the group originated in the Late Cretaceous (of the order of 70- 65 million years ago) from rainforest forbears and that over the last 40 million years, as rainforests contracted, *Eucalyptus* and *Corymbia* (the bloodwood eucalypts) adapted to drier environments, weathered soils and fire-prone landscapes. The amazing ability of many eucalypts to re-sprout from dormant buds allows them to survive fire, drought and climate change.

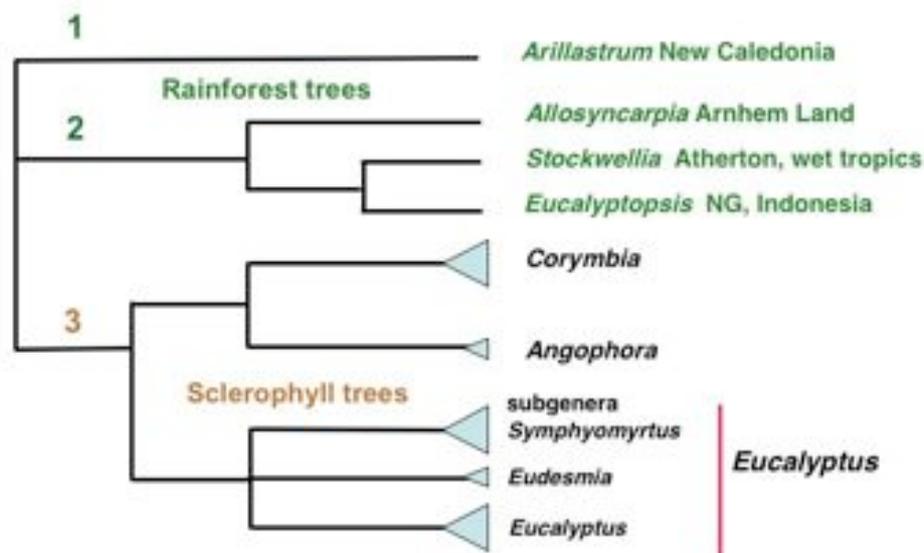
FOSSILS AND BIOGEOGRAPHY

Fossils are evidence that eucalypts once lived in other parts of the southern super-continent Gondwana. *Eucalyptus* fossil fruits and leaves have been discovered recently in the Caldera Lake Flora of Patagonia, Argentina in South America (Gandolfo et al. 2011). These impression fossils are very detailed and have been dated at 52 million years old (Early Eocene), a time when both South America and Australia were still connected to Antarctica as part of the southern landmass Gondwana. In Australia fossil pollen (called *Myrtaceidites eucalyptoides*) is recorded from the Paleocene-Early Eocene (60-50 million years ago), and there are some fossil fruits known, for example, from Queensland and the Woomera area. Fossil leaves are also found in New Zealand.

PHYLOGENY AND BIOGEOGRAPHY OF THE ‘EUCALYPT GROUP’

Within the family Myrtaceae, one early line of evolution led to the ‘eucalypt group’. It includes not just *Eucalyptus*, but seven genera (Ladiges et al. 2003). Four of these genera are relictual rainforest taxa of restricted distribution, while the other three are the more species-rich, familiar gum trees that dominate the drier, harsher environments. The tree diagram (A) below shows the phylogenetic relationships of these genera based on DNA sequencing and morphological characters.

A



Relictual rainforests are a glimpse into the past. The four rainforest genera of the eucalypt group include only five species living today, all of which are of high conservation value. They are: *Arillastrum* (one species, *A. gummiferum* from New Caledonia), *Allosyncrapia* (one species, *A. ternata* in Arnhem Land), *Stockwellia* (one species *S. quadrifida*, Queensland wet tropics), and *Eucalyptopsis* (two species, New Guinea and nearby islands). *Allosyncrapia* survives on the Arnhem Land plateau in deep rocky gorges, and dominates small patches of monsoonal rainforest. The species is fire-sensitive and needs to be protected from severe wild-fire.

Geographic distributions of the rainforest genera support the fossil evidence that the eucalypt group is old. For example, the divergence of the New Caledonian *Arillastrum* from its relatives in Australia, is likely related to the rifting of a crustal block from Queensland that moved eastwards into the Pacific. Fragments of continental crust outboard of the Australian continent thinned, and they ultimately subsided below sea level. However, other processes, such as hot spots that produce sea mounts, may have kept part of these blocks above sea level by increasing buoyancy, thus maintaining the presence of land carrying flora and fauna that ended up in the region of New Caledonia as we know it today (Ladiges and Cantrill 2007). New Caledonia has a rich endemic flora, much of which is considered old. Seeds of eucalypts, such as *Arillastrum* are not adapted to long distance over-water dispersal. The isolation and divergence of *Allosyncrapia* (B, below) from *Stockwellia* (C) and *Eucalyptopsis* relates to the drying and increased fire frequency in northern Australia from the Oligocene (c.30-25 Ma).

B



C

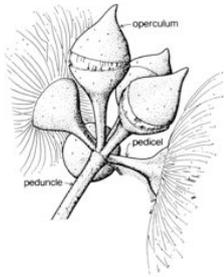


The dominant sclerophyll gum trees: The more species-rich, sclerophyll (meaning ‘hard-leaved’) genera are *Eucalyptus* and the sister genera *Angophora* and *Corymbia*. Both *Eucalyptus* and *Corymbia* occur in New Guinea, and one species of *Eucalyptus* (the rainbow gum *E. deglupta*) extends from New Guinea and New Britain to the southern Philippines and Sulawesi; three species of *Eucalyptus* are endemic to Timor. These distributions are likely range expansions as the Australian continent drifted north and came close to South-Asia in the last 10 million years.

An important adaptation of most species of *Eucalyptus* is their amazing ability to resprout (epicormic shoots or coppice) from dormant buds that lie beneath the bark, or

from buds stored in lignotubers at the base of the stem, allowing them to survive fire, drought and climate change. The high oil gland content of eucalypt leaves makes the bush flammable, resulting in fast-fires and less damage than a slow burn.

D



E



The protective opercula (caps) that characteristically cover the flower buds of *Eucalyptus* and *Corymbia* have evolved more than once: independently in *Corymbia*, and in the three main subgenera of *Eucalyptus*. One operculum only is characteristic of *Eucalyptus* subgenus *Eucalyptus* (D, upper left photo, *E. erectifolia*); *Eucalyptus* subgenus *Symphyomyrtus* has flowers with two caps equivalent to sepals and petals (D, lower left photo, *E. pulverulenta*); *Eucalyptus* subgenus *Eudesmia* has one operculum but free teeth-like sepals (E, photo on right, *E. erythrocorys*). Developmental studies of flowers and anatomical structures, such as trichomes (bristle glands), oxalate crystal shape, and seeds, support the DNA data that *Corymbia* is related to *Angophora* (see Figure A). This is why *Corymbia* was recognised in 1995 by Ken Hill and Dr Lawrie Johnson as a genus separate from *Eucalyptus*.

Corymbia ficifolia



REFERENCES

- Carr, D.J., Carr, S.G.M., Hyland, B., Wilson, P.G., and Ladiges P.Y. (2002). *Stockwellia quadrifida* (Myrtaceae), a new Australian genus and species in the eucalypt group. *Botanical Journal of the Linnean Society*, **139**, 415-421.
- Gandolfo, M.A. et al. (2011) Oldest known *Eucalyptus* fossils are from South America. *PloS One*: e21084.
- Ladiges, P.Y., Udovicic, and Nelson, G. (2003). Australian biogeographic connections and the phylogeny of large genera in the plant family Myrtaceae. *Journal of Biogeography*. **30**, 989-998.
- Ladiges, PY and Cantrill, D. (2007). New Caledonia-Australian connections: comment on biogeographic patterns and geology. *Australian Systematic Botany*, **20**, 383-389.
- Parra-O, C., Bayly, M., Udovicic, F., Ladiges, P.Y. (2006). ETS sequences support the monophyly of the eucalypt genus *Corymbia* (Myrtaceae). *Taxon*, **55**, 653-663.
- Parra-O, C., Bayly, M., Drinnan, A., Udovicic, F., Ladiges, P.Y. (2009). Phylogeny, major clades and infrageneric classification of *Corymbia* (Myrtaceae), based on nuclear ribosomal DNA and morphology. *Australian Systematic Botany* **22**, 1384-399.
- Steane, D.A., Nicolle, D., McKinnon, G.E., Vaillancourt, R.E. and Potts, B.M. (2002). Higher level relationships among the eucalypts are resolved by ITS-sequence data. *Australian Systematic Botany* **15**, 49-62.
- Udovicic, F., and Ladiges, P.Y. (2000). Informativeness of nuclear and chloroplast DNA relationships of the eucalypt and related genera (Myrtaceae). *Kew Bulletin* **55**, 633-645.