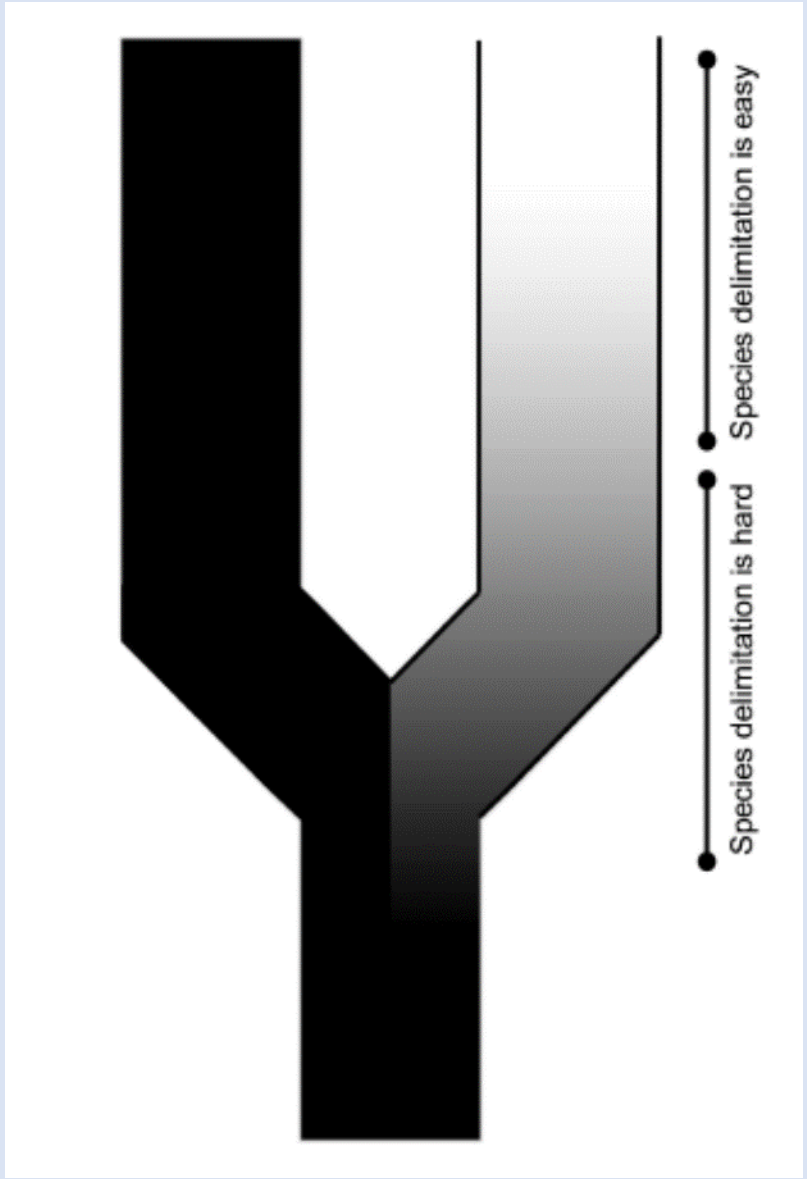
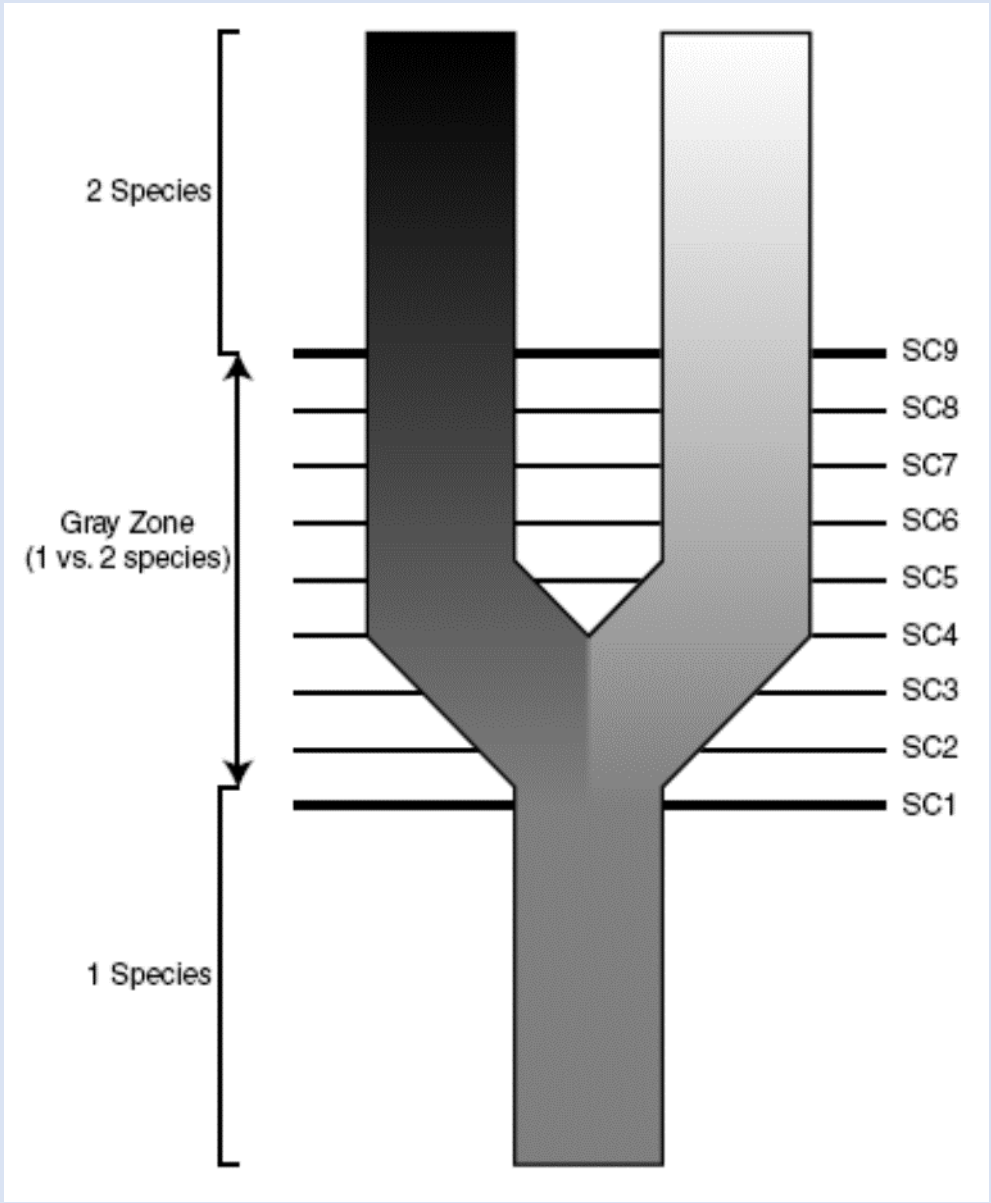
What’s in a Species?

Peter J. de Lange

Organisms evolve





Taxonomy – the ‘dead’ science

- Taxonomy is seriously underfunded.
- Most practitioners are >80 years of age.
- Citation rate is low.
- Perversely the name usage is high.
- Conventional measures of scientific success hard to measure.
- Funding hard to attain.
- So fewer and fewer taxonomists.

Impact Fact = Uptake from the Masses

As impact factors are low for taxonomy, taxonomists….

- Demonstrate impact by uptake – thus the more you advocate your cause, the more people use your taxonomy the more ‘successful’ you are.
- Then you *may* get more funding…..
- So, it’s important to knock back independent voices that could threaten uptake of your work.
- Ensure any collaborations follow your point of view.
- Prepare taxonomies that appease the funder.

But do I need to use new classifications / taxonomies?

Scientific names can only be enforced in these situations.

- **Name has priority** e.g., ***Clianthus magnificus*** (Van Houtte) C.Dickens, 1856 has priority over ***C. maximus*** Colenso (1886).
- **Name has been conserved** e.g., it has been agreed that ***Kunzea*** Rchb. 1828 has been conserved over ***Tillospermum*** Salisb (1914) - *nomen conservum.*
- A new name was necessary at a different rank or combination as the epithet was preoccupied – ***nomen novum*** e.g., ***Ranunculus ranceorum*** de Lange (2008).

Nomen Novum – why?

- ***Tillaea acutifolia* Kirk (1899)** - New Zealand endemic.
- ***Crassula acutifolia* (Kirk) A.P.Druce et Given (1985)** – new combination.
- ***Crassula acutifolia* Lam. (1786)** South African Endemic.
- ***Crassula ruamahanga* A.P.Druce (1987)** – nomen novum (new name).
- Note that ***Tillaea acutifolia*** is the legitimate name in ***Tillaea*** for this plant and ***Crassula ruamahanga*** in ***Crassula*** for the same plant.

A case of types - *Coprosma autumnalis* Colenso

- Kanono / raureka has been called by many scientific names.
- ***Coprosma australis*** B.L.Rob. (1910).
- ***Coprosma grandifolia*** Hook.f. (1852).
- Both these names are heterotypic synonyms of ***Coprosma lucida*** J.R.Forst. & G.Forst.
- ***Coprosma autumnalis*** Colenso (1887) is therefore the correct name for kanono.

References

Large, M.F.; Mabberly, D.J.; Wood, E. 2020: *Coprosma autumnalis* (kanono; Rubiaceae) in New Zealand: nomenclature, iconography and phenology, *Kew Bulletin 75*: 37-43.

Perrie, L.R. 2021: Proposal to conserve the name *Coprosma grandifolia* (Rubiaceae) with a conserved type. *Taxon 70(1)*: 211.

So, do I need to use these names?

- *Kunzea robusta* de Lange & Toelken (2014)
- *Leptospermum repo* de Lange & L.M.H.Schmid (2021)
- *Pectinopitys ferruginea* C.N.Page (2019)
- *Beilschmiedia tawaroa* A.E.Wright (1984)
- *Alseuosmia turneri* R.O.Gardner (1978)
- *Montigena* Heenan (1998)
- *Icarus* Gasper & Salino (2016)

So, do I need to use these names?

- *Podocarpus laetus* Hooibr. ex Endl. (1847)
- *Podocarpus cunninghamii* Colenso (1884)
- *Podocarpus hallii* Kirk (1889)
- *Hebe brevifolia* (Cheeseman) de Lange (1997)
- *Veronica punicea* Garn.-Jones (2007)
- *Pittosporum ellipticum* subsp. *serpentinum* de Lange (1998)
- *Pittosporum serpentinum* (de Lange) de Lange (2003)
- *Avicennia resinifera* G.Forst. (1786)
- *Avicennia marina* var. *resinifera* (G.Forst) Bakh (1921)
- *Avicennia marina* subsp. *australasica* (Walp.) J.Everett (1994)
- *Cyathea dealbata* (G.Forst.) Sw. (1801)
- Alsophila dealbata C.Presl
- Alsophila tricolor (Colenso) Tryon (1970)

What is a taxonomic treatment?

A taxonomic treatment brings together the nomenclature, types, description and other data (morphological, ecological, chemical etc) to present a unified assessment of a taxon or taxa.

Examples

Heenan P.B. 2019: A taxonomic revision of *Notothlaspi* (Brassicaceae), a specialist alpine genus from New Zealand. *Phytotaxa 399*: 248-260.

de Lange, P.J.; Heenan, P.B.; Clarkson, B.D.; Clarkson, B.R. 1999: Taxonomy, ecology, and conservation of *Sporadanthus* (Restionaceae) in New Zealand. *New Zealand Journal of Botany 37*: 413–431.

Raven, P.H.; Raven, T.E. 1976: The genus *Epilobium* in Australasia. New Zealand DSIR Bulletin 216. Wellington, Government Printer.

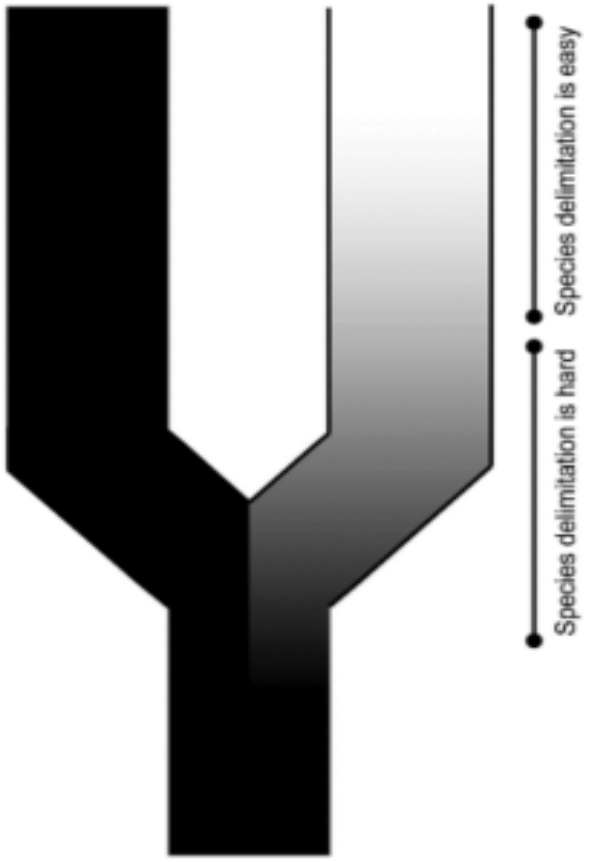
What is a species?

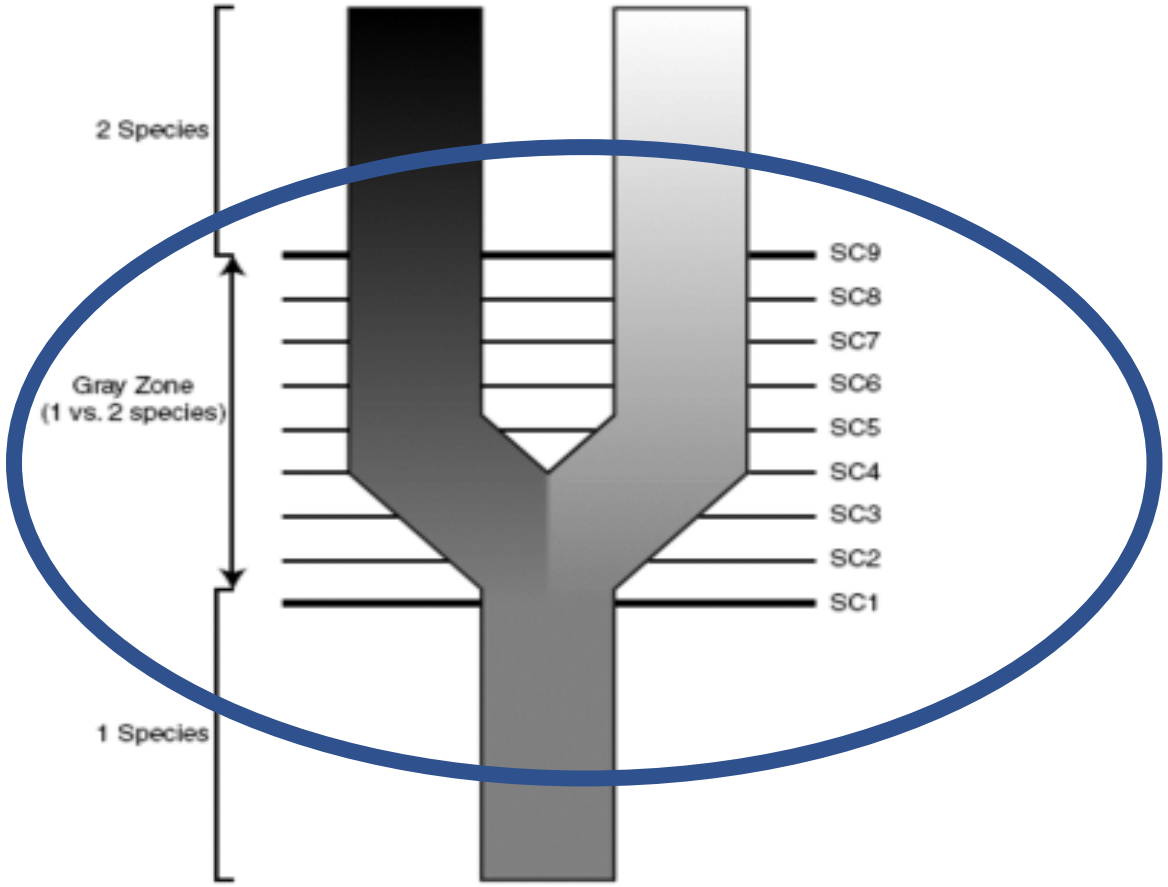
- An hypothesis.
- Enables biodiversity and the complexity therein to be classified into ‘palatable’ units we think we understand.
- However, all life is pretty much about passing on genes, organisms don’t care what we call them, they just get on with their lives.
- No ‘species’ is truly stable either – most ‘species’ last less 3 million years (less now!!!!), and all ‘species’ are consistently changing through evolution.

Species concepts

- Lots of them – all purport to be better than the others but essentially state ‘multiple lines of evidence make the best species’.
- Increasingly much is made of a ‘unified species approach’ or ‘integrative taxonomy- new terms that cover what most people have tended to do anyway i.e., utilise multiple lines of evidence.
- The key is being consistent in your approach – and this does not mean favouring one technique over many.

Remember this?





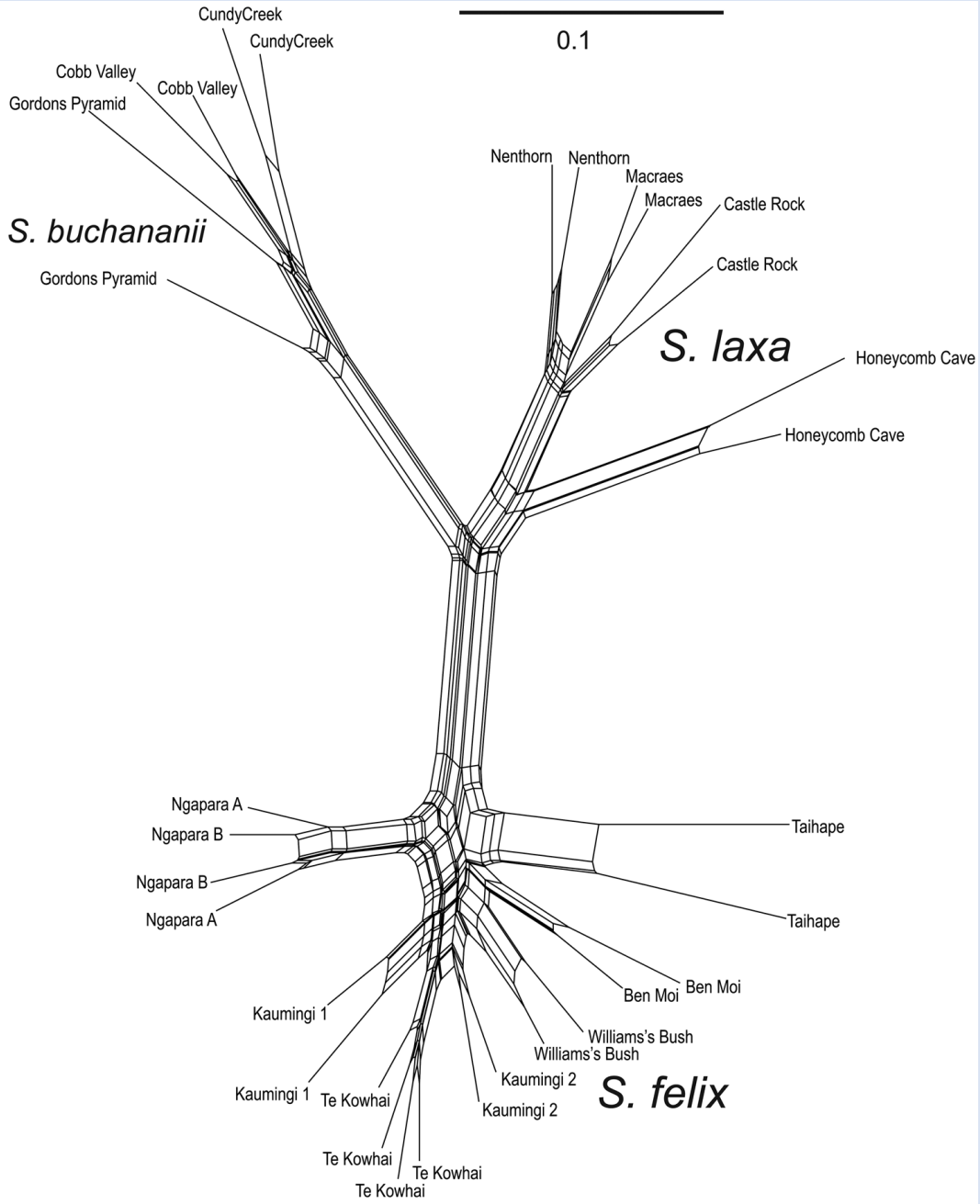
Molecular Systematics

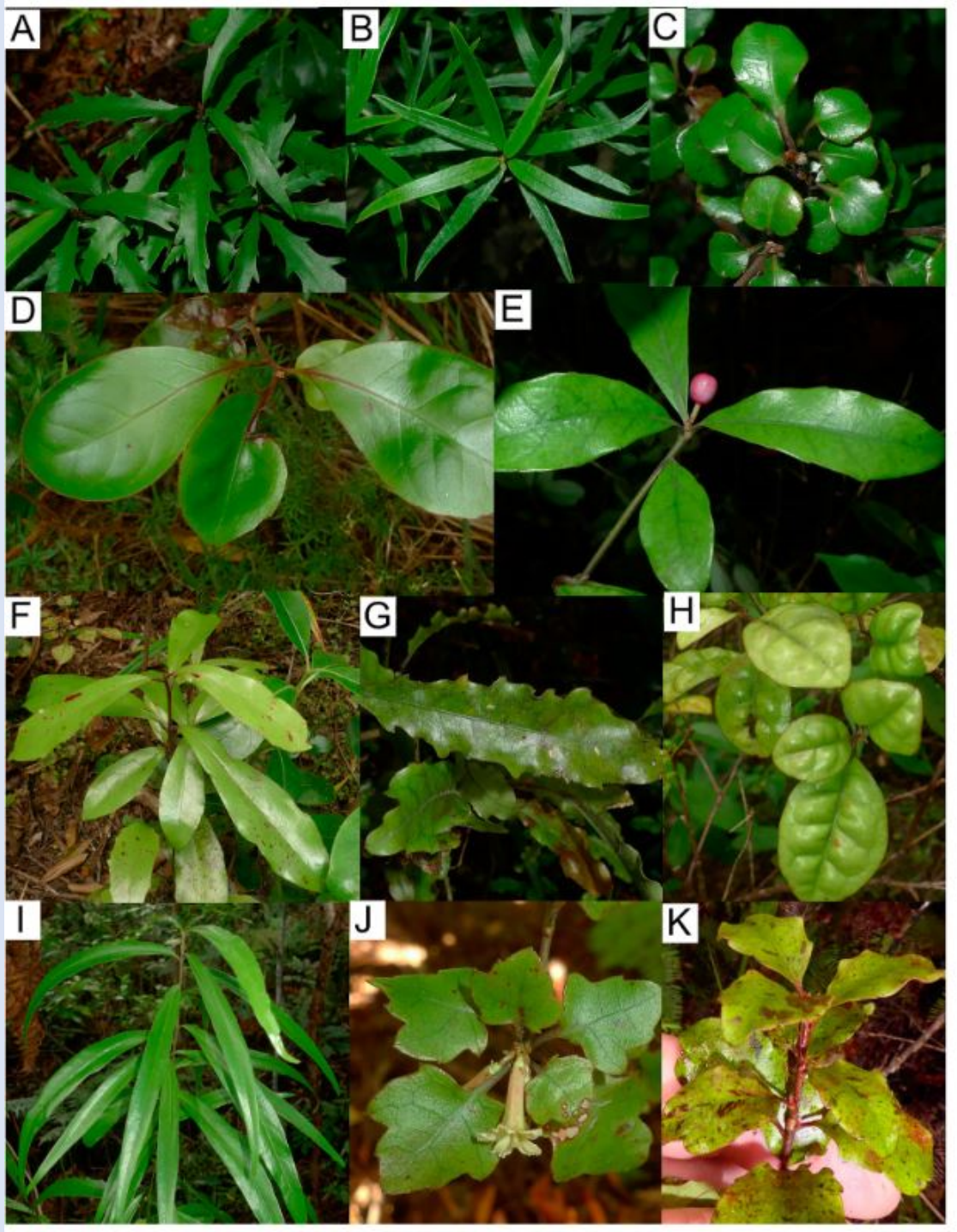
- DNA data can be used to show the relationships between taxa.
- Such data is now routinely used to construct phylogenetic trees.
- Such tree's work best using multi-marker or 'whole' genome data.
- Increasingly DNA data has been used to develop a framework on which one can develop a taxonomy.
- The problem is where DNA data fails e.g., recent species radiations, reticulation events and of course, we still don't know what all DNA does or doesn't do.

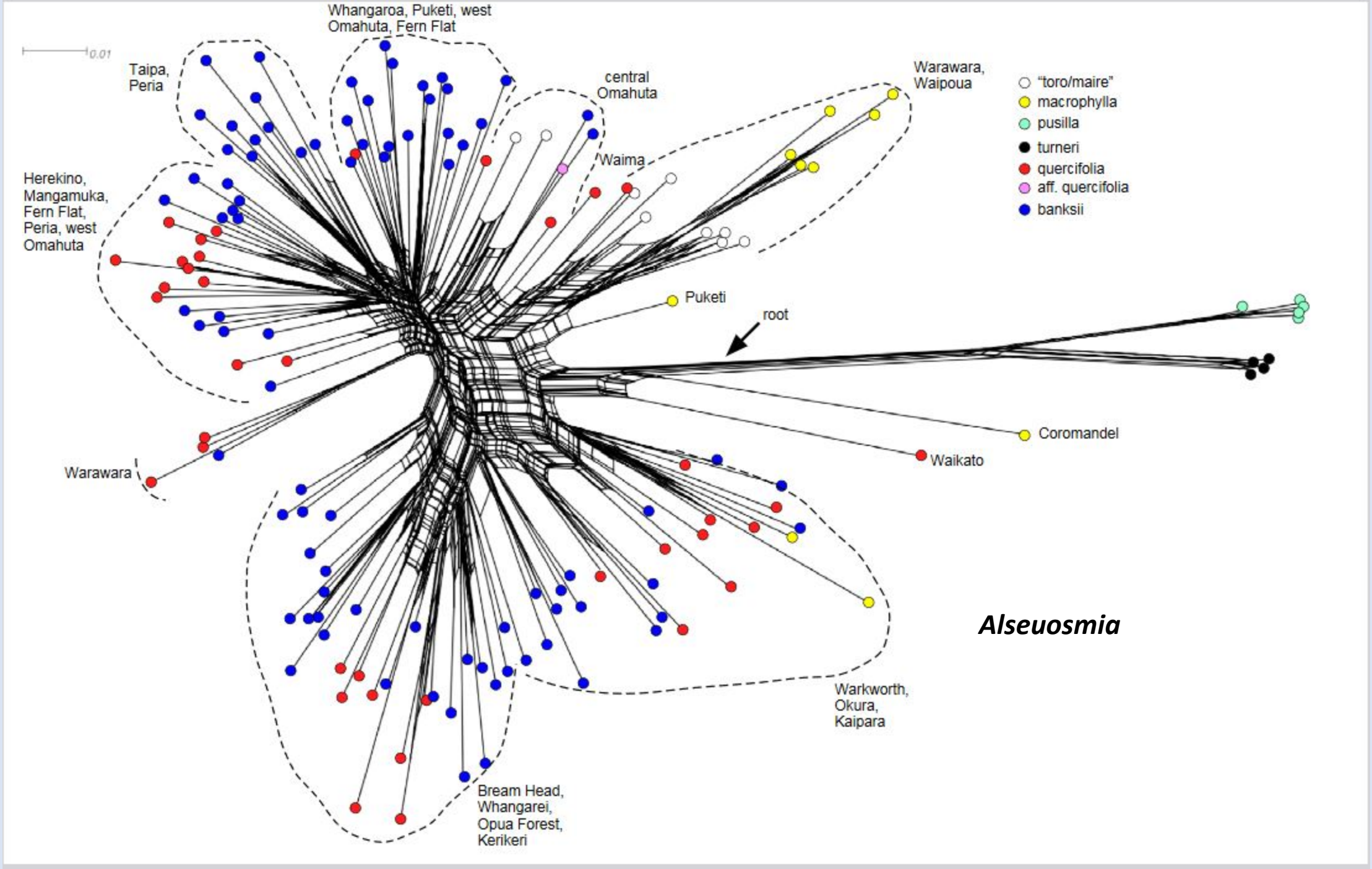
DNA and Recent Species Radiations

- Aotearoa / New Zealand is characterised by rapidly evolving, closely related plant lineages.
- Reticulation events are widespread i.e. our Flora is full of hybrids (most fertile) and introgressive swarms.
- Evolution here seems to be rapid, possibly a consequence of our ‘active’ tectonic setting and variable climate.
- Thus, DNA data can become confused - especially when involving hybridism cycles / events.

Reticulation and Rapid Species Radiations



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Waima
Herekino, Mangamuka, Fern Flat, Peria, west Omahuta
Puketi
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Coromandel
Waikato
Warawara
Warkworth, Okura, Kaipara
Bream Head, Whangarei, Opua Forest, Kerikeri
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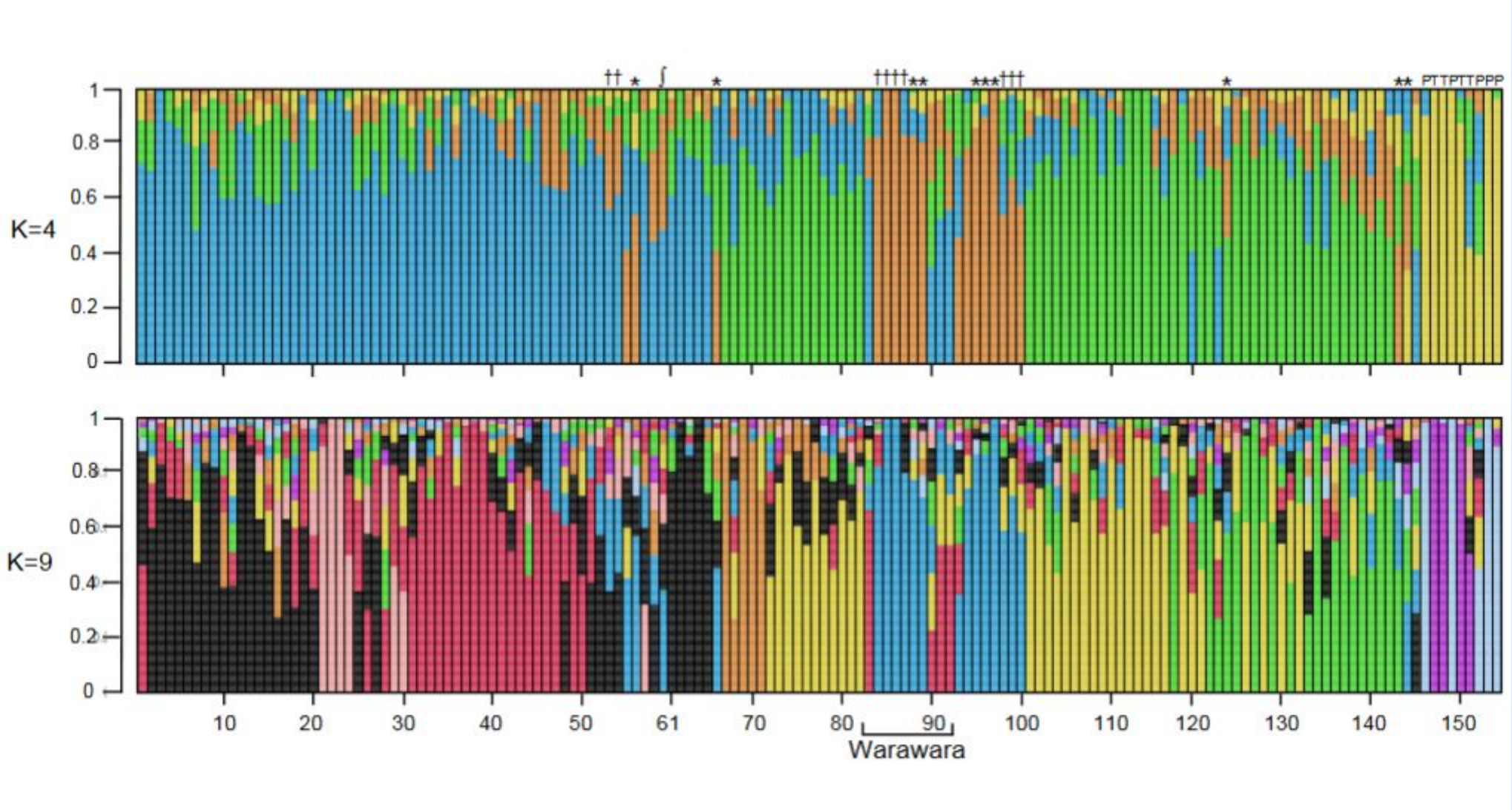
Alseuosmia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B. elaegnifolia


Bedfordia


Traversia


Dolichoglottis

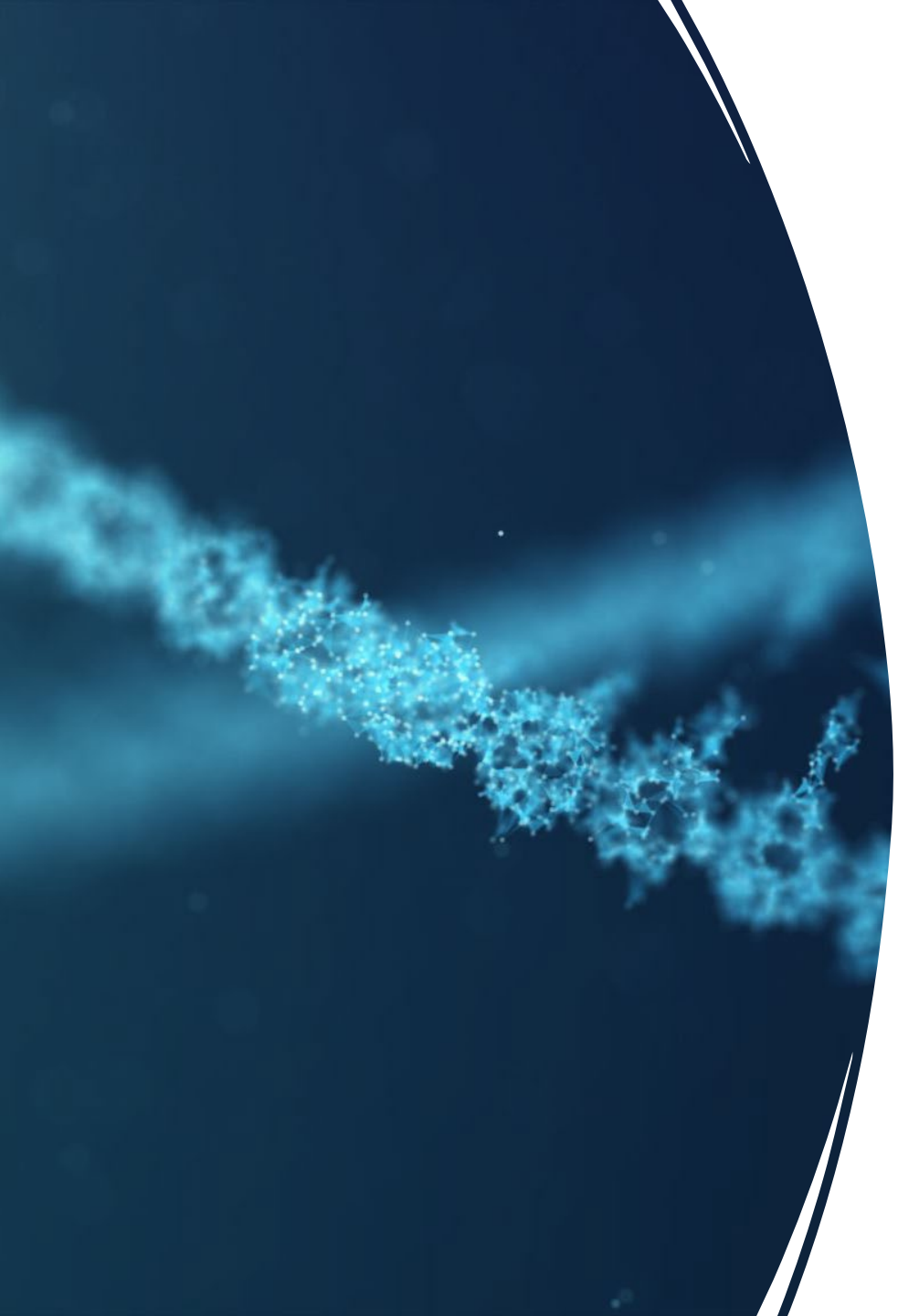

Haastia


Lordhowea

Myosotis australis – is it really one species?

Epilobium – one species?

- DNA phylogenies to date cannot separate in any meaningful way the majority of the *Epilobia* found in Aotearoa / New Zealand
- Logically then, if we accept molecular data as the basis for classification we have one species (or close to it)



Coalescent Theory

A model of how alleles sampled from a population may have originated from a common ancestor. Coalescent theory assumes ***no recombination, no natural selection, and no gene flow or population structure***, meaning that each variant is equally likely to have been passed from one generation to the next. The model looks backward in time, merging alleles into a single ancestral copy according to a random process in coalescence events.

The Multispecies Coalescent

- A model describing the genealogical relationships for a sample of DNA sequences taken from several ‘species’. It applies coalescent theory to the case of multiple ‘species’. The multispecies coalescent results in cases where the relationships among ‘species’ for an individual gene (the gene tree) can differ from the broader history of the species (the species tree). ***It has important implications for the theory and practice of phylogenetics and for understanding genome evolution***.

- A gene tree is a ***binary graph describing evolutionary relationships between a sample of sequences for a non-recombining locus***. A species tree describes the evolutionary relationships between a set of species, ***assuming tree-like evolution***. However, **several processes can lead to discordance between gene trees and species trees**. The ***Multispecies Coalescent model provides a framework for inferring species phylogenies*** while accounting for **ancestral polymorphism and gene tree-species tree conflict**.

- ***Multispecies coalescent assumes Hardy-Weinberg Equilibrium occurs within populations*** but this assumption is ***susceptible to error because it violates the five key assumptions underpinning Hardy-Weinberg Equilibrium, and this includes model-based clustering*** (Sukumaran & Knowles 2007)

- In other words, ***the multispecies coalescent does not define species*** it provides a phylogenetic framework based on molecular data (Sukumaran & Knowles, 2007)

References

Sukumaran, J.; Knowles, L.L. 2017: Multispecies coalescent delimits structure, not species. *PNAS 114 (7)*: 1607-1612.

So….

Studies that use molecular data in isolation to define species, and base their assumptions on the Multispecies Coalescent are flawed

Further studies that use gene data in absence of other tests are ***not*** Unified Species Concepts i.e., you must bring together multiple lines of evidence to define evolutionary units (‘species’)

Kunzea – one species or 10?

- de Lange (2014) in his treatment of *Kunzea* recognised 10 species (four already recognised at some level of taxonomic rank), six new to science
- That treatment bought together molecular (nrDNA ITS, ETS), cytological (karyology / Genomic In situ Hybridism data), common garden experiments, experimental hybridism, morphological, chemical, ecological and cultural data to support the treatment. Typifications for those taxa already recognised were corrected or newly undertaken
- de Lange (2014) did not state it, but he used a ‘unified species concept’

References

de Lange, P.J. 2014: A revision of the New Zealand *Kunzea ericoides* (Myrtaceae) complex. *PhytoKeys 40*: 1–185.

Kunzea continued

- Heenan et al. (2023) used molecular data to test the species recognised by de Lange (2014).
- Their paper does not use the ‘unified species’ concept recommended by the authors, and it violates the assumptions behind using a ‘multispecies coalescent’.
- This paper is *not* a taxonomic treatment – it is test of one aspect of a treatment using a molecular technique too expensive to utilise in the early 2000s.
- Ironically, their data shows a structure that equates to the majority of the species recognised by de Lange (2014). Further they contradicted themselves with respect to their K values – there are K8-10 (i.e. 8-10 unique clusters of alleles) but they state there were K4 – their data shows otherwise.

References

Heenan, P.B.; McGlone, M.S.; Mitchell, C.M.; McCarthy, J.K.; Houliston, G.J. 2023: Genotypic variation, phylogeography, unified species concept, and the ‘grey zone’ of taxonomic uncertainty in kānuka: recognition of *Kunzea ericoides* (A.Rich.) Joy Thomps. sens. lat. (Myrtaceae). *New Zealand Journal of Botany*: 1–30 (online). (Published online: 12 Jan 2023)

Contradictions: *Clianthus* – two species or one?

- Heenan (2000) reinstated at species rank *Clianthus maximus* Colenso, segregating it from *C. puniceus* on the basis of reproductive and morphological characters.
- Song (2008) using *LEAFY* found geographic structure in *Clianthus*, they questioned the validity of recognising two species, noting that northern Tairawhiti populations (*C. maximus*) had the same *LEAFY* sequence as Moturemu *C. puniceus* and cultivated examples of that species.
- Houliston (2013) undertook a more comprehensive study for the Department of Conservation (contract – never formally published), using multiple DNA markers, AFLP and Microsatellites and could not distinguish two species.
- Yet *Clianthus* is still maintained as two species though *C. magnificus* has priority over *C. maximus*.
- For conservation purposes it is better to maintain the genus and worry about the species when the genus is secure in the wild……

References

Heenan, P.B. 2000: *Clianthus* (Fabaceae) in New Zealand: a reappraisal of Colenso's taxonomy. *New Zealand Journal of Botany 38(3)*: 361–371.

Song, J.; Murdoch, J.; Gardiner, S.E.; Young, A.; Jameson, P.E.; Clemens, J. 2008: Molecular markers and sequence deletion in intron 2 of the putative partial homologue of LEAFY reveal geographical structure to genetic diversity in the acutely threatened legume genus *Clianthus*. *Biological Conservation 141 (8):* 2041-2053.

Clubmoss and Fern weirdness

- *Parapolystichum* has no unique morphological characters to distinguish it from *Lastreopsis*.
- *Parapolystichum* was resurrected to ‘save’ the mass lumping of other fern genera into *Rumohra* – due to paraphyly at a molecular level.
- *Austroblechnum*, *Cranfillia*, *Diploblechnum*, *Doodia* and *Parablechnum* are chemically, morphologically and genetically distinct from *Blechnum* but because one small group favour a single ‘genus’ *Blechnum* (because of their interpretation of molecular paraphyly) people are being told to use *Blechnum* and legitimate researchers are being threatened.
- Lycopodiaceae have been split into 10 genera on the basis of a unifed species concept but one small group favour using three genera otherwise Aotearoa / New Zealand would not have any *Lycopodium*…..
- Cyatheaceae were split in 1970 into a number of genera, this was rejected for not clear reason and one genus *Cyathea* became favoured. Subsequent molecular analyses confirm the 1970 splits – and this is followed internationally but not in Aotearoa / New Zealand – why?

Swainsona or *Montigena*?

- *Swainsona novae-zelandiae* was placed in the monotypic genus *Montigena* on the basis of a single nucleotide sequence region (nrDNA ITS) and the way the seed pod microfibres are arranged.
- Most authorities do not accept this genus, seeing it as merely a slightly divergent *Swainsona*.

Take home message

- **Caveat Emptor.**
- First ask yourself – are these new names ones that I need to use?
- Then – look at the methodology – does it make sense? Is this a treatment or an opinion?
- Read the literature and make your own mind up.
- Remember that National Databases are only as good as the people who manage them.


Me rongo