A phylogenetic study of NZ wax-caps

(Mycological Notes 42)

Jerry Cooper, April 2021

(A presentation at the FUNNZ colloquium)

With photos/collections from numerous forays, individuals and iNat observers

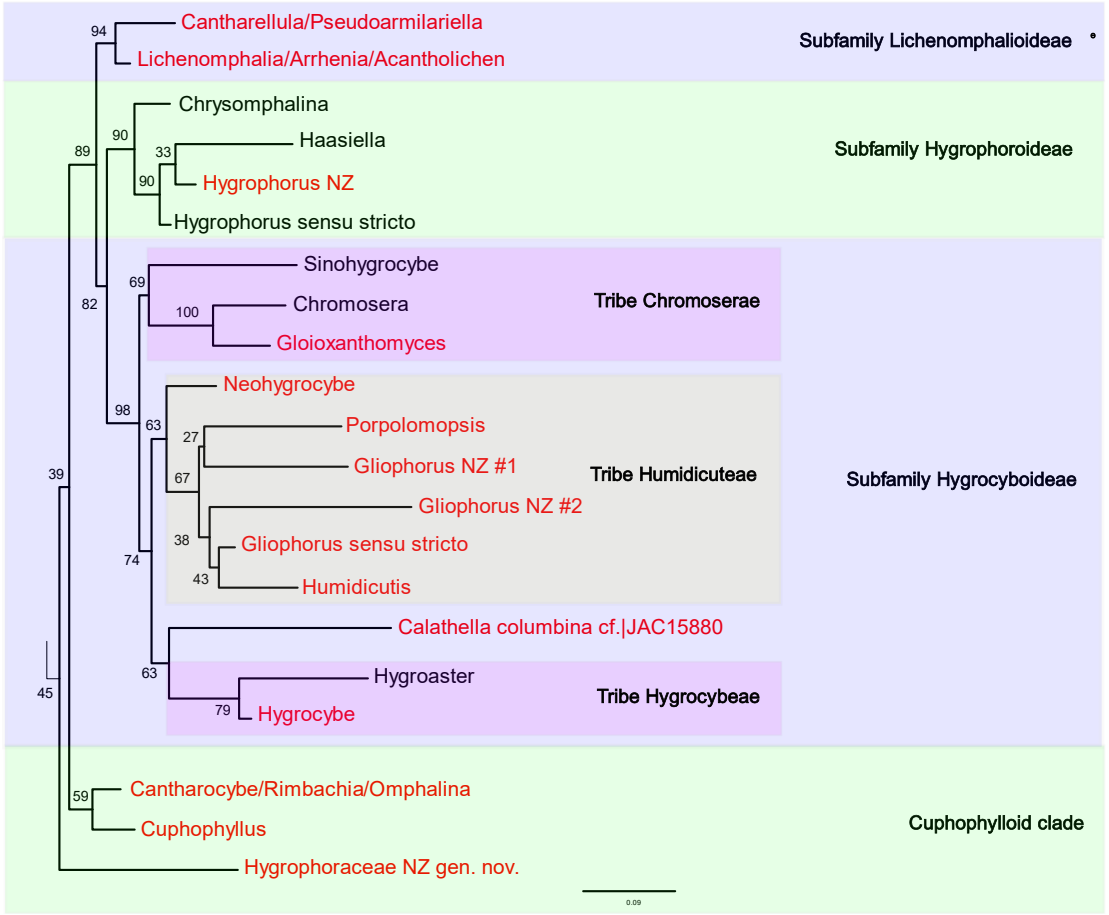
Sequencing mostly by Duckchul Park

Analysis and errors of interpretation entirely by me

Historical work on NZ Wax-Caps

- 1962 Greta Stevenson tackled '*Hygrophorus* sensu lato' (Agaricales of NZ IV)
  - She included 25 species of which 22 survive
- 1973 Egon Horak 1st revision (Fungi Agaricina Novaezelandiae)
  - He added 26 taxa
- 1990 Egon Horak monograph
  - He re-organised, resurrected, merged and added 6 taxa. Then 57 taxa in total
- 2014
  - Lodge, Padamsee et al establish a modern global phylogenetic treatment
- 2021 changes since 1990?
  - Added 4 introductions from Europe/North America (*Hygrocybe conica, H. singeri, Cuphophyllus virgineus, Gliophorus psittacinus*)
  - Added 2 indigenous described Australian species *('Hygrocybe' cheelii, Porpolomopsis lewelliniae*)
  - Uncovered lots of undescribed species in current sequence data, lots of uncertain identifications, several described species still need sequences
  - Horak's generic placements need updating
  - Some 'wax-caps' moved to the Clavariaceae – *Hodophilus, Camarophyllopsis* sensu stricto
  - Probably ~100 true wax-cap species present in NZ, with 64 currently named (some are complexes) and 18 'tagged'

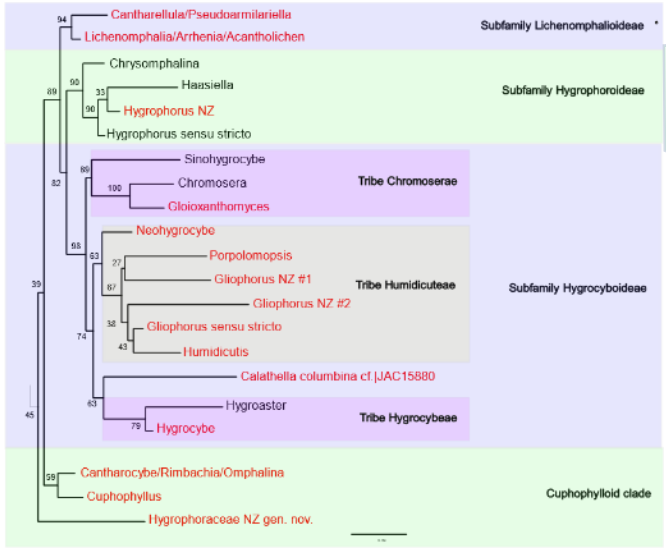
Phylogeny of NZ Hygrophoraceae



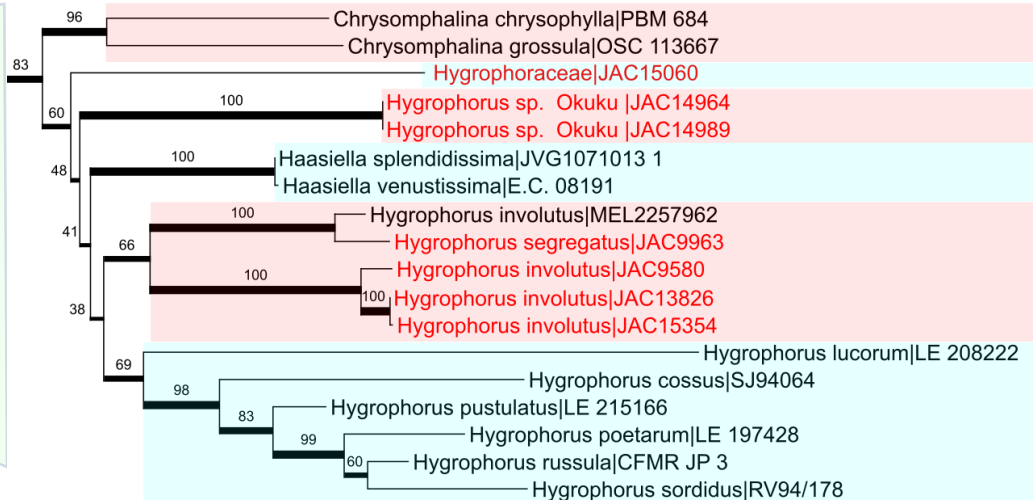
ITS+LSU+SSU+RPB2

- Genera with NZ representatives are in RED
- Here not considering the moss/lichen associated species
- *Cantharellula/Pseudoarmillariella* in NZ but not seen recently (please find them)
- Some unfamiliar genera – the NZ taxa in them are currently included in inappropriate genera
- *Hygrocybe* is a mess
- There's some weird stuff

Subfamily Hygrophoroideae



Gen. nov. x 3 ?
Ectomycorrhizal?
Metachromatic spores?



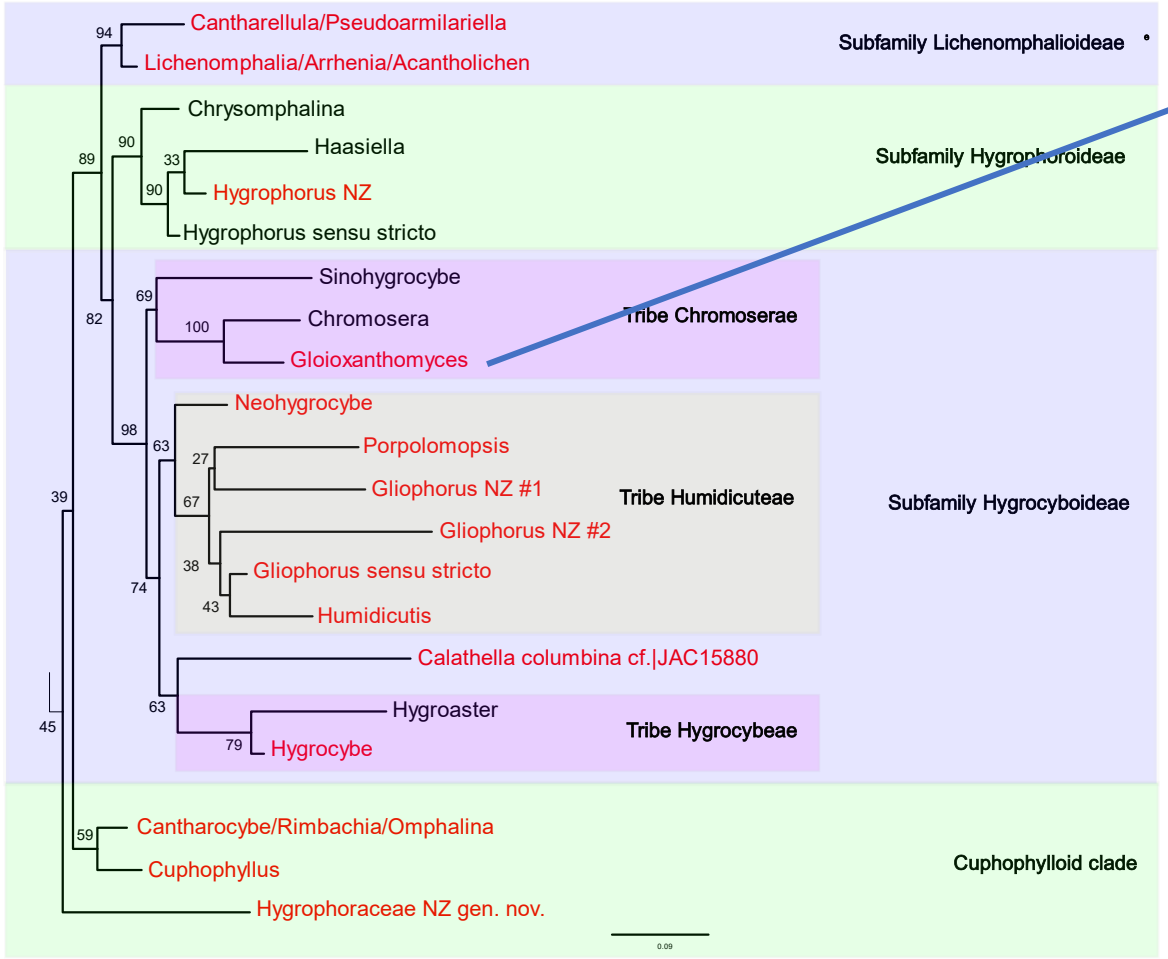
Hygrophorus involutus

Hygrophorus segregatus

Hygrophorus sp. 'Okuku'
(see also 'Camarophyllus' muritaiensis)

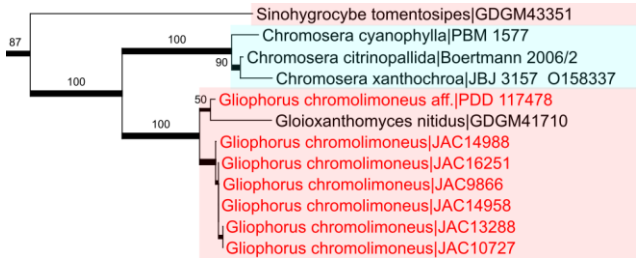
'Hygrophorus' sp. JAC15060

Phylogeny of NZ Hygrophoraceae



Subfamily Hygrociboideae – Tribe Chromoserae

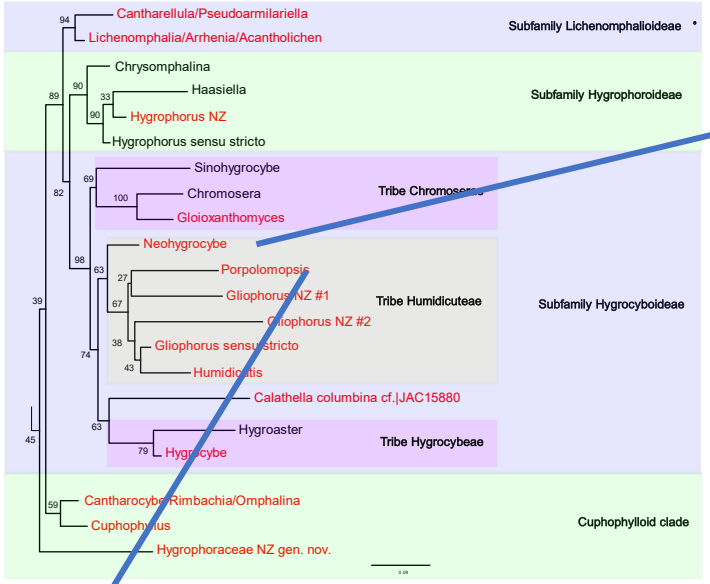
Gloioxanthomyces



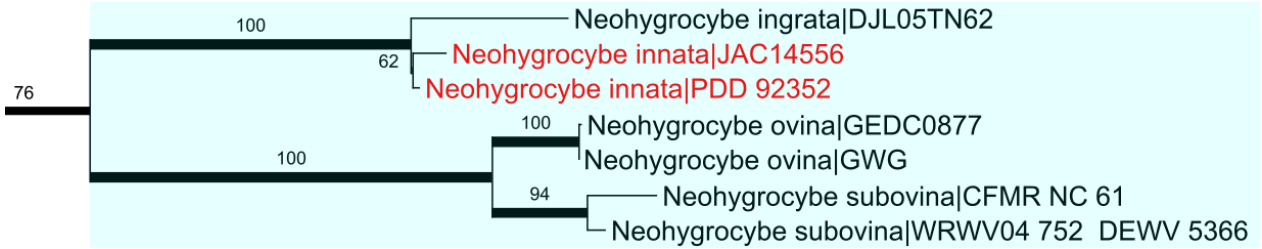
'Gliophorus' chromolimoneus

- If it's a yellow '*Gliophorus'* then it probably belongs in *Gloioxanthomyces*
- *Gliophorus luteoglutinousus* & *G. sulfureus* belong here?

Subfamily Hygrociboideae – Tribe Humidicuteae



Neohygrocybe

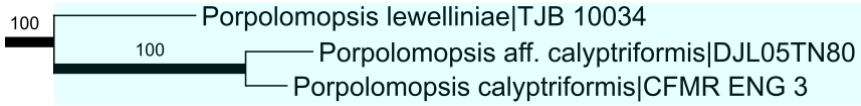


Neohygrocybe innata

Neohygrocybe squarrosa

- Horak described 2 NZ species of *Neohygrocybe*.
- They are hard to recognise as ‘wax caps’.
- Very similar to a number of Tricholomataceae.
- *N. innata* is close to European *N. ingrata*
- *N. squarrosa* no convincing material sequenced
- *H. lawsonensis* of Au – a *Neohygrocybe*?

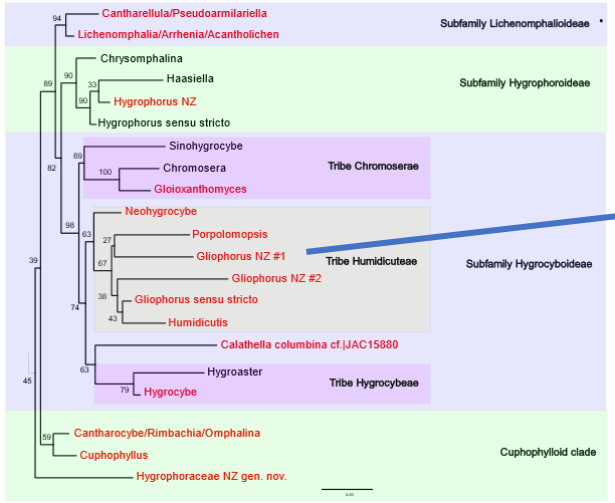
Porpolomopsis



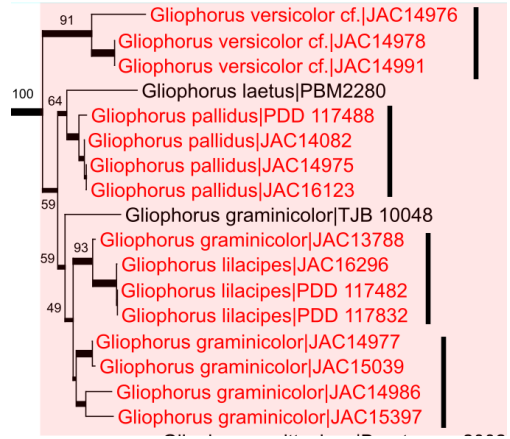
Porpolomopsis ‘lewelliniae’

- A recent addition to the NZ list
- Described from Australia and it has yet to be demonstrated the NZ taxon is identical
- Sequencing of NZ collections failed – twice

Subfamily Hygrociboideae – Tribe Humidicuteae



Gliophorus NZ #1



Gliophorus is very poorly sampled for multiple loci so not much is certain

Gliophorus pallidus

Gliophorus graminicolor s.l.

Gliophorus lilacipes

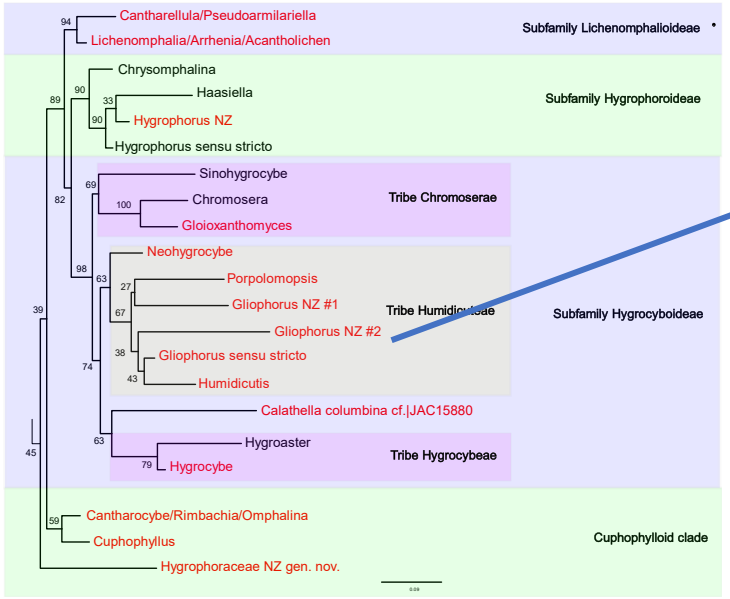
Gliophorus versicolor cf.

Gliophorus* NZ #1 corresponds to *Gliophorus* section *Glutinosae and has high Australasian diversity

This group often has a granular appearance, cheilocystidia and a separable thread on the gill edge

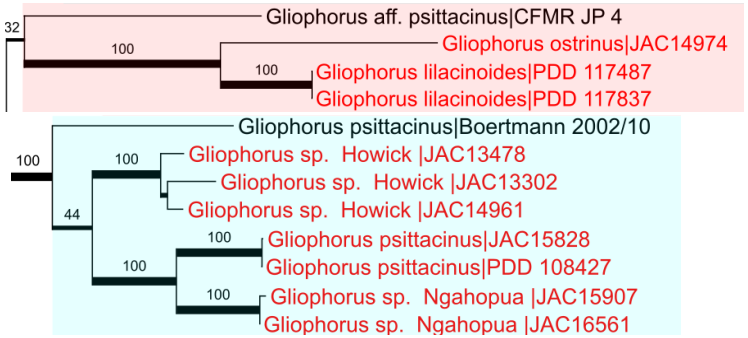
- *G. pallidus* is a good separate species and not a synonym of *G. graminicolor*
- *G. graminicolor* **is** however a diverse species complex with broad colour variants, not just green.
- *G. versicolor* is another species complex
- *G. viscaurantius* perhaps does not belong in this group (= *Hygrocybe*?)

Subfamily Hygrociboideae – Tribe Humidicuteae



Gliophorus NZ #2 & SS

Gliophorus is very poorly sampled for multiple loci so not much is certain



Gliophorus psittacinus aff. *Gliophorus sp. 'Ngahopua'* *Gliophorus sp. 'Howick'*

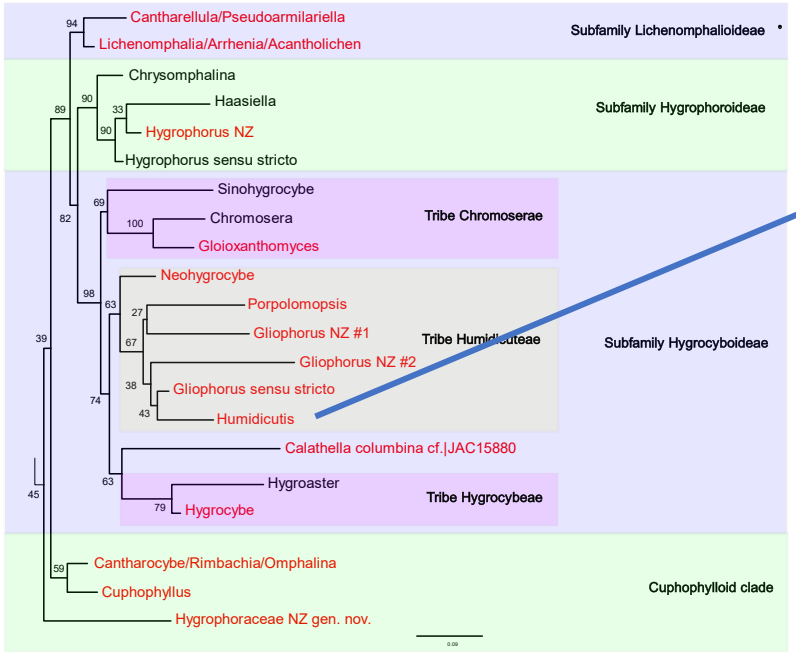
***Gliophorus* NZ #2 (lilacinoides) is part of *Gliophorus* section *Gliophorus* (sensu stricto)**

This group lacks cheilocystidia and a separable thread on the gill edge.

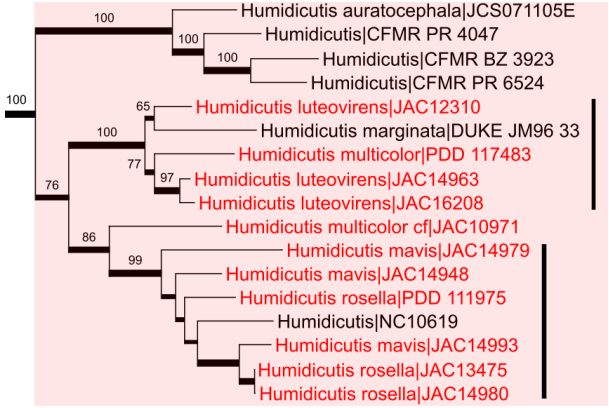
- *G. psittacinus aff.* is introduced from somewhere – but is not the European version
- The *G. lilacinoides/ostrinus* group needs more sampling
- There is no sequenced material of *G. viridis* (that hasn't come out in the *G. graminicolor* group)
- The yellow species in Horak's group are now recognised as *Gloioxanthomyces*
- The bright red *G. subheteromorphus* (Chile) belongs in *Hygrocybe* where it was placed originally
- *G. fumosogriseus* is also not a *Gliophorus* – although I'm not sure where it belongs. Sequences fail

Gliophorus ostrinus *Gliophorus lilacinoides*

Subfamily Hygrociboideae – Tribe Humidicuteae



Humidicutis



- All species are without clamp connections – and most other NZ Hygrophoraceae have them. Also usually with a splitting cap

- *H. mavis/rosella* form a species complex with white/pink variable colour
- *H. multicolor/luteovirens* form a species complex. More sampling needed
- *H. multicolor* was described from Sri Lanka and will not be the correct name for the NZ taxon
- *H. conspicua* was described with 'aborted clamps' and may not be *Humidicutis*

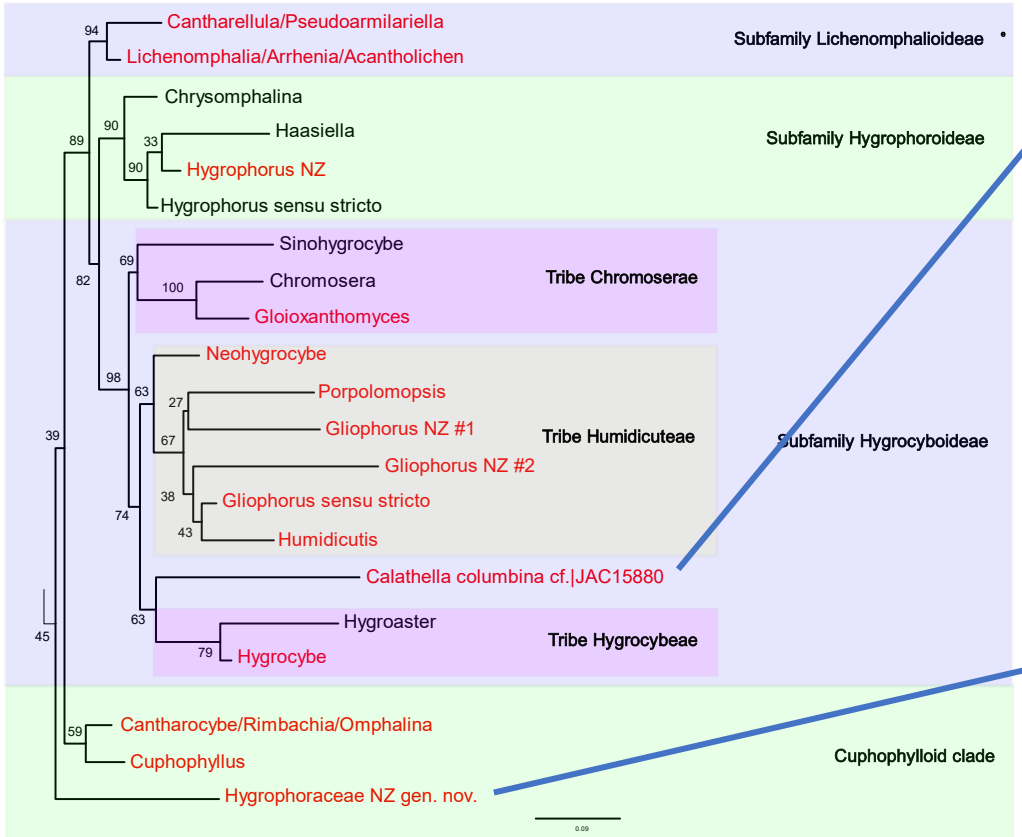
Humidicutis mavis

Humdicutis rosella

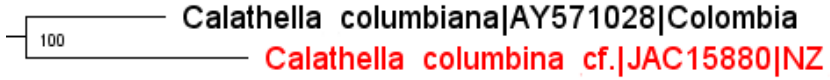
Humidicutis multicolor cf.

Humidicutis luteovirens

Odd stuff



Calathella



Calathella columbina cf.

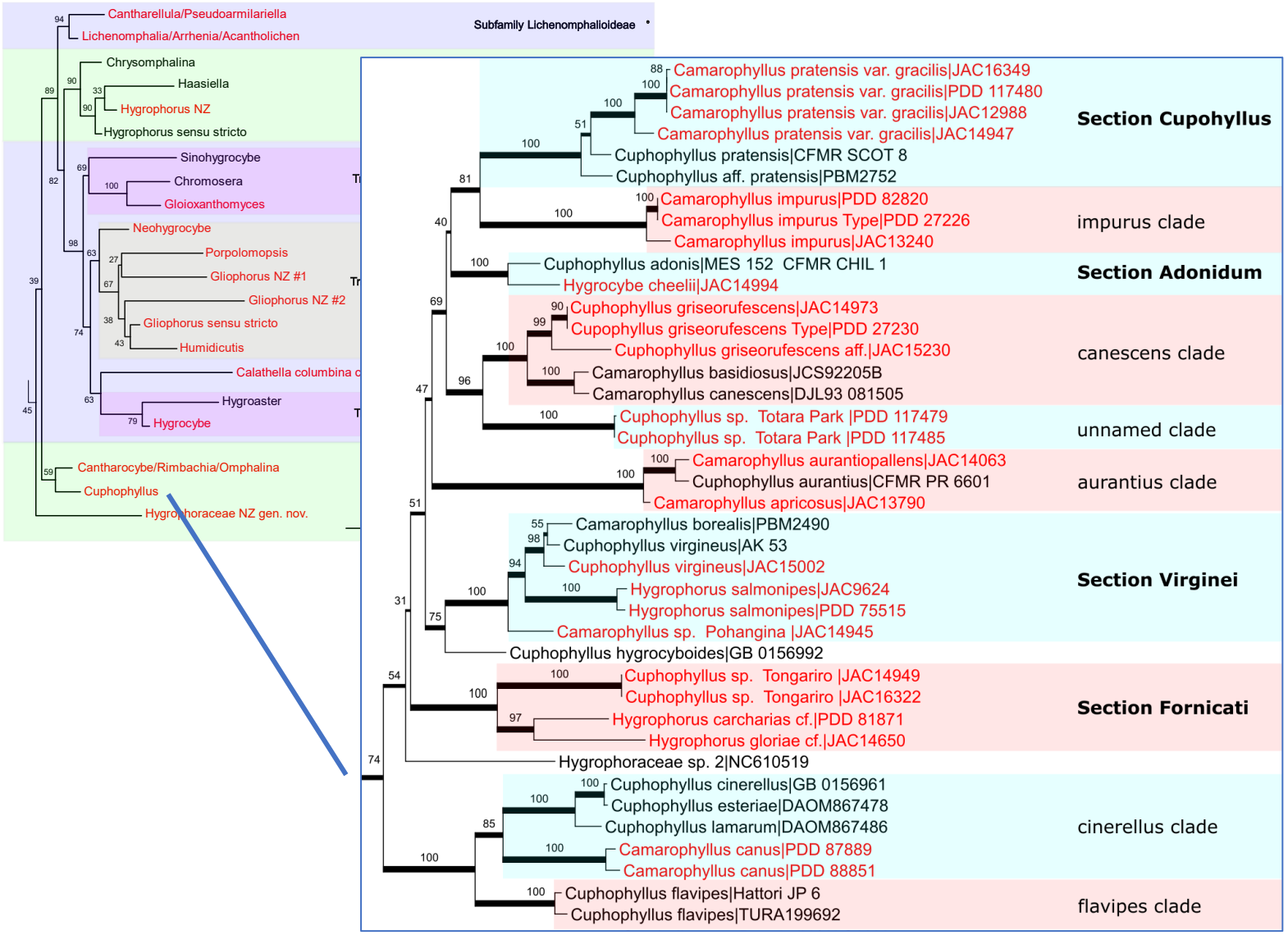
- One of Noah Siegel's contributions
- An unlikely member of the Hygrophoraceae!
- The genus is probably polylphyletic

Hygrophoraceae unplaced

PDD 72853

JAC16203

The Cuphophylloid clade



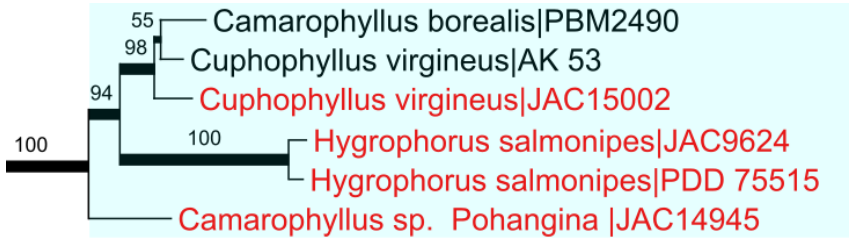
- Irregular trama (regular in most groups)
- Most of Horak's *Camarophyllus* species belong here in *Cuphophyllus*
- *'Hygrophorus' salmonipes* is a *Cuphophyllus*
- *'Camarophyllus' impurus* includes *'Camarophyllus' patinicolor*
- We have the Australian *'Hygrocybe' cheelii* and the introduced European *Cuphophyllus virgineus*
- *Cupophyllus austropratensis* should be the correct name for *C. pratensis* var. *gracilis*
- *'Camarophyllus' muritaiensis not found recently (= C. austropratensis? Or Hygrophorius sp. 'Okuku'?)*

The Cuphophylloid clade – Section Virginei

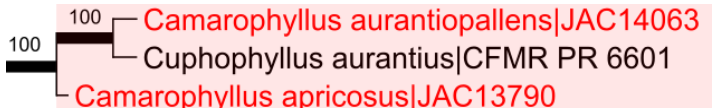
Cuphophyllus virgineus

'Hygrophorus' salmonipes

Cupophyllus sp. 'Pohangina'



– aurantius clade

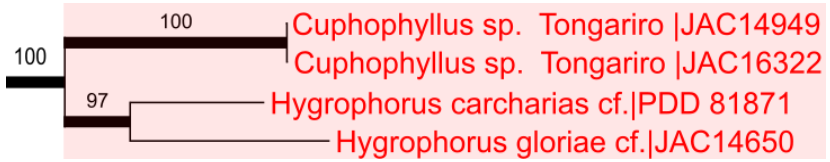


Not typical for the genus
Australia interpretation = *Hygrocybe*

'Camarophyllus' apricosus

'Camarophyllus' aurantiopallens?

The Cuphophylloid clade – Section Fornicati

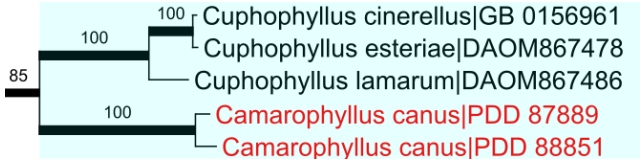


Cuphophyllus sp. 'Tongariro'

'Hygrophorus' carcharias?

'Hygrophorus' gloriae (sensu Horak)

– cinerellus clade

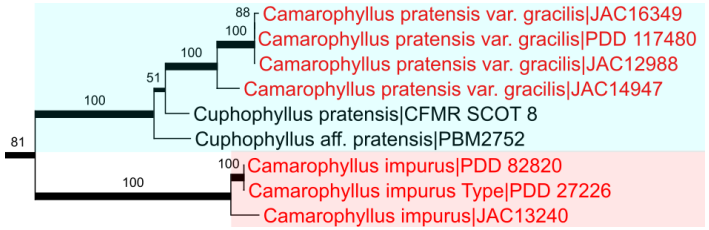


'Camarophyllus' canus (cf. H. griseoramosa/watangensis)

– Section Adonidum

'Hygrocybe' cheelii = 'Camarophyllus' lilacinus, or 'Hygrocybe' reesiae

The Cuphophylloid clade – Section Cuphophyllus



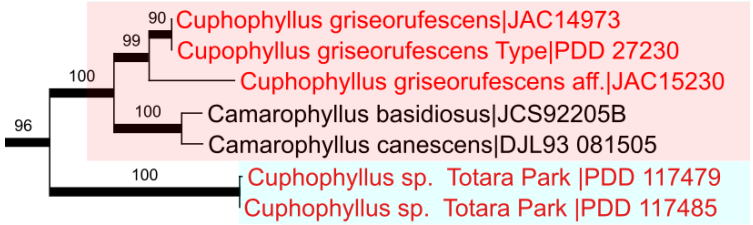
'Camarophyllus' impurus

= 'Camarophyllus' patinicolor

'Camarophyllus' pratensis var. gracilis = 'Hygrocybe' austropratensis

Var. *gracilis* is rarely gracile!

Description based on 1 collection



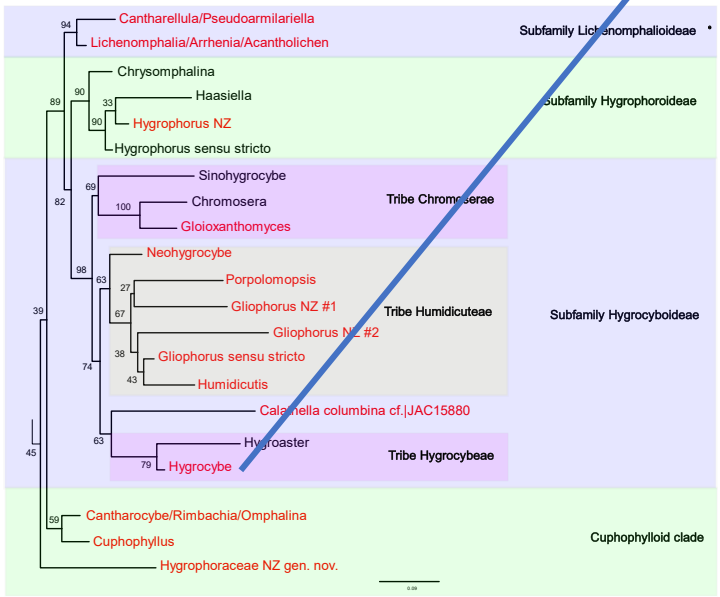
– canescens clade

Cuphophyllus sp. 'Totara Park'

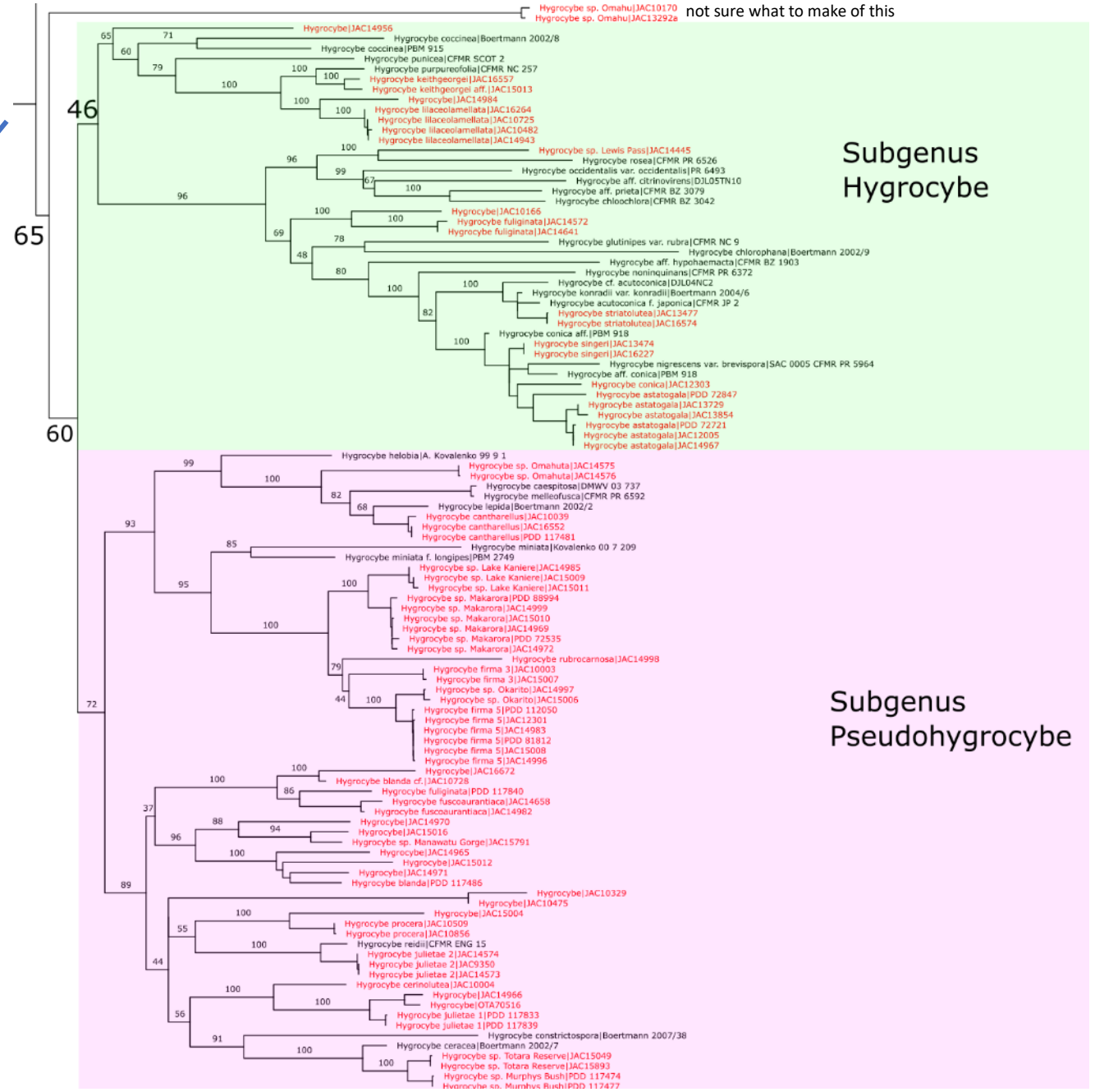
Cupophyllus griseorufescens aff.

Cupophyllus griseorufescens

Hygrocybe



H. sp. 'Omahu' … huh?



Two subgenera and numerous sections are recognised

But …

The subgeneric classification remains phylogenetically dodgy and the sub-clades move around in analyses

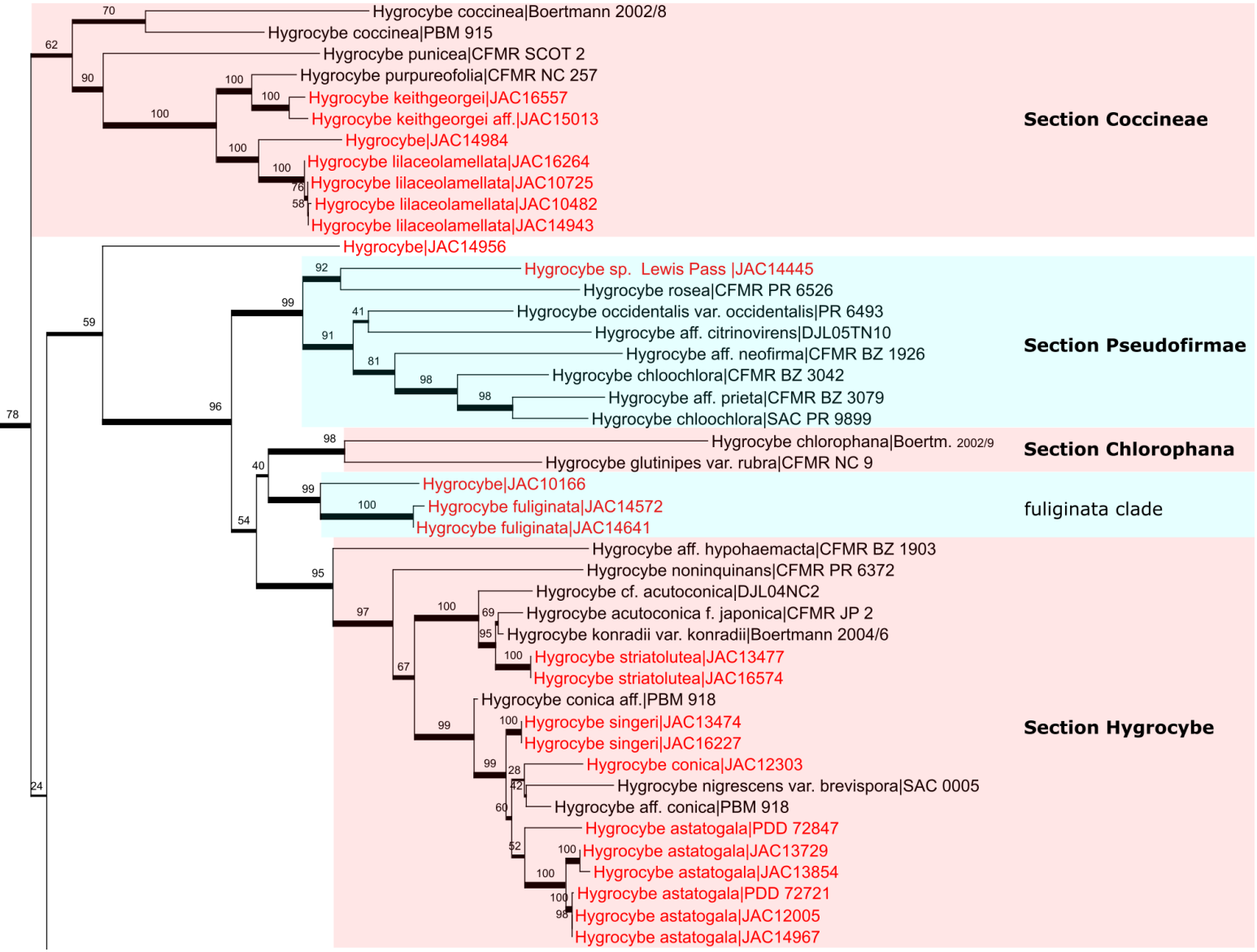
Many infrageneric sections do not have robust morphological separators

The group contains the noticeable/attractive red/yellow waxcaps (DOPA pigments)

Many NZ species were described from just 1 or 2 collections and not sufficiently pinned-down

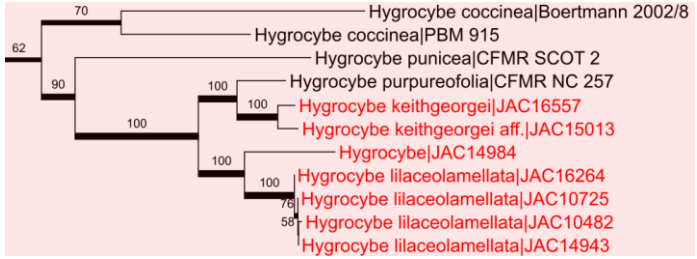
There are many undescribed species in NZ

Hygrocybe subgenus Hygrocybe



- Section Coccinea is traditionally considered part of Pseudohygrocybe. Here supported at separate at subgenus level – but barely
- The traditional subsections of Coccineae appear in Pseudohygrocybe

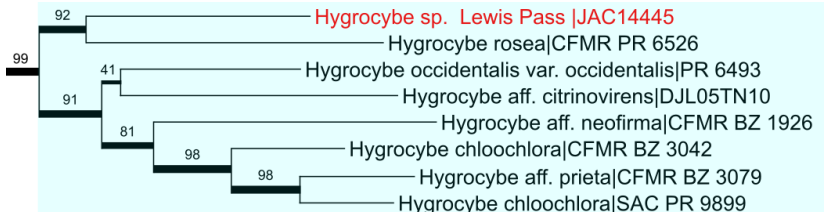
Section Coccineae ?



H. keithgeorgii
= H. lilaceolamellata auct Au

H. lilaceolamellata
non auct Au

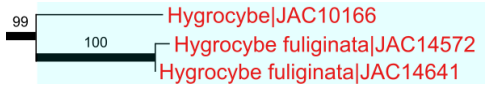
Section Pseudofirmae



H. sp. 'Lewis Pass'

Misidentified as
H. subheteromorphus
and *H. miniata*

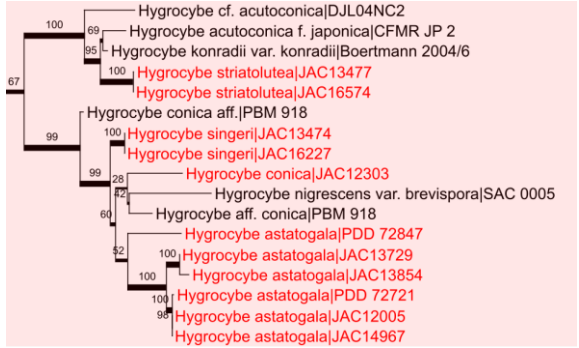
fuliginata clade



H. fuliginata

H. subheteromorphus
sensu E. Horak (as Gliophorus)

Section Hygrocybe



H. striatolutea

H. singeri

H. conica

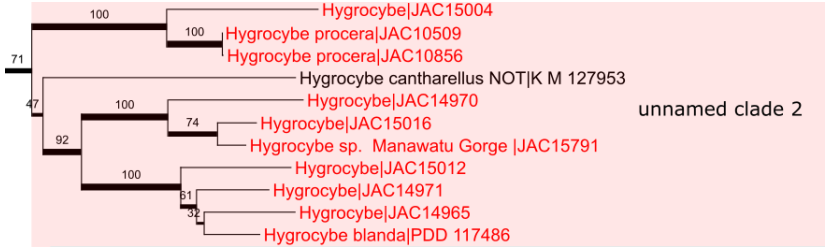
H. astatoglala
(greenish)

H. astatoglala
(orangey)

Hygrocybe subgenus Pseudohygrocybe

- Many phylogenetic species are not reconciled with existing NZ names and sampling will no doubt uncover more
- Subsection-level northern hemisphere clades not supported with NZ taxa included
- Five species in Section Firmae have dimorphic basidia but *H. rubrocarnosa* does not
- *H. sp. 'Omahuta'* in the Squamulosae also has dimorphic basidia
- Species in the Siccae-related clades have variably sized basidia, spore number and spore size (but do not have dimorphic basidia)
- *H. blanda and H. procera* are names used very broadly in NZ
- The names *H. miniata & H. helobia* are misapplied in many countries. They are European species. Nothing so far in NZ in the *H. miniata* clade
- *H. elegans, H. miniceps* and *H. cavipes* belong here somewhere, but without consistent and convincing sequenced material

unnamed clades 1 & 2



JAC15004

H. procera

JAC14970

JAC5016

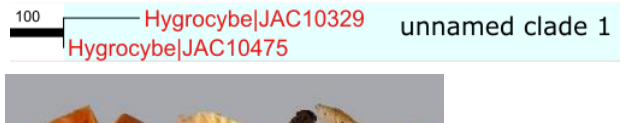
JAC15012

JAC14971

JAC14965

H. sp. 'Manawatu Gorge'

H. blanda

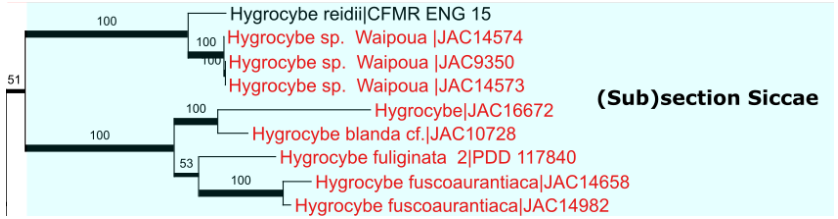


JAC10329

JAC10475

High diversity and similar species – multiple candidates for Horak's taxa.
Convincing collections of *H. elegans, cavipes and miniceps* are not yet sampled or incorrectly assigned

Subsection Siccae and unnamed clade 3

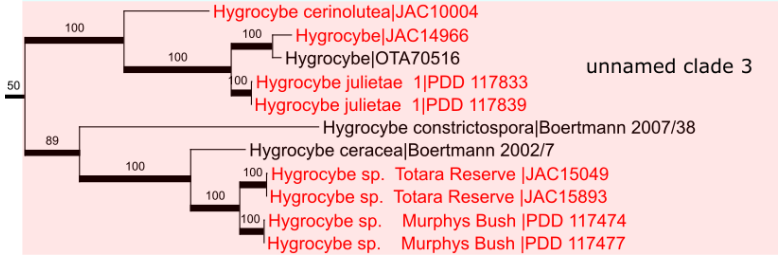


H. sp. 'Waipoua'

JAC16672 - Raoul

H. blanda cf.

H. fuscoaurantiaca



Multiple candidates for *H. cerinolutea, procera* and *julietae*

H. cerinolutea

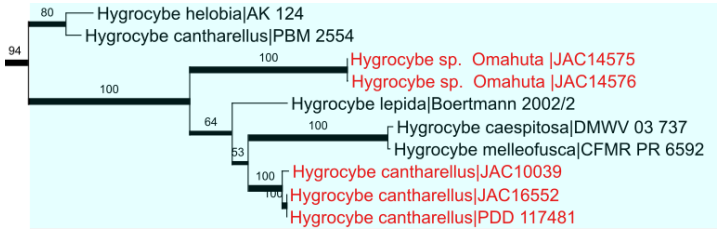
JAC14966

H. julietae

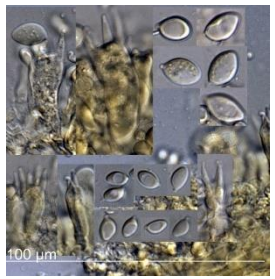
H. sp. 'Totara Reserve'

H. sp. 'Murphy's Bush'

(Sub)section Squamulosae

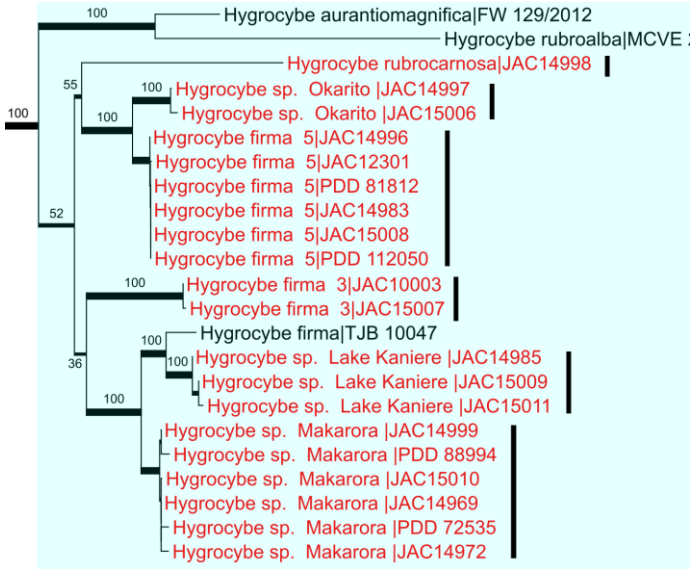


H. sp. 'Omahuta'



H. 'cantharellus'

(Sub)section Firmae



- *H. 'cantharellus'* NZ is not the same species as the Jamaican original but is within the *cantharellus/lepida/turundae* clade
- All these species have dimorphic basidia except *H. cantharellus* and *H. rubrocarnosa*
- None of the NZ species in the firmae clade will be the same as the original *H. firma* from Sri Lanka
- *H. firma* #3 & #5 correspond to Horak's concept
- Section Firmae is said to be tropical – yeh right

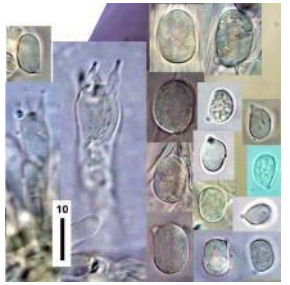
H. sp. 'Lake Kaniere'

H. sp. 'Makarora'

H. rubrocarnosa

H. firma #3

H. sp. 'Okarito'



H. firma #5

Where are we going next?

- One of many diverse NZ groups that needs much more sampling
- Perennial problem of unambiguously linking modern material to old species concepts, especially when based on 1 or 2 collections
- Multiple candidates for Horak's species – agreeing both macroscopically and microscopically but phylogenetically unique
- Lots of new species for (someone) to describe, but probably unrecognised cross-Tasman species. Very few named Australian sequences for comparison – as usual
- The infra-generic classification of *Hygrocybe* needs more work at the global level

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- Noah Siegel (NS)
- Christian Schwarz (CFS)
- Clive Shirley (CS)
- Grey Smith (GS)
- Egon Horak (EH)
- Lois Allison-Cooper (LAC)
- Jerry Cooper (JAC)