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A new classification of sections and series in *Eucalyptus* subg. *Eudesmia* (Myrtaceae)

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Abstract

The classification of sections and series in *Eucalyptus* subg. *Eudesmia* (R.Br.) L.A.S.Johnson & K.D.Hill is updated to align with results of a recent phylogenomic study. This revised classification involves recognition of one new section and two new series, namely *E.* sect. *Aurantistamineae* Bayly & R.Fowler, *E.* ser. *Phoeniceosae* (A.K.Gibbs & Ladiges) Bayly & R.Fowler, and *E.* ser. *Erythrocorythosae* (A.K.Gibbs & Ladiges) Bayly & R.Fowler.

***Keywords*:** taxonomy, phylogeny, eudesmid, new taxa

Introduction

Detailed infrageneric classifications of the eudesmid eucalypts, *Eucalyptus* subg. *Eudesmia* (R.Br.) L.A.S.Johnson & K.D.Hill, using the ranks of section, series and subseries, include those proposed informally by Hill & Johnson (1998) and formally by Blakely (1934), Chippendale (1988), Brooker (2000), Gibbs *et al*. (2009) and Nicolle (2022). Those classifications are based largely on morphology, but more recently have also been informed by molecular phylogenetic studies employing small numbers of molecular markers, e.g., variously those of Steane *et al*. (2002, 2011), Gibbs *et al*. (2009) and Thornhill *et al*. (2019).

Here we present a new classification of sections and series in *E.* subg. *Eudesmia* based on recent phylogenomic analyses of McLay *et al*. (2023). That study, based on a dataset of 73 eudesmid samples and sequences of 522 nuclear genes, and a smaller set of plastid genes, provided new insight into eudesmid relationships and resolved some infrageneric taxa, recognised in the recent classifications of Gibbs *et al*. (2009) and Nicolle (2022), as polyphyletic. In particular, in the nuclear phylogeny, *E.* sect. *Complanatae* Brooker, sensu Nicolle (2022) or Gibbs *et al*. (2009), was resolved as polyphyletic because of the placement of *E. tetrodonta*

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F.Muell. with members of *E.* sect. *Limbatae* Brooker, and *E.* ser. *Heteropterae* Maiden was polyphyletic because *E. erythrocorys* F.Muell was placed outside that group. In addition, placement of different accessions of *E. gittinsii* Brooker & Blaxell in multiple positions in the nuclear tree rendered subser. *Tetraedrae* Brooker, sensu Gibbs *et al*. (2009), polyphyletic.

Our new classification for the eudesmids is intentionally phylogenetic, recognising only monophyletic groups, and focusing only on clades resolved in the nuclear phylogeny with robust support; we have not focussed on analyses of plastid DNA, which are frequently discordant with nuclear phylogenies and with classification of eucalypts (McKinnon *et al*. 1999; Bayly 2016; Schuster et al. 2018; Fahey *et al*. 2021), including in *E*. subg. *Eudesmia* (McLay *et al*. 2023). The nuclear DNA analyses of McLay *et al*. (2023) identified three main eudesmid clades (labelled by McLay *et al*. as Clades A, B and C), which are each recognised here at the rank of section (Figure 1). We recognise robust clades within those groups at the rank of series, largely using existing series names, but establishing new series names for two groups previously recognised at the rank of subseries. We do not use the rank of subseries, primarily because most series are small, and we don't see great value in recognising subseries with small numbers of species. Additionally, there is taxonomic and phylogenetic uncertainty (discussed below) in the largest series, *E*. ser. *Heteropterae*, and the presence of potentially polyphyletic species hinders the recognition of subseries in that group.

Taxonomy

We recognise the following sections and series in *Eucalyptus* subg. *Eudesmia*. The relationship of these taxa to the eudesmid phylogeny of McLay *et al*. (2023) is shown in Figure 1.

Eucalyptus sect. *Aurantistamineae* Bayly & R.Fowler, sect. nov.

***Type*:** *Eucalyptus miniata* Schauer

Diagnostic description: Distinguished from other sections of *Eucalyptus* by the combination of: orange staminal filaments; calyx fused to the corolla and evident, in bud, as four small teeth at apex of corolline operculum.

Etymology: The name refers to the conspicuous orange stamens that characterise this group within *E.* subg. *Eudesmia*.

Eucalyptus ser. *Phoeniceosae* (A.K.Gibbs & Ladiges) Bayly & R.Fowler, stat. nov.

***Basionym*:** *Eucalyptus* subser. *Phoeniceosae* A.K.Gibbs & Ladiges, *Austral. Syst. Bot*. 22(3):174 (2009).

***Type*:** *E. phoenicea* F.Muell.

***Included species*:** *E. ceracea* Brooker & Done, *E. phoenicea*

Notes: Nicolle (2022) recognises Queensland populations of *E. phoenicea* as a distinct, undescribed species, "*E*. sp. Battlecamp (*Nicolle 1789*)" that would also be included in this series.

Eucalyptus ser. *Miniatae* Blakely

***Type*:** *Eucalyptus miniata* Schauer

***Included species*:** *E. chartaboma* D.Nicolle, *E. miniata*

Notes: Also included in this series is *E. aurantiaca* F.Muell., which is generally regarded as a synonym of *E. miniata* (e.g., Chippendale 1988; Hill & Johnson 1998; Slee *et al*. 2006, 2022; CHAH 2023), but is treated as a distinct species by Nicolle (2022). We have not assessed the distinctiveness of these taxa, but samples used in the nuclear DNA phylogeny (Figure 1) likely fit with Dean Nicolle's concept of *E. aurantiaca* (based on their field location), rather than *E. miniata sensu stricto* (D. Nicolle pers. comm., 2022).

Eucalyptus sect. *Reticulatae* Brooker

***Type*:** *Eucalyptus baileyana* F.Muell.

Eucalyptus ser. *Scutelliformes* Maiden

***Lectotype and only included species*:** (designated by Chippendale 1988, p. 505) *E. baileyana* F.Muell

Eucalyptus ser. *Similes* A.K.Gibbs & Ladiges

***Type*:** *E. similis* Maiden

***Included species*:** *E. lirata* W.Fitzg. ex Maiden, *E. similis*

Eucalyptus sect. *Limbatae* Brooker

***Type*:** *Eudesmia tetragona* R.Br. [considered an intergrade between *E. extrica* D.Nicolle and *E. pleurocarpa* Schauer; Nicolle (2000)]

***Notes*:** The section names *Limbatae* Brooker and *Complanatae* Brooker could both apply to this group

and have equal priority, being simultaneously published in the same work. Here we opt to use the name sect. *Limbatae*, thus establishing priority under Art. 11.5 of the International Code of Nomenclature for Algae, Fungi and Plants (Turland *et al*. 2017), because that usage more closely matches circumscriptions used in recent classifications.

Eucalyptus ser. *Tetrodontae* Chippend.

***Type*:** *Eucalyptus tetrodonta* F.Muell.

***Included species*:** *E. tetrodonta*, *E. megasepala* A.R.Bean

Eucalyptus ser. *Edentatae* Brooker

***Type and only included species*:** *Eucalyptus gongylocarpa* Blakely

Eucalyptus ser. *Jucundae* Chippend.

***Type*:** *Eucalyptus jucunda* C.Gardner

***Included species*:** *E. jucunda*, *E. roycei* S.G.M.Carr, D.J.Carr & A.S.George

Eucalyptus ser. *Erythrocorythosae* (A.K.Gibbs & Ladiges) Bayly & R.Fowler, stat. nov.

***Basionym*:** *Eucalyptus* subser. *Erythrocorythosae* A.K.Gibbs & Ladiges, *Austral. Syst. Bot.* 22(3):175 (2009).

***Type and only included species*:** *Eucalyptus erythrocorys* F.Muell.

Eucalyptus ser. *Ebbanoenses* Chippend.

***Type and only included species*:** *E. ebbanoensis* Maiden

Eucalyptus ser. *Odontocarpae* Chippend.

***Type*:** *E. odontocarpa* F.Muell.

***Included species*:** *E. odontocarpa*, *E. gamophylla* F.Muell.

Eucalyptus ser. *Heteropterae* Maiden

***Lectotype*:** (designated by Chippendale 1988, p. 498) *Eucalyptus tetragona* (R.Br.) F.Muell. [considered an intergrade between *E. extrica* D.Nicolle and *E. pleurocarpa* Schauer; Nicolle (2000)]

***Included species*:** *E. conveniens* L.A.S.Johnson & K.D.Hill, *E. eudesmioides* F.Muell., *E. extrica*, *E. gittinsii* Brooker & Blaxell, *E. pallida* L.A.S.Johnson & K.D.Hill, *E. pleurocarpa, E. selachiana* L.A.S.Johnson & K.D.Hill

***Notes*:** This is the largest series recognised in this classification. The included species were separated by Gibbs *et al*. (2009) into three subseries (*Tetraedrae* Brooker, *Pleurocarpae* A.K.Gibbs & Ladiges, and *Convenienses* A.K.Gibbs & Ladiges) of a more broadly defined sect. *Heteropterae*, but were included as the only members of a single subseries (*Tetraedrae*) by Nicolle (2022). They are not divided into subseries here, because of uncertainty about species boundaries and because of low support for some relationships in the group.

Species taxonomy in this group requires attention, and our list of included species is intended to be indicative, rather than making firm assertions about the species that should be recognised. Here, as done by McLay *et al*. (2023), we follow the taxonomy of the Australian Plant Census (CHAH 2023) and Euclid (Slee *et al*. 2006), in including both *Eucalyptus selachiana* L.A.S.Johnson & K.D.Hill and *E. pallida* L.A.S.Johnson & K.D.Hill, informally, as subspecies under *E. eudesmioides*. An alternative classification is proposed by Slee *et al*. (2020) who recognise *E. selachiana* as distinct, but continue to include *E. pallida* under *E. eudesmioides*. Nicolle (2000) also indicated that *E. pallida* should be included under *E. eudesmioides*, but the list of Nicolle (2022) includes all three species. The nuclear phylogeny (Figure 1) does not resolve these taxa as distinct from each other (or from *E. gittinsii* subsp. *gittinsii*), but support in that part of the tree is low, and we have not investigated the morphology of these taxa in sufficient detail to make firm recommendations on species limits.

Previous discussions of other species in *E.* ser. *Heteropterae* suggest that introgression is widespread and contributes to difficulties in species delimitation. *Eucalyptus conveniens* is considered, on morphological grounds, to be a stable intergrade between *E. gittinsii* (subsp. *illucida*) and *E. pleurocarpa* (Hill & Johnson 1998; Nicolle 2000, 2022; French & Nicolle 2019), which could be consistent with the positions of those taxa in the nuclear phylogeny. Intergrades are also reported between *E. extrica* and *E. pleurocarpa*, and have morphology matching the type of *E. tetragona*, as indicated by Brooker (2000) and Nicolle (2000). Intergrades between *E. gittinsii* subsp. *illucida* and *E. eudesmioides* were noted by Nicolle (2000); Nicolle & French (2019) also indicated that *E. gittinsii* subsp. *gittinsii* and *E. eudesmioides* sometimes interbreed,

forming populations of plants with intermediate characteristics. The close association of the last two taxa in the nuclear phylogeny (Figure 1), as well as in the plastid phylogeny of McLay et al. (2023), hints at the possibility of a close relationship, if not gene flow between them, but relationships in that part of the tree are not well supported.

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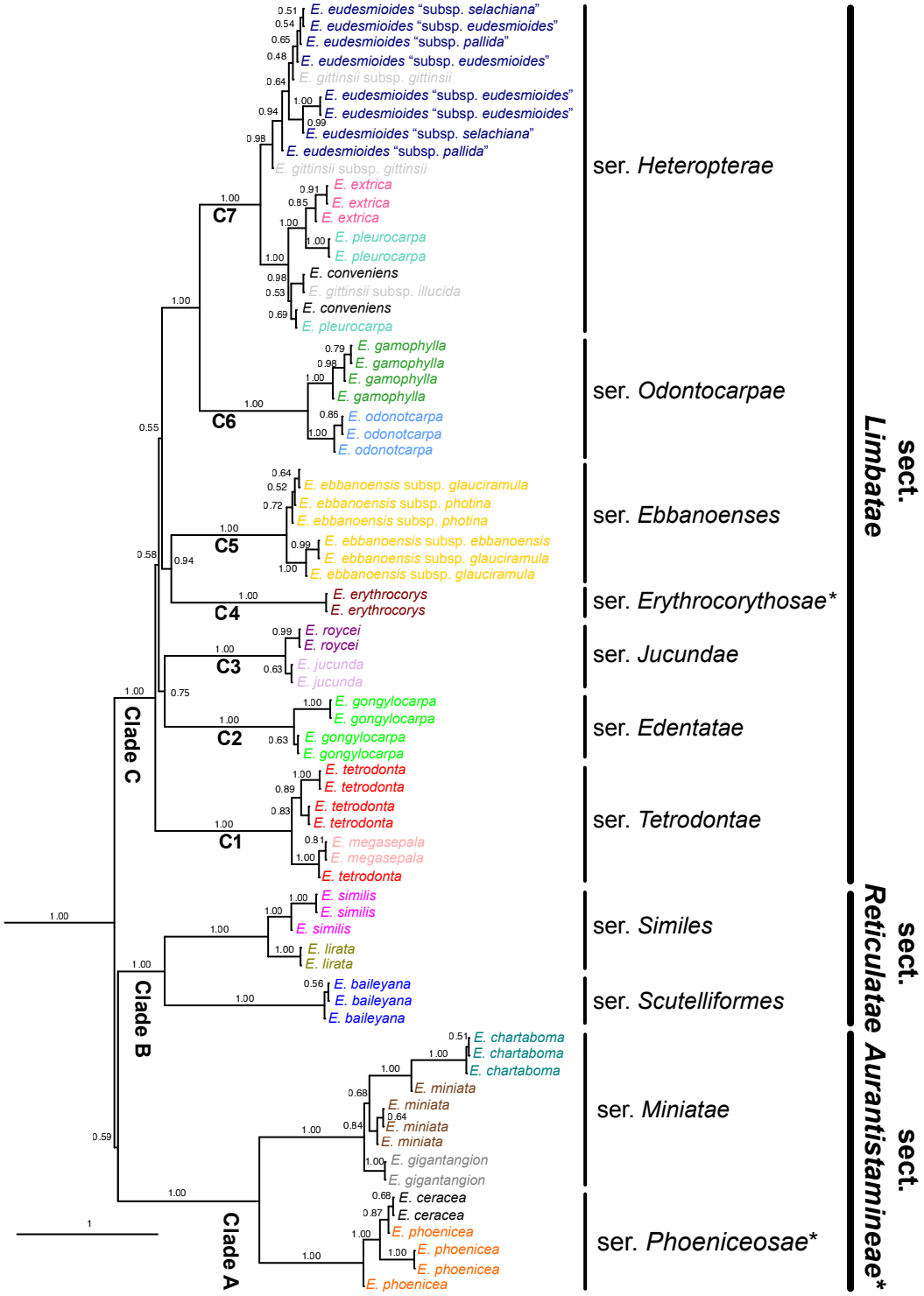

Figure 1. New classification of sections and series in *Eucalyptus* subg. *Eudesmia* aligned with a phylogenetic tree produced by McLay *et al*. (2023). Newly named taxa are indicated by an asterisk. The tree is an ASTRAL phylogeny based on 522 nuclear gene trees. Values on branches represent local posterior probability (LPP); major clades (A, B and C1–C7) identified and discussed by McLay *et al*. (2023) are also labelled. Species labels are colour-coded; see McLay *et al*. (2023) for collecting details of each accession (the order of samples in this tree is identical to that in Fig. 2 of McLay *et al*. 2023).