Phenetic analyses of *Ozothamnus hookeri* (Asteraceae), with the recognition of a new species, *O. cupressoides*

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Abstract

Phenetic analyses of the south-eastern Australian shrub *Ozothamnus hookeri* Sond. *s.l.* using 12 morphological characters scored from 72 herbarium specimens produced ordinations and classifications that revealed two discrete clusters. These clusters represent distinct populations from mainland Australia and Tasmania supporting the recognition of a separate species for the mainland taxon, here described as *O. cupressoides* Puttock & D. Ohlsen.

Keywords: kerosene bush, taxonomy, alpine shrub

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Introduction

Kerosene bush, *Ozothamnus hookeri* Sond. (Asteraceae) is a small alpine shrub that is widespread above the snowline throughout the alps of mainland Australia and the mountains of Tasmania (Burbidge 1958). It is most common on the margins of wet heathland communities (Puttock 1999) and, at least in Tasmania, in disturbed localities such as in areas that have been burnt (Kirkpatrick 1997). It can be distinguished from other south-eastern Australian species of *Ozothamnus* in having few-flowered capitula, minute leaves which have revolute margins and are closely appressed to the terete, unridged stems, and in the mainly alpine or subalpine habitat (Curtis 1963; Everett 1992; Puttock 1999).

Ozothamnus hookeri has been subjected to several nomenclatural changes. It was first published as *Baccharis*(?) *lepidophylla* DC. (de Candolle 1836) based on a specimen collected by Alan Cunningham from Mt. Wellington, Tasmania in 1819. Its generic placement was based presumably on a superficial resemblance to the New World genus *Baccharis* L. (Tribe Astereae), which also contains alpine species with small, appressed leaves (Muller 2006).

Joseph Hooker (1847) recognised the incorrect placement of the species and proposed the new combination *Ozothamnus lepidophyllus* Hook.f. In this publication he indicated that he was basing the new name on de Candolle's, thus making a new combination, although subsequent works (e.g. Bentham 1867; Burbidge 1958; APNI 2009) have attributed the name to Hooker alone. Nonetheless, this name is a junior homonym of *O. lepidophyllus* Steetz (1845) based on plants collected from King George Sound, Western Australia by James Drummond (holotype: W; isotypes include G, FI, MEL, MO, P, S). Apart from its disjunct occurrence in near-coastal Western Australia, the strongly reflexed leaves and capitula with distinct peduncles 1–3 mm long, clearly distinguish *O. lepidophyllus* Steetz from Hooker's species

of the same name. Sonder (1853) agreed with Hooker's generic placement and recognising the nomenclatural confusion, created the new name *O. hookeri* Sond. commemorating Joseph Hooker.

Mueller and Bentham took a conservative approach to the gnaphalioid composites and included several narrowly defined genera into a broadly circumscribed *Helichrysum* Miller. The characters that united members of the enlarged *Helichrysum* included opaquely scarious or petal-like involucral bracts, epaleate receptacles with few or no outer female florets, and the cypselas having a pappus of barbellate bristles. This resulted in the transferal of *Ozothamnus hookeri* to *Helichrysum* by Mueller (1865), but instead of retaining the epithet, Mueller deliberately proposed the new name *H. baccharoides* F.Muell. Bentham (1867) adopted Mueller's name in *Flora Australiensis*. Druce (1917) corrected Mueller's illegitimate name by making the new combination *Helichrysum hookeri* (Sond.) Druce. In attempting to resurrect the original epithet of de Candolle for the eastern alpine shrub, Tovey and Morris (1923) created a further homonym *Helichrysum lepidophyllum* (DC.) Tovey & P.F.Morris, as the Western Australian *O. lepidophyllus* had already been transferred by Mueller and published by Bentham (1867) as *H. lepidophyllum* F.Muell. ex Benth.

An infraspecific variety, *Helichrysum hookeri* var. *expansifolium* Sieber ex P.Morris & J.H.Willis (1942) was based on a Tasmanian plant with leaves that are spreading rather than being appressed to the stem. This taxon was later elevated to species rank by Burbidge (1958) and transferred to *Ozothamnus* by Anderberg (1991). The taxon is a putative natural hybrid between *O. hookeri* and *O. ledifolius* (A.Cunn. ex DC.) Hook.f. (Puttock in prep.; Kirkpatrick 1997).

Cladistics studies undertaken by Anderberg (1991) and Puttock (1994) on tribe Gnaphalieae using morphological, anatomical and cytological characters, and molecular studies by Bayer et al. (2002) and Galbany-Casals *et al.* (2004) have shown that including the Australian and New Zealand genera such as *Ozothamnus* with the African and Eurasian *Helichrysum* renders *Helichrysum* polyphyletic which necessitated the reinstatement of many segregate genera including *Ozothamnus*. Anderberg (1991) suspected *Ozothamnus* to be paraphyletic with respect to the other genera in the '*Cassinia* group' as defined by him, comprising *Apalochlamys*, *Cassinia*, *Haeckeria*, *Ixodia*, *Odixia* and *Ozothamnus*. *Cassinia* is nested within *Ozothamnus* in morphological and molecular analyses (Puttock, unpublished data), although Orchard (2004) suggested that a 'core', and by implication, monophyletic *Ozothamnus* could be identified. Further study in this group may show that it is necessary to propose further combinations to maintain monophyly within the *Cassinia* group.

The differences between mainland Australian and Tasmanian specimens of *Ozothamnus hookeri* were noted by Puttock (1999, in prep.), where he suggests that mainland specimens had larger leaves and synflorescences with more numerous, pedunculate capitula. He considered these character states as being of sufficient difference to treat them as separate species. No morphological distinction between mainland and Tasmanian plants was noted in earlier floras (e.g. Everett 1992). To test Puttock's assertion, the present study uses phenetic analyses to determine the level of divergence between mainland and Tasmanian populations using a range of morphological characters. This study also investigates whether other possible forms occur within these areas.

Materials and methods

Plant material used in this phenetic study included 72 herbarium collections of *Ozothamnus hookeri s.l.* comprising 41 specimens from mainland Australia housed at MEL and 31 specimens from Tasmania received on loan from HO (Fig. 1). Several flowering specimens were selected for scoring from all geographically isolated areas of the species' range, which are used here to divide mainland Australia and Tasmania into smaller regions. This was done in order to encompass the full range of morphological variation that may exist within and between these areas. The specimens were examined under a dissecting microscope and scored for 12 morphological characters that were then used in multivariate analyses. These included four quantitative vegetative characters, seven quantitative floral characters and a binary floral character (Table 1). Lengths and widths were measured with the aid of a graticule lens. Five replicates were measured from each specimen for each quantitative character.

Figure 1: Distribution of *Ozothamnus cupressoides* (triangles) and *O. hookeri* (circles). Specimens used in analyses are indicated in black, other herbarium records in grey.

Analyses

For each character of each specimen the mean of the replicates was calculated and used in the analyses. Analyses were undertaken with the computer program PATN (Belbin 2004) based on a dissimilarity matrix using Gower's (1971) association coefficient also constructed in this program. The Gower metric is a range-standardised coefficient that can be applied to both the binary and quantitative characters used in this data set. Ordination and classification techniques were employed to identify clusters of similar individuals and to determine how distinct these clusters are from each other.

Ordination was undertaken by semi hybrid multidimensional scaling (SHMDS) which for these data favoured metric multidimensional scaling, to produce two- and three-dimensional ordinations. Multidimensional scaling is an iterative technique that assesses the locations of points in *n-space* relative to each other and attempts to represent the same spacing in a reduced number of dimensions so that visual interpretation can be made (Shepard 1962). The ordination with the lowest stress was selected after 100 iterations.

Sequential agglomerative hierarchal non-overlapping (SAHN) classifications were produced using the flexible clustering strategy of unweighted pair group method of averaging (UPGMA: Sokal & Michener 1958).

Ordinations and classifications were applied to the entire data set as well as separately to specimens of any discrete clusters that arose. This was done to see if the clusters that result from using the entire specimen set are an artifact of using a larger spread in character values.

Table 1. Characters used in analyses. All quantitative characters are measured to the nearest 0.1 mm. Character abbreviations are given in italics.

Quantitative characters
1. Leaf length measured from the apex of the leaf to the base of the revolute margin (*LL*)
2. Leaf width measured at the widest point (*LW*)
3. Width of the stem and leaves measured from the narrowest point immediately below the capitula (*WSL*)
4. Number of leaves visible from one side of the stem within 10 mm below the capitula (*NL*)
5. Number of capitula per synflorescence (*NC*)
6. Capitulum length measured from the apex of the inner involucral bracts to the pedicel tissue or base of the capitulum (*CL*)
7. Number of involucral bracts per capitulum including all series (*NB*)
8. Length of the inner involucral bracts (*BL*)
9. Number of florets per capitulum (*NF*)
10. Length of floret measured from the apex of the perianth lobes to the point of attachment with the receptacle (*FL*)
11. Pappus length measured from the point of attachment on the ovary to the apex of the pappus (*PL*).
Qualitative characters
1. Capitula sessile (0), pedunculate (1)

Photographs were taken using an Olympus DP71 camera set up on an Olympus SZX16 microscope of a specimen representative of each of the clusters that were obtained from the analyses.

For each of the quantitative characters, box plots were constructed from the mean of the character replicates for each specimen belonging to a cluster as well as for specimens belonging to each smaller region. This therefore constructs a box plot for each cluster or region for each quantitative character so that differences in mean character values can be observed between clusters or regions, demonstrating the characters responsible for contributing to any difference that occur between clusters and between regions.

Results

The two-dimensional ordination obtained using SHMDS (stress=0.1466, 100 iterations) shows that all specimens from the mainland form a cluster and all specimens from Tasmania form another cluster separated from one another in ordination space (Fig. 2). Also shown in the ordination (Fig. 2) is the location of specimens according to the region that they inhabit within the mainland or Tasmania. All regions are positioned in ordination space so that their specimens are interspersed among the specimens of other regions and as a result no region forms a cluster that shows no overlap with specimens from other regions. For some regions such as the Baw Baw Plateau the specimens are congregated into a cluster but the ordination space the specimens occupy is also shared by specimens from other regions, in this case from Lake Mountain. The three-dimensional ordination (stress=0.0882, 100 iterations) gave similar results, so are not presented.

Congruence is gained from the UPGMA phenogram (Fig. 3) that produces two clusters (dissimilarity=0.8879) that correspond to the specimens of the mainland and those from Tasmania. Other than these clusters there are no other groups that cluster on a geographic basis.

Ordinations in both two- and three-dimensions and UPGMA phenograms generated for specimens from the mainland or Tasmania separately also failed to distinguish any other discrete groups.

Box plots of the mean values of characters of each specimen from either the mainland or from Tasmania (Fig. 4), indicate that the largest difference between the mainland and Tasmanian specimens is the character leaf length (*LL*). There is no overlap in the range of mean values of this character for these specimens. Substantial distinctions in mean character

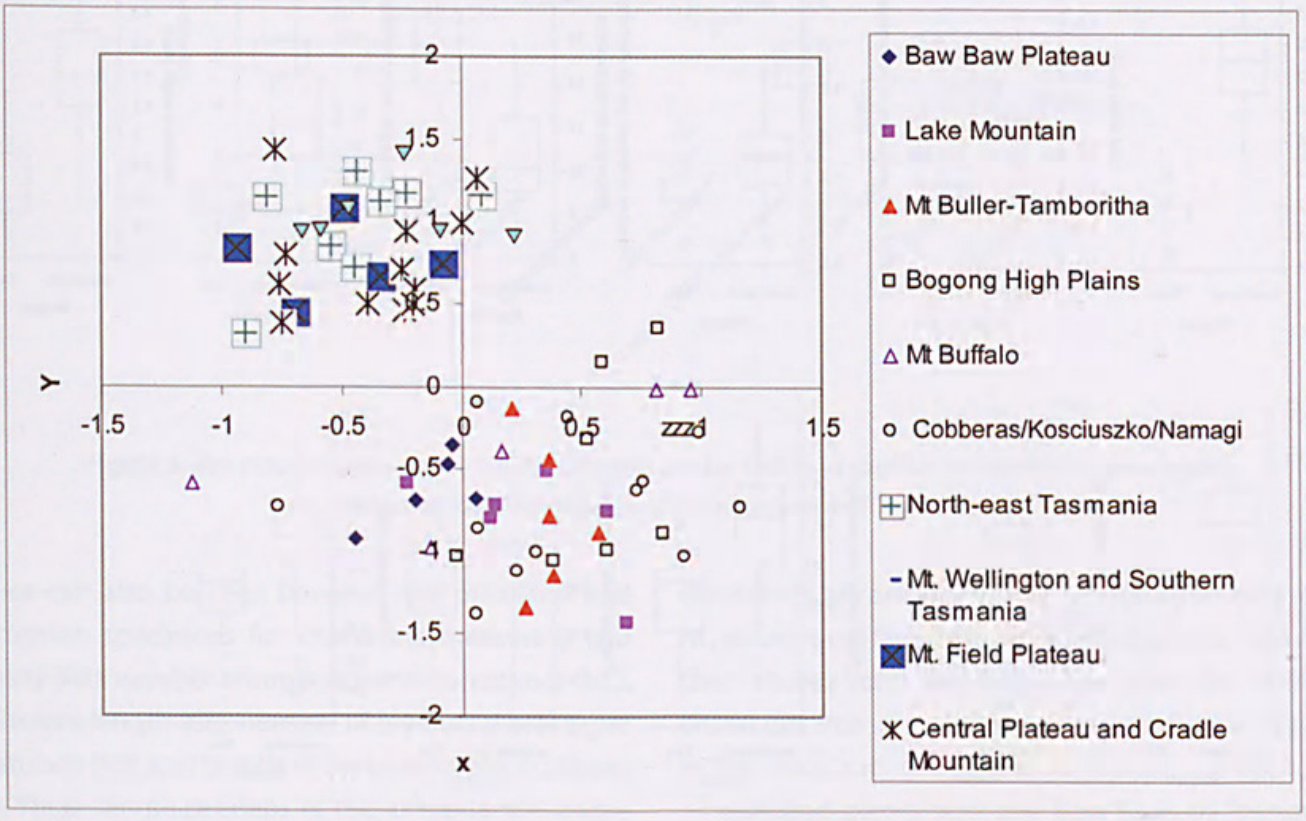

Figure 2: Two-dimensional ordination obtained using SHMDS (stress=0.1466, 100 iterations)

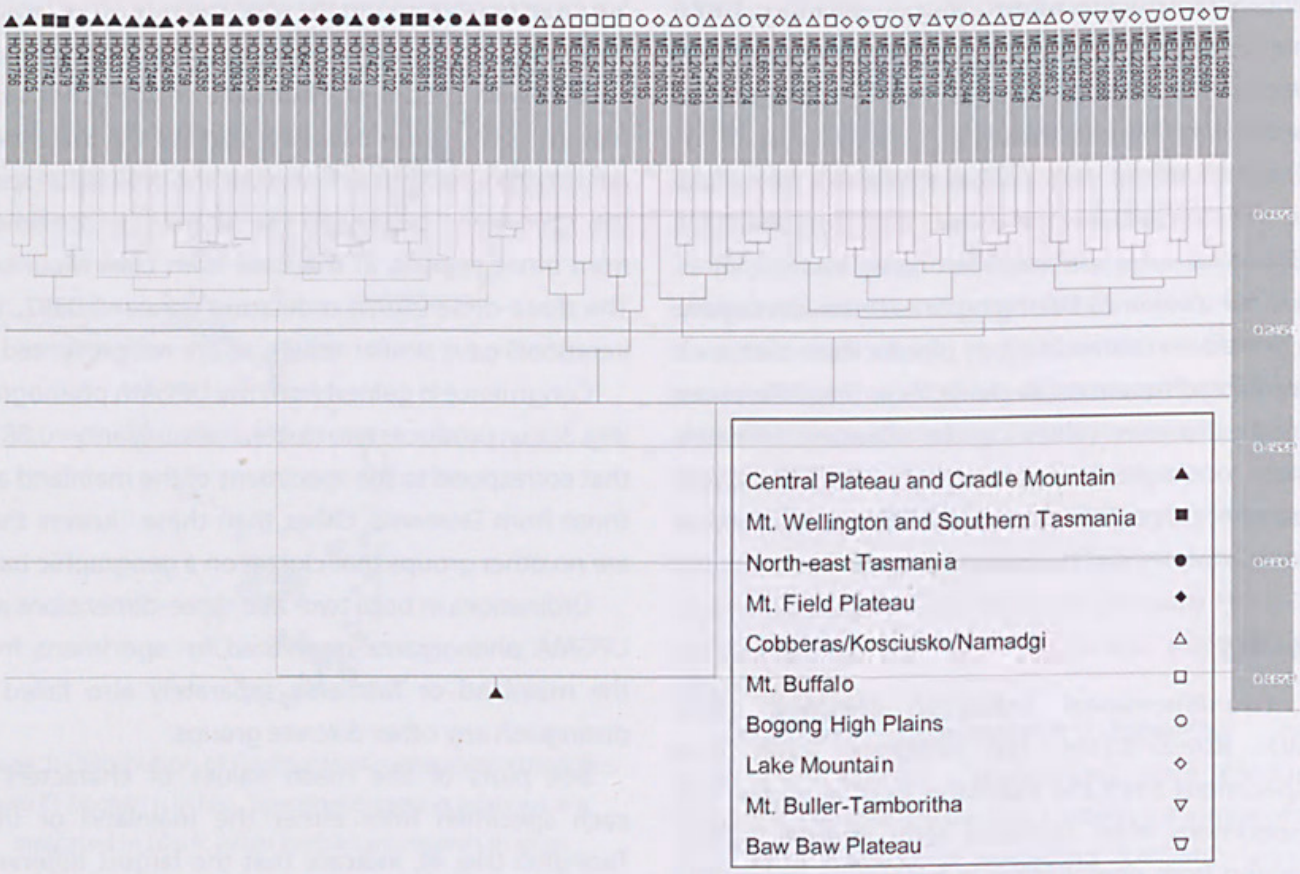

Figure 3: Phenogram from the UPGMA analysis

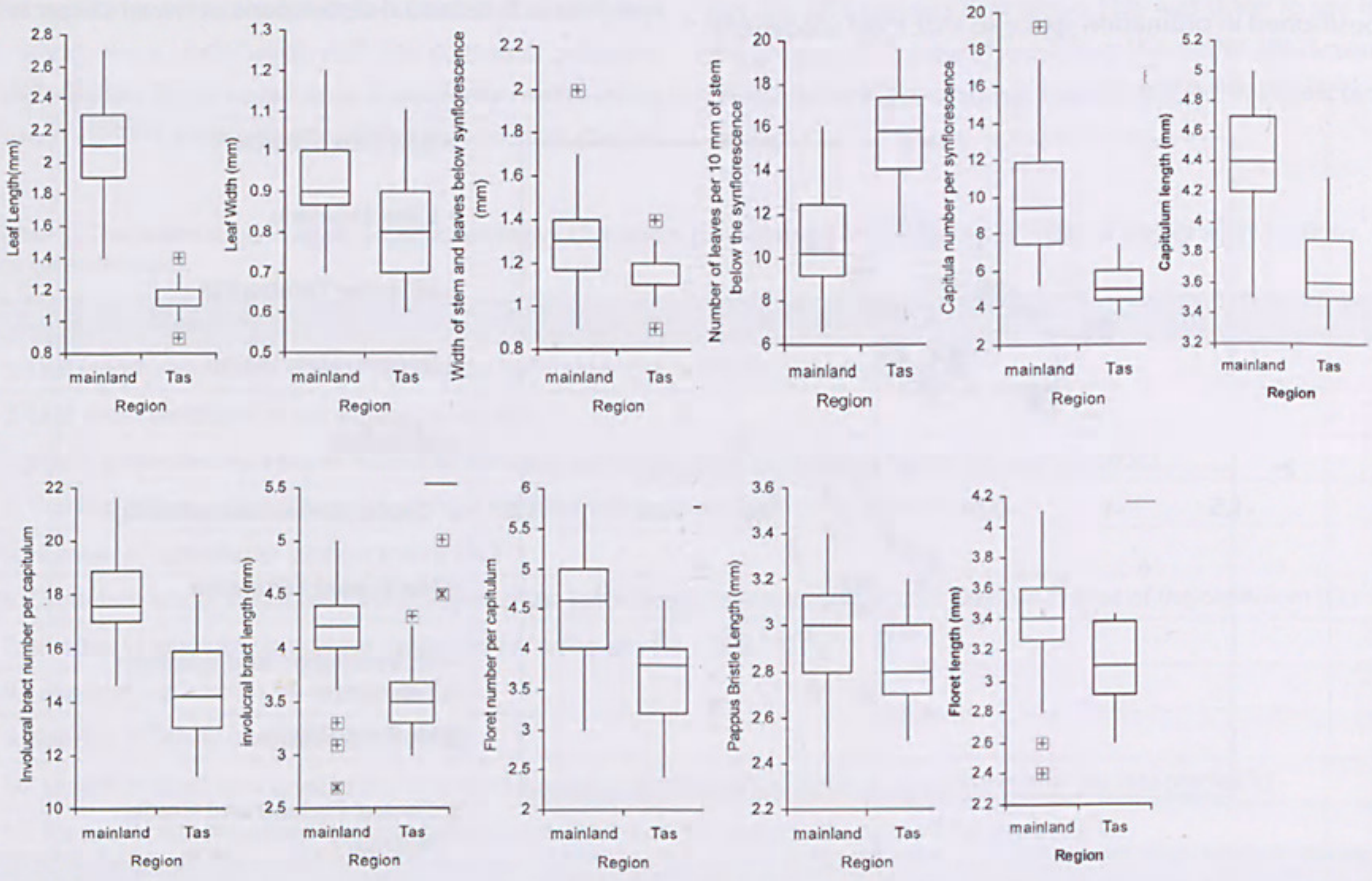

Figure 4: Box plots of mean values for each quantitative character compared between the mainland and Tasmania

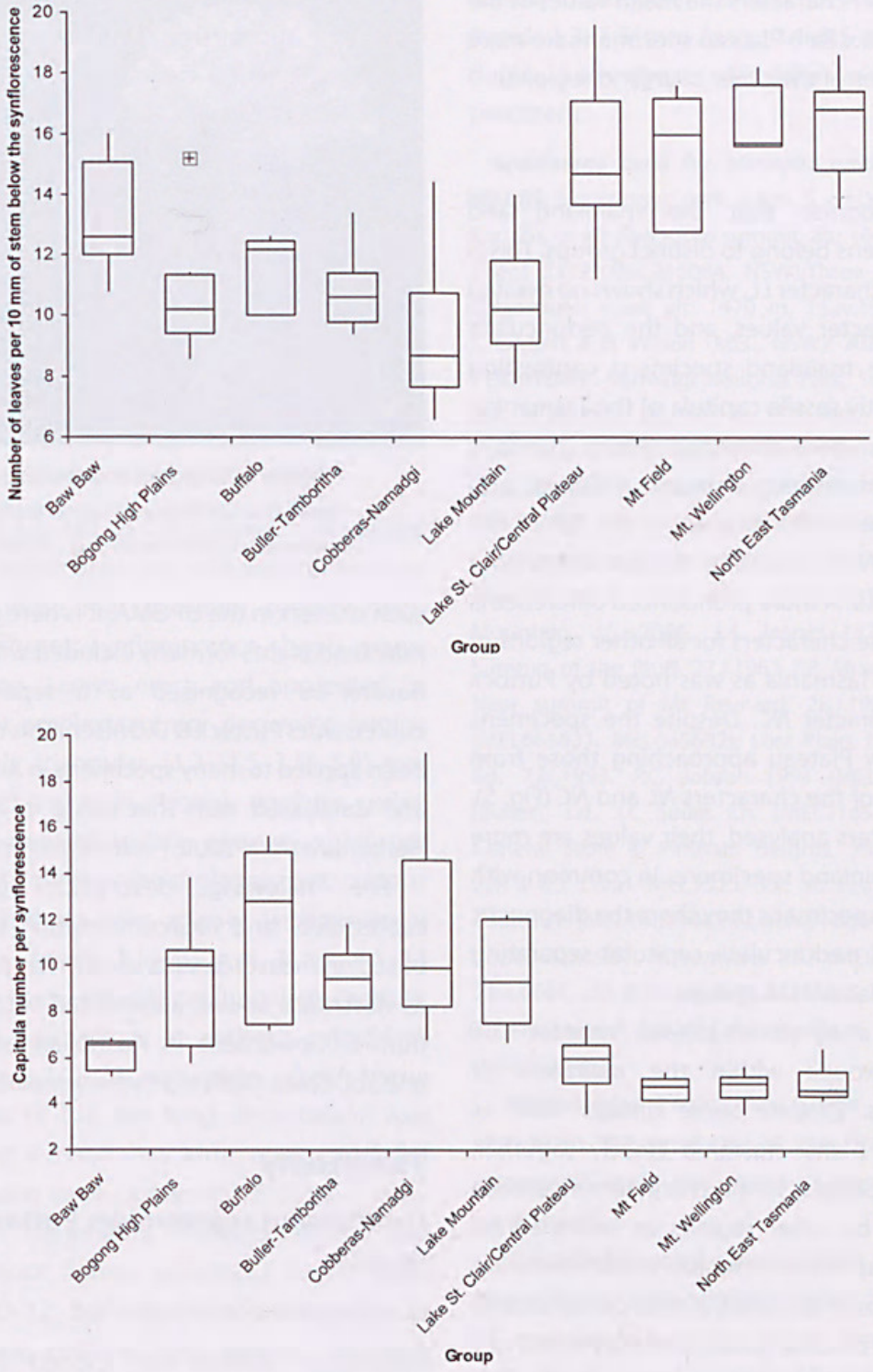

Figure 5: Box plots of mean values for leaf numbers per cm (left) and capitula per synflorescence (right) compared between regions of the mainland and Tasmania

values can also be seen between the mainland and Tasmanian specimens for characters measuring leaf density (*NL*), number of capitula per inflorescence (*NC*), capitulum length (*CL*), number of involucral bracts per capitulum (*NB*) and length of the inner involucral bract (*BL*). There are no overlaps in the interquartile ranges (IQRs) for these characters. For all other characters the differences are only minor. For all characters except for *NL*, values were larger for specimens from the mainland than those from Tasmania. Box plots for selected characters for populations from particular regions in the mainland and Tasmania indicate an approach of mainland plants from the Baw Baws to Tasmanian populations for the characters *NL* and *NC* (Fig. 5).

However, in all other characters the mean values of the characters in the Baw Baw Plateau specimens are more similar to specimens of the other mainland regions.

Discussion

All analyses recognise that the mainland and Tasmanian specimens belong to distinct groups. This is largely due to the character *LL*, which shows no overlap in the mean character values, and the pedunculate capitula of all the mainland specimens contrasting with the consistently sessile capitula of the Tasmanian specimens (Fig. 6). These characters would therefore be useful for discriminating between mainland and Tasmanian specimens. The overlap in the IQR of the characters *NL* and *NC* is caused by the specimens from the Baw Baw Plateau. A more pronounced difference is seen between these characters for all other regions of the mainland and Tasmania as was noted by Puttock (1999) for the character *NC*. Despite the specimens from the Baw Baw Plateau approaching those from Tasmania in terms of the characters *NL* and *NC* (Fig. 5), in all other characters analysed, their values are more typical of other mainland specimens. In common with all other mainland specimens they share the diagnostic characters (*LL* and pedunculate capitula) separating the mainland and Tasmanian groups.

None of the analyses employed support the recognition of groups within the mainland or Tasmanian entities. Despite some groups such as Baw Baw Plateau being clustered closely together, the variation they possess in the characters measured is also possessed by other regions as indicated by considerable overlap in the ordinations and clustering among other groups in the UPGMA. This demonstrates that they are not a discrete group and they could not be acknowledged as a separate taxonomic entity. The lack of distinctiveness between Tasmanian groups is perhaps surprising given the recognition of major differences in the vegetation composition between the western mountains and the eastern mountains in Tasmania according to classification systems of Australian alpine vegetation (Kirkpatrick 1986, 1997).

Due to the several characters that consistently differ between the mainland and Tasmanian specimens, reflected by the large distance separating clusters in ordination space and the high dissimilarity between

Figure 6: Branchlet and synflorescences of mainland *Ozothamnus cupressoides* (left) and Tasmanian *O. hookeri* (right). Scalebar = 2 mm.

such clusters in the UPGMA, it is here proposed that all mainland plants formerly included within *Ozothamnus hookeri* be recognised as a separate species, *O. cupressoides* Puttock & D.Ohlsen. This name has already been applied to many specimens in Australian herbaria and databased with that name in Australia's Virtual Herbarium (AVH 2009; Puttock *in sched.*).

The following description of *Ozothamnus cupressoides* and recircumscription of *O. hookeri* are based on measurements used in the phenetic analyses as described above, augmented with measurements from all specimens in Australian herbaria (Puttock, unpubl. data). Outlying measurements are bracketed.

Taxonomy

Ozothamnus cupressoides Puttock & D.Ohlsen sp. nov.

O. cupressoides Puttock *in sched.*.

Helichrysum hookeri non (Sond.) Druce; Burbidge (1958); 281, Fig. 11; N.T. Burbidge and M. Gray, *Flora of the A.C.T.* 385 (1970); J.H. Willis, *Handbook to plants in Victoria* 2: 718 (1973).

Ozothamnus hookeri non Sond.; Everett (1992).

Ozothamnus sp.1. C.F. Puttock in N.G. Walsh and T.J. Entwisle (eds) *Flora of Victoria* 4: 739, Fig. 144e (1999); M.G. Corrick and B.A. Fuhrer, *Wildflowers of Victoria* 35 (2000); *Ozothamnus* sp. (*aff. hookeri*) Sond. A. Costin, M. Gray, C. Totterdell and D. Wimbush, *Kosciuszko alpine flora*, pp. 205, 344 (2000).

Ab Ozothamno hookeri *Sond. foliis longioribus ((1.2–)1.5–3.5(–3.8) mm) ramulis sparsioribus, pedunculis capitularum distinctis (sed minus quam 1.2(–2) mm longis) et inflorescentis capitulis pluribus (3–)5–15(–35) compositis differt.*

Type: Victoria. Alpine National Park, Bogong High Plains. Beside Big River Fire Trail, c. 300 m from High Plains Rd, 28.i.2009, *J.A. Jeanes 2125 G. Lay, K. Lake & P. Evans* (holotype: MEL2325620; isotypes CANB, K, NSW, S).

Illustrations: N.T. Burbidge *Aust. J. Bot.* 6: 281 Fig. 11 (1958); N.G. Walsh and T.J. Entwisle *Fl. Victoria* 4: Fig. 144e (1999); A. Costin, M. Gray, C. Totterdell and D. Wimbush, *Kosciuszko alpine flora*, p. 205 (2000).

Erect *shrub* 0.6–1.2 m tall, to 0.8 m diam.; main lateral branches many; upper branches with an indumentum of very dense, loose mat of white cottony hairs; glandular hairs absent; synflorescence shoots many; 40–120 mm long. *Leaves* erect and appressed to stem, sessile, not amplexicaul nor decurrent; lamina ovate to narrowly triangular, (1.2–)1.5–3.5(–3.8) mm long, 0.5–0.9(–1.7) mm wide, strongly revolute, curled to the midvein; base auriculate; apex rounded, not mucronate; adaxial surface viscid, glabrescent; cottony hairs absent; glandular hairs sparse. *Synflorescences* dense umbellate heads 5.5–9.0 mm long, 9.5–13 mm diam., with (3–)5–15(–35) pedunculate capitula. Capitula in bud dull yellow; at anthesis cylindrical, 3.7–5.0 mm long, 1.2–1.3 mm wide, viscid borne on peduncles up to 1.0 mm long. *Receptacular* axis 0.5–0.7 mm long, 0.3–0.4 mm wide; apex small, flat to slightly elongate. *Involucral bracts* 15–22, 5–7 inner involucral bracts subtending florets or several and 1–3 paleae without florets; outermost bracts straw yellow, ovate, 10–12, 2.4–2.8(–3.8) mm long, 0.7–0.9 mm wide, glossy; cottony hairs absent; stereome 2.1–2.4 mm long; *innermost bracts* spathulate, 5–6, 3.6–4.5(–5.4) mm long, 0.5–0.8 mm wide; stereome 2.2–3.1 mm long; lamina deltoid, 0.8–1.0(–1.4) mm long, 0.8–0.9(–1.1) mm wide, sub-erect, plicate, white and occasionally with purple immediately adjacent to the stereome; margin lacerate; paleae (when present) slightly narrower than the other innermost bracts. *Female florets* 0; hermaphrodite florets 3–6, 3.5–4.5 mm long; ovary cylindrical 0.7–1.0 mm long. *Pappus* of 26–34 flattened bristles 2.8–3.7 mm long, barbed throughout; apex narrow clavate. *Corolla* white, very narrow crateriform, 2.8–3.6 mm long. *Cypsela* narrow ovoid, 1.2–1.3 mm long, 0.4–0.5 mm diam., brown; duplex hairs dense; glandular hairs absent; pappus persistent.

***Specimens used for phenetic analyses*: NEW SOUTH WALES**. Big Boggy Creek, 2 km. S. of Dead Horse Gap, c. 10 km. SSE of Mt Kosciusko summit, alt: 1600 m, 18.iv.1972, *B.G. Briggs 3319* (MEL216084, NSW);Three Mile Dam, Kiandra-Cabramurra road, alt: 1470 m, 11.iv.1986, *A.N. Rodd 5382, S. Corbett & D. Wilson* (MEL, NSW); **AUSTRALIAN CAPITAL TERRITORY**. Namadgi National Park, Scabby Range, 3.5 km SSW of Mt Kelly. alt: 1560 m, 11.iii.1992, *I.R. Telford 11553* (AD, BISH, HO, K, MEL1012018, NSW, PERTH, US); Murrays Gap Flats, Bimberi Range, alt: ca. 5000 ft, 15.i.1961 *P. Darbyshire 160* (CANB, MEL2160845).**VICTORIA**. Baw Baw Plateau Mt St Gwinnear, c. 300 m south-west from summit, alt: 1460 m, 26.ii.1991, *N.G. Walsh 3063* (MEL1548159); Echo Flat, Lake Mountain, 15.ii.2006, *J.A. Jeanes 1575* (MEL2280906, K); Summit of the Bluff, 27.i.1963 *T.B. Muir 2757* (MEL2160868); Near summit of Mt Reynard, 28.i.1984, *S.J. Forbes 1950*, (MEL665631, MEL665632); Lost Plain, N side of Tamboritha Rd, 7.iii.1993, *P.C. Jobson 1994* (MEL2023910); Mt Bulla [Buller], *s.d., J.L. Soues s.n.* (MEL2165326); 2.7 km SE of General Store at Hotham Heights, 23.ii.1984, *D.E. Albrecht 226 & B.J. Conn* (MEL1525766); Mt Feathertop, 16.ii.1985, *F. Coates 16* (MEL1562844); Bogong High Plains, 0.7 km NE Mt Cope, 20.i.1981, *H. van Rees 262* (MEL598195); Mt Buffalo, 21.ii.1963, *J.H. Willis s.n.* (MEL2165361); Black Mountain Road, 7.2 km. ca south of Mt Cobberas No. 1, 17.i.1984, *D.M. Parkes* (MEL1543451).

Etymology: From the Greek meaning 'cypress-like', from the similarity of the branchlets with their appressed, scale-like leaves to members of the genus *Cupressus* L.

Distribution and conservation status: Widespread throughout alpine and higher subalpine regions of mainland Australia south from Ginini Swamp, including Kosciusko National Park in New South Wales, Namagi National Park in Australian Capital Territory and Mt Cobberas, the Bogong High Plains, Mt Buffalo, Mt Buller, the Baw Baw Plateau and Lake Mountain in Victoria. It has been recorded at altitudes between 1300 and 1850 metres above sea level. The conservation status of *Ozothamnus cupressoides* is assessed as 'of least concern' according to IUCN criteria (IUCN 2001), although increasing global temperatures could lead to an assessment of higher concern.

Habitat: Most frequent at open localities in

grassland and heath and common near bogs and drainage lines. Occasionally in the margins of open *Eucalyptus pauciflora* Sieber ex Spreng. woodland. Soils are usually peats developed on sedimentary, metamorphic, granitic or occasionally basaltic parent material.

Phenology: Flowers December–February. Fruits March–April.

Vernacular names: Scaly Everlasting, Lattice Everlasting

Notes: The new species differs from *Ozothamnus hookeri* by its longer (1.2–3.8 mm) leaves that are less densely arranged on branchlets, the short pedunculate capitula, and by the more numerous capitula, (3–) 5–15(–35) per synflorescence. Puttock (1999, p. 739) described this species as *Ozothamnus.* sp.1 and mentioned them possessing 1–3 receptacular bracts (paleae). In this treatment the inner ring of bracts not subtending a floret are considered as paleae or receptacular bracts. There are usually six inner bracts, however, there are often fewer florets.

The capitula are borne on very short peduncles in this species. In most cases they are only visible with the aid of a hand lens or microscope. The peduncles are long enough to allow separation of capitula from synflorescences in herbarium specimens using fine forceps without causing any damage to the capitulum, c.f. *O. hookeri* where the capitula disintegrate when attempting to separate them from the synflorescence in herbarium material.

Ozothamnus hookeri Sond., *Linnaea* 25: 509 (1853); Hooker.f. *Fl. Tasman.* 201, pl. LV (1856); J.B. Kirkpatrick, *Alpine Tasmania* 23 (1997).

Helichrysum hookeri (Sond) Druce, *Rep. Bot. Soc. Exch. Club Brit. Isles* 1916: 626 (1917); W.T. Curtis, *Students flora of Tasmania* 2: 337 (1963).

Basionym: *Baccharis lepidophylla* DC., *Prodr.* 5: 427 (1836); *Ozothamnus lepidophyllus* (DC.) Hook.f., *London J. Bot.* 6: 120 (1847), *nom. illeg. non* Steetz in Lehmann, *Pl. Preiss.* 1: 468 (1845). *Helichrysum lepidophyllum* (DC.) Tovey & P.F.Morris, *Proc. Roy. Soc. Victoria* 35: 195 (1923) *nom. illeg., non H. lepidophyllum* (Steetz) F.Muell. ex Benth., *Fl. Austral.* 3: 633 (1867).

Type: Tasmania. Van-Diemen prope Hobart- Town ad summitatem frigidam montis Wellington alt. 4100 ped angl. Supra mare legit cl. A. Cunningham (holo: G-DC!, iso: K!).

Helichrysum baccharoides (DC.) F.Muell. ex Benth. *Fl. Austral.* 3: 633 (1867), *superfl. nom. nov.*

Illustration: J.D. Hooker *Fl. Tasman.* pl. 55 (1856).

Erect *shrub*, 0.5–1(–2) m tall; to 0.7 m diam.; main lateral branches many; upper branches with an indumentum of very dense, loose mat of white cottony hairs, glandular hairs absent; synflorescence shoots many, 40–60 mm long. *Leaves* erect and appressed to stem, sessile, not amplexicaul nor decurrent; lamina ovate, 0.5–1.5(–2.5) mm long, 0.5–1.0(–1.8) mm wide, strongly revolute, curled to the midvein; base cordate; apex rounded, not mucronate; adaxial surface viscid, cottony hairs absent; glandular hairs sparse; scabrous uni- or biseriate hairs absent; abaxial surface with very dense, loosely matted, cottony hairs on lamina and midvein; glandular hairs sparse. *Synflorescences* dense umbellate heads 4.5–5.5 mm long, 6–9 mm diam., with (3–)4–6(–10) sessile capitula. Capitula in bud dull yellow, at anthesis cylindrical, 3.0–4.5 mm long, 1.2–1.3 mm wide, viscid. *Receptacular axis* 0.5–0.6 mm long, 0.3–0.4 mm wide; apex small, flat to slightly elongate. *Involucral bracts* 14–19, 5–6 inner involucral bracts subtending florets or several and 1–2 paleae without florets; outermost bracts cream, ovate 6–9, 2.2–2.9 mm long, 0.8–1.0 mm wide, glossy; cottony hairs sparse, loosely matted; stereome 1.8–2.2 mm long; *innermost bracts* spathulate, 7–10, 3.7–4.4 mm long, 0.6–0.8 mm wide; stereome 2.2–2.8 mm long; lamina deltoid, 0.9–1.3 mm long, 0.7–1.0 mm wide, sub-erect, plicate, white and occasionally with purple immediately adjacent to the stereome; margin irregular; paleae (when present) slightly narrower than the innermost bracts. *Female florets* 0; hermaphrodite florets (2–)3–6(–7), 3.0–3.9(–4.4) mm long; ovary cylindrical, 0.5–0.9 mm long. *Pappus* of 26–36 flattened bristles, 2.8–3.4 mm long, barbed throughout; apex narrow clavate. *Corolla* white, very narrow crateriform, 2.7–3.5 mm long. *Cypsela* narrow ovoid, 1.2–1.3 mm long, 0.4–0.5 mm diam., brown; duplex hairs moderately dense; globular hairs absent; pappus persistent.

Specimens used for phenetic analyses: **TASMANIA**. Mt Barrow, on switchback just before plateau surface. 27.ii.2006,

M.F. Duretto 2113, A.M. Buchanan, A.M. Gray (HO); Mt Maurice-summit, *A.M. Buchanan 225* (HO); Little Plain, Blue River, Blue Tier, 1.ii.1878, *A. Simpson 1048* (HO, MEL); Little Mt Michael, 12.iii.1985, *M.J. Brown 873* (HO); Northern M road, Black Marsh c. 33 km N of Old Coach Road, 14.i.1995, *A.M. Gray 773* (HO); Headwaters of Mountain River, Mt Wellington, 13.i.1981, *A. Brown 104* (HO, MEL598317); Eastern shore of Ooze Lake, ii.1981, *A. Brown 211* (HO, MEL2103591); Mt Field National Park, 1 km E of Lake Dobson, 14.ii.1989, *J.R. Croft 10029 & M.M. Richardson* (CANB, CHR, HO, MEL713670, NSW); Great Lake, 31.iii.1891, *A. Simson 2337* (HO); Small creek on south side of Breona, Great Lake, 19.i.1990, *A.E. Orchard 6104* (HO); Quamby Bluff, summit, 7.iii.1986, *A. Moscal 12608* (HO); King William Saddle, 4.ii.1984, *A. Moscal 6133* (HO); Near Lake Rodway, Cradle Mountain, 30.i.1982, *A.M. Buchanan 865* (HO).

Distribution and conservation status: Occurs on the mountains of Tasmania generally, but largely absent from the south-west. Usually in the alpine and subalpine zone but occasionally at lower altitudes such as the Blue Tiers in the north-east. It has been recorded at altitudes between 500 and 1300 metres. The conservation status of *Ozothamnus hookeri* is assessed as 'of least concern' according to IUCN criteria (IUCN 2001).

Habitat: Most frequent at open localities in grasslands and heath and common near bogs and drainage lines. Occasionally in *Eucalyptus gunnii* Hook.f. woodland on the Central Plateau. At lower elevations occasionally it is found in mixed *E. delegatensis* R.T.Baker and *E. dalrympleana* Maiden woodland. Soils usually peaty or humic with variable degrees of drainage. Geology is variable including granite, dolerite and quartzite.

Phenology: Flowers January–February. Fruits March–April.

Vernacular name: Kerosene Bush.

Putative hybrids

Some 15 or more putative natural hybrids are known between species of *Ozothamnus*, and between *Ozothamnus* and *Cassinia* (Puttock unpublished data), the majority of which are sterile F1s.

Ozothamnus hookeri X *O. ledifolius* (A.Cunn. ex DC.) Hook.f. = *O.* X *expansifolius* (Sieber ex P.Morris & J.H.Willis)

Helichrysum hookeri var. *expansifolium* Sieber ex P.Morris & J.H.Willis, *Vict. Naturalist* 59: 87 (1942); *H. expansifolium* (Sieber ex P.Morris & J.H.Willis) N.T. Burb., *Austral. J. Bot.* 6: 278 (1958); *Ozothamnus expansifolius* (Sieber ex P.Morris & J.H.Willis) A.Anderb. *Opera Bot.* 104: 89 (1991).

Type: Tasmania. Cradle Mt, Feb. 1919, Sutton 2661 (holo: MEL307437).

Notes: Sterile F1 hybrid. In raising this taxon to species Burbidge (1958) was ambivalent on whether this represented a hybrid or not.

Ozothamnus cupressoides X *O. alpinus* (N.A.Wakef.) A.Anderb.

Representative specimen: Victoria, Langfords Gap near Falls Creek, *.D. Ohlsen 18* (MEL2323803).

Notes: Putative hybrids between these two species have been reported on the Bogong High Plains near Falls Creek. These plants differ from typical *O. cupressoides* in the longer (3–3.5 mm) and broader (1.5–2.5 mm) leaves that are triangular to elliptic and not closely appressed to the stem, with the apex often recurved exposing most of the abaxial surface. The synflorescences are hemispherical and the florets are longer ((4–)4.5–5 mm) than those of *O. cupressoides*. Both putative parent species have been observed in the vicinity of these plants, flowering at the same time (D. Ohlsen pers. observ.).

Two mainland specimens mentioned by Morris and Willis (1942, p87) "Bogong and Mt. Wellington, Victoria .... bear a strong resemblance to *H. Hookeri*, var. *expansifolium*" and being "intermediate between *Backhousii* and *Hookeri*?" were at the time the undescribed species *Ozothamnus alpinus*.

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Appendix 1

O. cupressoides

Further representative specimens (total 104): **NEW SOUTH WALES**. Cascade Trail, 6 miles S. of Dead Horse Gap, 12.iii.1970, *J. Pickard and R. Coveny 2775* (MEL2160842, NSW); Kosciusko area, between Perisher Valley and Sawpit Creek, 19.ii.1990, *M.G. Corrick 10670* (MEL1578957); Hillside above Daners creek (NW side) near junction with Pipers creek, Kosciusko N. P. 36°22'S 148°28'E, alt: 1600 m, 3.ii.1979, *L. Haegi 1611* (MEL, NSW). **VICTORIA**. Mt Mueller, 1895, *C.H. French, s.n.* (MEL2165367); Mt Mueller near Mt Baw Baw, 1889, *J. Melvin s.n.* (MEL2160848); Mt St. Phillack on highest point, 20.iii.1951, *J.H. Willis, s.n.* (MEL2160851); Mustering Flat, Mount Baw Baw Plateau, 19.ii.1980, *N.G. Walsh 477* (MEL596095); Echo Flat, Lake Mountain,

21.iii.1995, *P.C. Jobson 3481* (CANB, MEL2025314); Frost Hollow, Lake Mountain, 11.i.1973, *B. Conn, s.n.* (MEL625690); Lake Mount[ain], ii.1926, *P.R.H. StJohn, s.n.* (MEL1622797); Lake Mountain Echo Flat, 17.ii.1963, *H.I. Aston, s.n.*, (MEL2160849); Central Highlands, Lake Mt., 6.ii.1943, *J.H.Willis, s.n.* (MEL2160852); Mt. Buller, Boggy Creek area, 30.i.1983, *C.W. Huggins 73* (MEL294562); Mt Buller, top of Old Hut Spur, 27.i.1981, *N.G. Walsh* (AD, MEL663136); Bogong High Plains, Buckety Plain, 28.i.1966, *A.C. Beauglehole 15762* (MEL1504485); Mt Loch, 24.ii.1983, *C. Beardsell, s.n.* (MEL1563224); Langfords West Aqueduct, 14.6 km SE of Falls Creek, 23.ii.1996, *P.C. Jobson 4132*, (CANB, MEL2041189, NSW); Bogong High Plains Between Niggerheads and Mt. Fainter-at waterfall, 26.i.1967, *A.C. Beauglehole 22521* (MEL15044489); Mount Buffalo, 24.i.1973 *M.A. Todd 104* (MEL547331); Summit of Buffalo Mountains, x.1891, *C. Walter, s.n*, (MEL2165366); Mt. Buffalo National Park, between snowplain and The Gap, 28.i.1982, *P.S. Short 1399* (MEL601839); Mt. Buffalo, Lake Catani, 29.i.1938 *J.H. Willis, s.n.* (MEL2165323); Cobberas No. 1., 28.i.1971, *A.C. Beauglehole 36604 & E.W. Finck* (MEL519108); Middle Peak area, Cobberas Mts., 25.i.1971, *A.C. Beauglehole 36512 & E.W. Finck* (MEL519109); Cobberas Mts, 10.ii.1946, *J.H. Willis, s.n.* (MEL2160867); Mount Cobberas *s.d., F. Mueller, s.n.* (MEL).

O. hookeri

Further representative specimens (total 125): **TASMANIA**. Mt Barrow plateau, 27.ii.2006, *M.F. Duretto 2099, A.M. Buchanan & A.M. Gray* (HO); Mt Barrow, track near summit, 1.iii.1996, *A.C. Rozefelds 187* (HO); Mt Barrow, 28.i.1980, *M.G. Noble 28994* (HO); Mt. Wellington, *s.d., C.F. Puttock 10* (CANB, HO); Mt. Wellington, 31.i.1840, *R.C. Gunn 123* (HO); Mt. Wellington, Collins Bonnet Track, 8.ii.1947, *J. Somerville s.n.* (HO); Dead Island, Mt Wellington, 6.ii.2000, *A.C. Rozefelds1623* (HO); Mt. Field National Park, c. 0.8 km SE of Lake Dobson, 24.i.1983, *P.S. Short 1829* (HO, MEL626458, 2165509); Mt. Field, iii.1902, *L. Rodway 410* (HO); Kangaroo Moor, Lake Fenton, Mt Field National Park, 26.iii.1932, *O. Rodway 116* (HO); Wombat Moor, Mt. Field National Park, *G. Kantvilas s.n.*, (HO); Poatina Intake Road, 17.iii.2006, *M. Visoiu 174 & N. Kent* (K, KRA, HO); S ridge of Western Bluff, 13.iv.1986, *P. Collier 1332* (HO); Below Pine Tier Lagoon, 2.ii.2000, *B. French 451* (HO); Between Derwent Bridge and Bronte, 27.xi.1949, *N.T.* Burbidge *3403* (CANB, HO); Mt Rufus Canal Road, 8.i.1986, *S.J. Jarman s.n.* (HO); Iris River- Cradle Valley Rd, crossing, 10.5 km N. Waldheim, 20.i.1982, *S.J. Forbes 1242* (HO, MEL663048, PERTH); Cradle Mountain area, iii.1949, *J. Somerville s.n.* (HO).