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Integrative approach resolves the taxonomy of the *Ozothamnus ledifolius* (Asteraceae: Gnaphaliae) species complex in Tasmania, Australia

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Abstract

Close examination of specimens of the *Ozothamnus ledifolius* species complex (*O. ledifolius*, *O. ericifolius* and *O. purpurascens*) collected throughout Tasmania, Australia, revealed the existence of more taxa than hitherto recognised. An integrative approach employing morphological, genotyping and environmental data of specimens resolved the complex, and showed good support for *O. ledifolius* and *O. ericifolius* as currently circumscribed, further clarifying the existence of four additional, distinct taxa: *Ozothamnus purpurascens*, with revised and clarified typification; *O. reflexus comb. & stat. nov.*, a taxon to which the name *O. purpurascens* was previously misapplied; *O. buchananii spec. nov.*, a novel taxon from mid–high elevations in north-eastern Tasmania; and *O. floribundus spec. nov.*, a rare and highly localised novel taxon in lowland south-eastern Tasmania.

Keywords: genotyping-by-sequencing, morphology, integrative taxonomy

Introduction

Scientifically defensible species delimitation is essential for effective management and conservation of biodiversity: species can only be managed if they are known to exist in the first place (Mace 2004). Particular challenges are posed by cryptic species and complexes (Bickford *et al.* 2007), groups of organisms or geographic areas that are poorly studied, and by differing opinions on species delimitation (Isaac *et al.* 2004).

Integrative taxonomy:—A large number of species concepts have been proposed in the literature (Mayden 1997; de Queiroz 2007), some of them applicable only to sexually-reproducing species or to single time-slices. However, recent years have seen a growing consensus to treat species as independently evolving metapopulations that may remain semipermeable to gene flow from other such populations (Hausdorf 2011; Naciri & Linder 2015). This move reflects the growing realisation that speciation is often a gradual process but may also reflect the pragmatic use of software for coalescent-based species tree inference and species delimitation analyses that assume such a concept (Yang & Rannala 2010; Carstens & Dewey 2010; Fujita *et al.* 2012).

More generally, species have been recognised as encompassing very different levels and patterns of diversity, ranging from clearly isolated lineages across polytypic species with hierarchical internal structure to entities showing taxonomically challenging variation that is uncorrelated between traits and with geography (ochlospecies of White 1962; Cronk 1998). At the same time, there has been a growing recognition that species delimitation should be based on a combination of different, and preferably all, available data sources, an approach labelled integrative taxonomy (Dayrat 2005; Padial *et al.* 2010; Schlick-Steiner *et al.* 2010). Ideally, geographic, ecological and morphological data would be studied together with increasingly available genomic data to provide a more comprehensive picture of concordant gaps in variation (Shaffer & Thomson 2007; Leaché *et al.* 2014).

Single Nucleotide Polymorphisms (SNPs):—Studies of species delimitation, introgression or speciation can make use of multi-locus sequence data (Yang and Rannala 2010) or of genome-wide Single Nucleotide Polymorphisms as produced by RAD-seq (Baird *et al.* 2008) or Genotyping-by-Sequencing (GbS) (Elshire *et al.* 2011). The former are generally from known loci. The latter are anonymous and in their vast majority situated in non-coding regions of the genome, but they have several advantages for species-level studies, not least because thousands of loci can now be obtained easily even for non-model organisms (Narum *et al.* 2013).

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SNPs provide a good trade-off between sequencing costs and number of characters, where whole genome sequencing is still expensive and bioinformatically challenging while locus-based approaches are too data-limiting (Narum *et al.* 2013). Recent studies have demonstrated that a high number of characters facilitates analyses: estimates of population structure can be accurate with as few as 4-6 samples per population if more than 1,000 markers are available (Willing *et al.* 2012), and information about population structure is maximised with many individuals and markers at the cost of coverage, even down to c. 1x (Buerkle and Gompert 2013). As a consequence of this, and despite remaining computational and modelling challenges, (Sousa and Hey 2013), SNP data are increasingly employed in studies of alpha taxonomy, population or landscape genomics, or hybridisation (e.g. Lu *et al.* 2013; Roda *et al.* 2013; Nicotra *et al.* 2016; Owens *et al.* 2016).

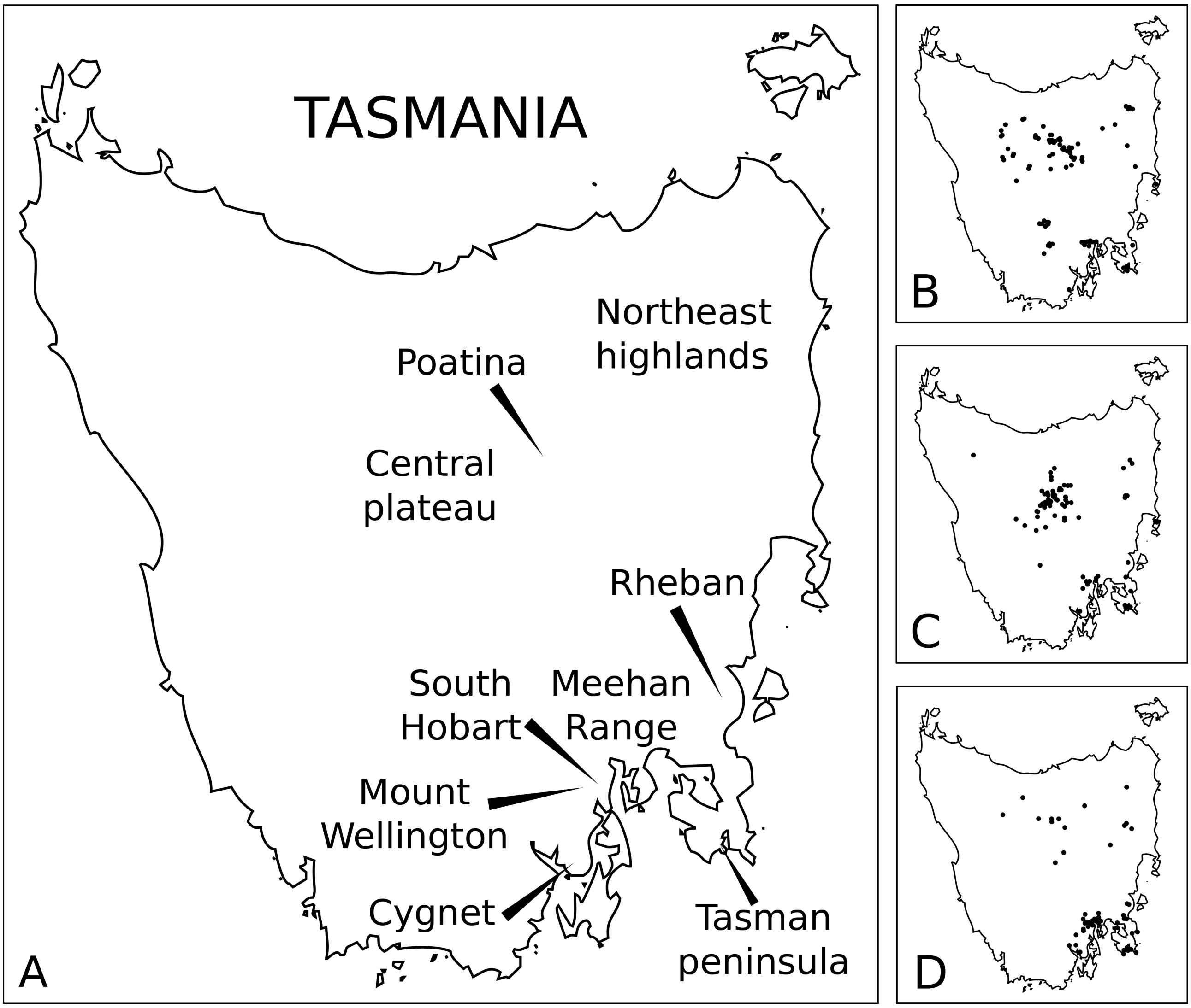

FIGURE 1. Map of the major localities mentioned in this study; **a** distribution of collections of the *Ozothamnus ledifolius* complex at the start of this study; **b** distribution of specimens identified *a priori* in HO and AVH as *O. ledifolius*; **c** distribution of specimens identified as *O. ericifolius*; **d** distribution of specimens identified as *O. purpurascens*.

Study group and location:—The predominantly Australian daisy genus *Ozothamnus* Brown (1818: 125) is a good example of a genus where traditional species concepts based exclusively on morphology have not been entirely successful. Following its description, *Ozothamnus* was reduced by Bentham (1867) to a section of *Helichrysum* Miller (1754: 462) then subsequently restored as a separate genus by Anderberg (1991). Tasmania, an island off south-eastern Australia (Fig. 1A), contains 22 of the 61 named Australian taxa of *Ozothamnus* (de Salas & Baker 2016; CHAH 2017), distributed in a broad range of habitats from coastal to alpine. In the Tasmanian context, Hooker (1856) and Rodway (1903) followed Brown's concept of *Ozothamnus*, whereas Curtis (1963) followed Bentham's lead and treated Tasmanian species within *Helichrysum*. The taxonomic history of the genus has been somewhat complex, and Morris & Willis (1942: 84) observed that species of *Ozothamnus* "have been variously reduced, resurrected, synonymised or otherwise juggled" since the group was first studied in the early 19th century. They identified *Ozothamnus* as a good example of a complex that is still in the process of speciating. In the seventy years that have elapsed since first treated, the taxonomic boundaries within the genus remain unclear.

The last major revision of *Ozothamnus* was carried out by Burbidge (1958). She recognised that the endemic Tasmanian species, *Ozothamnus ledifolius* (A.Cunn. ex de Candolle 1838: 155) Hooker (1856: 204), *O. ericifolius* Hook.f in Hooker (1847: 119) and *O. purpurascens* de Candolle (1838: 165), formed a complex which also included the mainland species, *Ozothamnus alpinus* (Wakefield 1951: 49) Anderberg (1991: 89)—as *Helichrysum alpinum* N.A.Wakef. The Tasmanian taxa were treated as conspecific and their differences recognised at subspecific rank: *Helichrysum ledifolium* (A.Cunn. ex DC.) Bentham (1867: 630) subsp. *ledifolium*, *H. ledifolium* subsp. *purpurascens* (DC.) Burbidge (1958: 270) and *H. ledifolium* subsp. *ericifolium* (Hook.f.) Burbidge (1958: 272) In addition, *H. ledifolium* subsp. *reflexum* Burbidge (1958: 270) was described for the taxon that grows in coastal areas of the Tasman Peninsula. In contrast, Curtis (1963) recognised three of these taxa at species rank: *Helichrysum ledifolium*; *H. purpurascens* (DC.) Curtis (1963: 334) which included both Burbidge's *H. ledifolium* subsp. *reflexum* and *Ozothamnus rosmarinifolius* var. *ericifolius* Rodway (1903: 89) in synonymy; and also *H. ericeteum* Curtis (1963: 334) her own, illegitimate (superfluous) name for *O. ericifolius.* At the time of writing the collections at the Tasmanian Herbarium (HO) have largely maintained Curtis' classification.

Close examination of *Ozothamnus* material in HO highlighted a taxonomic problem within the complex. Collections from the same population had been commonly ascribed to more than one species and, conversely, morphologically divergent and distinguishable populations had often been ascribed to the same species. The difficulty caused by the lack of taxonomic resolution is reflected in the distribution of collections within this complex, with the range of all three species fully overlapping (Fig. 1, B–D). Some distinct morphotypes have not been accounted for, and potentially up to five or six apparent taxa could be distinguished for a complex that contains only three currently recognised names.

As currently circumscribed, *O. ericifolius* is a small-leafed, tall columnar shrub, with a population concentrated in the Tasmanian Central Plateau (for major localities see Fig. 1A), largely on dolerite-derived soils, and occasional specimens from south-east and north-eastern Tasmania. *Ozothamnus ledifolius* consists of larger-leafed, shorter-growing, compact shrubs from Mt Wellington, and other south-eastern montane habitats as well as the margins of the Central Plateau, all at high elevation and all also on dolerite. Occasional specimens exist from other parts of Tasmania. *Ozothamnus purpurascens* (as understood at the commencement of this study) encompasses morphologically diverse but generally larger-leafed, taller shrubs, mostly of low elevations and coastal populations in south-eastern Tasmania, predominantly on Permian mudstone and Triassic sandstone. Some scattered collections from the Central Plateau and north-east highlands also exist. Populations from the north-east of Tasmania, subsequently referred to as *O.* "St Pauls Dome", and from Cygnet south of Hobart (Fig. 1A), subsequently referred to as *O.* "Merchants Hill", are morphologically distinct from the rest of the complex and do not fit well into the current species circumscription. *Ozothamnus* "St Pauls Dome" is a columnar shrub reminiscent of *O. ericifolius* but with larger, almost-terete leaves that are often antrorse, arranged in obvious spiralling ranks, and covered in an indumentum of crisped hairs that give it an overall cinerascent appearance. It grows at mid–high elevations in the northeast of Tasmania. *Ozothamnus* "Merchants Hill" is a small and highly floriferous shrub with very fine leaves that are entirely flat. It has a tiny, restricted range near sea-level in south-eastern Tasmania. Specimens from the last two populations have generally been ascribed in the past to all of the three currently recognised names. To further complicate the situation, the geographic origin and nature of the type of *O. purpurascens* remained unknown (Burbidge, 1958).

In this study, we have integrated morphological, genotyping and environmental data to review the taxonomy of this complex group. Our aims are to infer species limits with an integrative approach and to provide an updated treatment and identification key. We have also located and examined the type of the name *O. purpurascens* in order to clarify its application.

Materials and methods

Selection of material:—Ninety-one specimens of *Ozothamnus* taxa in the *O. ledifolius* complex were collected during the 2013–2014 summer season. Representative specimens were collected from known accessible populations to represent the geographic and morphological range within the complex. The following populations were sampled for the putative taxa: *O. ericifolius* from four localities in the Central Plateau, in the general area of its type locality; *O. ledifolius* from its type locality on Mt. Wellington; *O. purpurascens* (as applied at the start of this study) from the

Meehan Range and South Hobart, as well as from Rheban (east coast) and the Tasman Peninsula; *O.* "St Pauls Dome" from the Tower Hill area and Snow Hill (north-east highlands); and *O.* "Merchants Hill" from its sole population at Cygnet, in the south-east. In addition, a population was sampled at Poatina Road, in the north-eastern margin of the Central Plateau, whose specimens were variously assigned *a priori* to several different species in the complex, to *Ozothamnus* species outside of the complex, and to putative hybrids.

Genotyping:—A total of 96 individuals were sampled for genetic analysis. This represented all specimens from field work plus five additional specimens for which high-quality DNA was available from earlier collections. Genomic DNA was extracted using the Qiagen DNeasy Plant 96 Kit following the manufacturer's instructions. Individuals were genotyped using the Genotyping-by-Sequencing (GBS) approach of Elshire & al. (2011). This method involves digestion of genomic DNA with the *PstI* restriction enzyme, ligation of barcoded adaptor pairs, and PCR amplification followed by equimolar pooling of the individual libraries. Pooled libraries were reduced to fragments of ca. 250 to 600 bp length by gel cut-out and sequenced on an Illumina HiSeq2000 with the 100 bp paired end protocol.

SNP calling was conducted with the TASSEL UNEAK approach (Lu *et al.* 2013) and resulted in a haplotype map of 13,689 SNPs. The average number of scored reads per sample was 31,428 (±22,952), with a minimum of zero and a maximum of 159,387. Individual SNP loci (where scored) had an average coverage of 18.2 (±13.5). This suggests that missing data are less likely to be caused by lack of read coverage than by mutations in the restriction sites or additional mutations in the fragment leading to their rejection during homology establishment. Five samples showed no or virtually no (<20) successful SNP calls, and a sixth sample showed a very small number compared to the rest; these failed samples were consequently excluded from analysis. For the purposes of the present study, the dataset was ultimately reduced to ingroup samples (Supplementary Data S1) and filtered to include only SNPs successfully called in at least five samples, resulting in a matrix of 80 samples and 8,782 SNPs. Individual samples had data for a minimum of 831 and a maximum of 4,013 SNPs, with the average at 1,722.9 (±773.4).

STRUCTURE analysis:—Population structure was inferred with STRUCTURE 2.3.4 (Pritchard *et al.* 2000) and fastSTRUCTURE 1.0 (Raj *et al.* 2014) under numbers of clusters (K) ranging from 2 to 15. In the former case, analyses were conducted with default parameters (admixture model, allele frequencies correlated), 100,000 MCMC iterations of burn-in, 200,000 iterations of data collection, and five replicates for each K. In the latter case, only one analysis was run for each K using default parameters. Log and marginal likelihood scores respectively were examined to identify the values of K at which they started to plateau, and custom written Python 2.7 and R scripts were employed to visualise the results.

Network analysis:—SNP data were also submitted to a NeighborNet analysis in SplitsTree 4 (Huson 1998) using ordinary least squares.

Morphological characters:—Sixteen morphological characters (Table 1) were scored from a total of 80 herbarium vouchers of the individuals collected for the genotyping analysis (Supplementary Data S1). Characters were scored from herbarium specimens using a Wild Heerbrugg stereomicroscope and a set of digital Vernier calipers. The full matrix of morphological data is available as Supplementary Data S2.

3D ordination:—Morphological data were analysed using PATN v.3.12 (Belbin 2009). Some characters with multiple states, such as the appearance of the indumentum and exudate, were converted to matrix of multiple binary characters. Univariate characters were removed prior to the analysis. All characters were weighted equally. Analysis parameters were as follows: Gower metric association measure; non-hierarchical clustering (also Gower metric); semi-strong hybrid (SSH) multidimensional-scaling 3d ordination, cut-off value = 0.9. Gower metric was chosen due to its built-in range standardisation, which better suits a data set with measures in different ranges (Gower 1971, Streiber *et al.* 1999, Dennis & Walsh 2010). A K value of K=6 was chosen to provide consistency with the genotyping analysis. The optimal ordination stress value of 0.1149 was obtained when using a minimum of 100 random starts and 100 maximum iterations, so the analysis was run with 200 random starts to include a safety margin.

Two 3D axis views produced by the SSH multidimensional scaling were shaded to highlight individual clusters.

Ecological differentiation:—To test the degree to which species in the study group show ecological differentiation, we examined environmental data at their localities of occurrence. Geocoded specimen information for all available specimens belonging to the study group was obtained from Australia's Virtual Herbarium (AVH 2016), and combined with data from specimens collected for the present study, resulting in a dataset of 348 specimens. Climate and soil data for specimen localities were extracted with the R library raster. We used WorldClim / BIOCLIM climate layers 1, 4, 5, 6, 10, 11, 12, 13, 14, 15 and 17 for temperature and precipitation data at the highest, approximately 1 km resolution (Hijmans *et al.* 2005; worldclim.org, accessed 21 Sep 2016). For soil data, we used topsoil data layers established by Bui *et al.* (2014). They were derived from the National Geochemical Survey of Australia through interpolation to a 1 km scale.

After preliminary analyses, environmental layers were narrowed down to a selection that showed the strongest signal of differentiation: topsoil aluminium, chromium, iron, potassium, nickel, and pH value, as well as mean temperature, minimum temperature, and precipitation seasonality. These variables were then submitted to Principal Coordinates Analysis (PCO) in R using the library ecodist.

TABLE 1. Morphological characters measured for the phenetic analysis.

Character	Description
Florets Max	Maximum number of florets per capitulum (n=5)
Florets Mean	Mean number of florets per capitulum (n=5)
Leaf Length Max	Length of longest measured leaf in specimen (n=15)
Leaf Length Mean	Mean leaf length (n=15)
Leaf Length Range	Range of longest - shortest measured leaf (n=15)
Leaf Width Max	Width of widest measured leaf in specimen (n=15)
Leaf Width Mean	Mean leaf width (n=15)
Leaf Width Range	Range of widest - narrowest measured leaf (n=15)
Len:Wid ratio	Mean length:width ratio measured per individual leaf (n=15)
Leaf Thickness Mean	Mean leaf thickness (n=15)
Leaf wid:thi ratio	Mean ratio of leaf width:thickness measured per individual leaf (n=5)
Leaf widest point	Location of the widest point on the lamina (0=base, 1=near middle or leaf linear, 2=near apex)
Lamina flatness	0=lamina flat or almost flat, 1=lamina distinctly recurved, 2=lamina revolute almost to the mid-rib
Leaf Indumentum visibility	0=indumentum not visible to the naked eye, 1=clearly visible indumentum (leaves appear cin-erascent)
Indumentum texture	0=felty-appressed (woolly), 1=curly (cottony)
Exudate colour	0=clear, 1=pale yellow or green, 2=bright yellow

Results

Analysis of population structure:—Marginal likelihood scores from fastSTRUCTURE started to plateau at K = 6. The inferred six clusters were as follows (Supplementary Data S3): (1) *Ozothamnus* "St Pauls Dome"; (2) *O. ledifolius*; (3) *O. ericifolius*, including also the samples from Poatina and one sample from Cygnet; (4) *O. purpurascens,* predominantly from the Meehan Range and Rheban; (5) *O. purpurascens,* predominantly from the Tasman Peninsula; and (6) *O. purpurascens,* predominantly from South Hobart as well as four of the five samples from Cygnet (Supplementary Data S3). The overall highest score as identified by fastSTRUCTURE's chooseK script was that for twelve clusters, but the population structure in that case only comprised eight actual clusters. Two of those consisted of a single sample each, while the remaining four clusters were not assigned more than 0.05% of any sample.

The highest Log likelihood scores of STRUCTURE results for each K started plateauing at K = 5 but continued to increase slightly until K = 8. At five clusters (results not shown), the following groups were resolved: (1) the Tower Hill (north-east highlands) population of *Ozothamnus* "St Pauls Dome"; (2) *O. ledifolius*; (3) *O. ericifolius*, including the samples from Poatina Road and the samples from Cygnet; (4) *O. purpurascens* from the Meehan Range; and (5) *O. purpurascens* from other localities. The Snow Hill (north-east highlands) population of *O.* "St Pauls Dome" was shown as an admixture zone between the Tower Hill population and *O. purpurascens* from the Meehan Range, and the genetics of four samples of *O. purpurascens* of South Hobart were shown as divided approximately evenly between *O. ericifolius* and the two *O. purpurascens* clusters.

STRUCTURE results for six clusters, inferred for direct comparison with fastSTRUCTURE and PATN (see below), showed overall lower degrees of admixture (Fig. 2). *Ozothamnus* "St Pauls Dome", *O. ledifolius* and *O. ericifolius*, the latter including the samples from Poatina, showed little admixture. Specimens of *O. purpurascens* were divided into one cluster from South Hobart, one cluster from Rheban and Remarkable Cave (Tasman Peninsula), and one cluster from Meehan Range. The five samples from Cygnet were inferred to be strongly admixed between *O. ericifolius* and *O. purpurascens* from South Hobart.

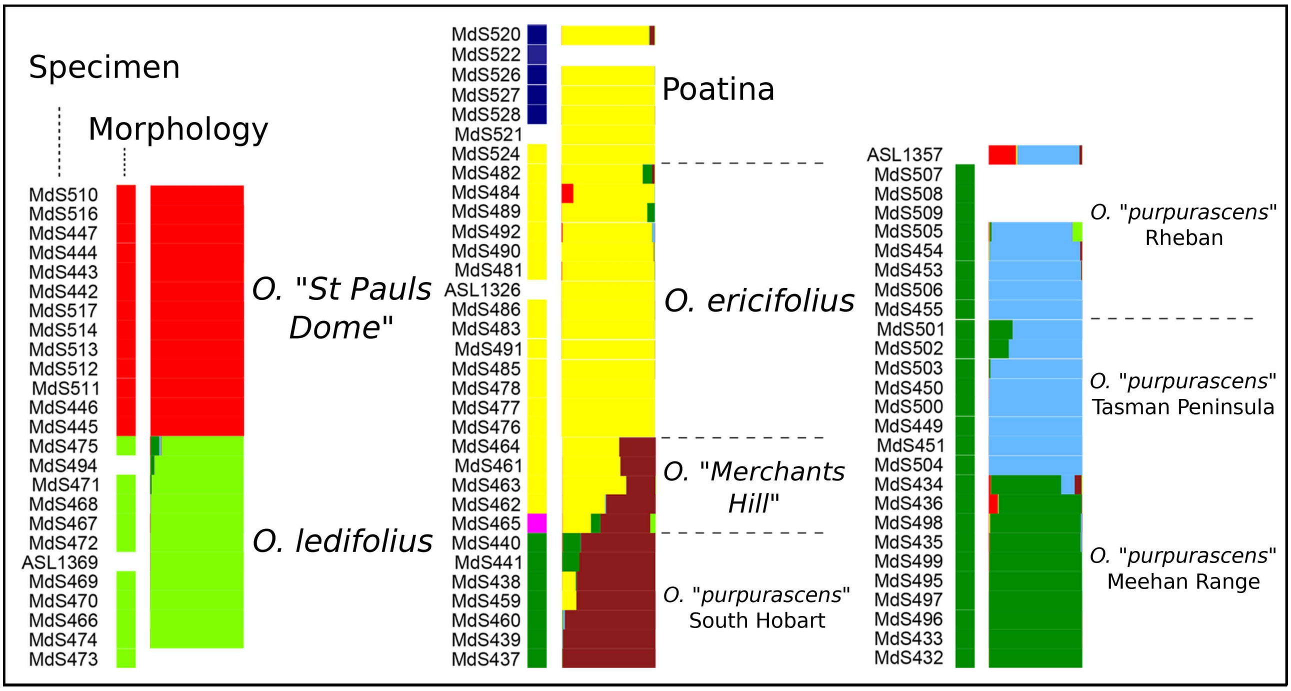

FIGURE 2. Combination of data from STRUCTURE analysis (K=6) and non-hierarchical cluster analysis of morphological characters using PATN (K=6), showing the geographic distribution of each cluster. White spaces indicate missing data.

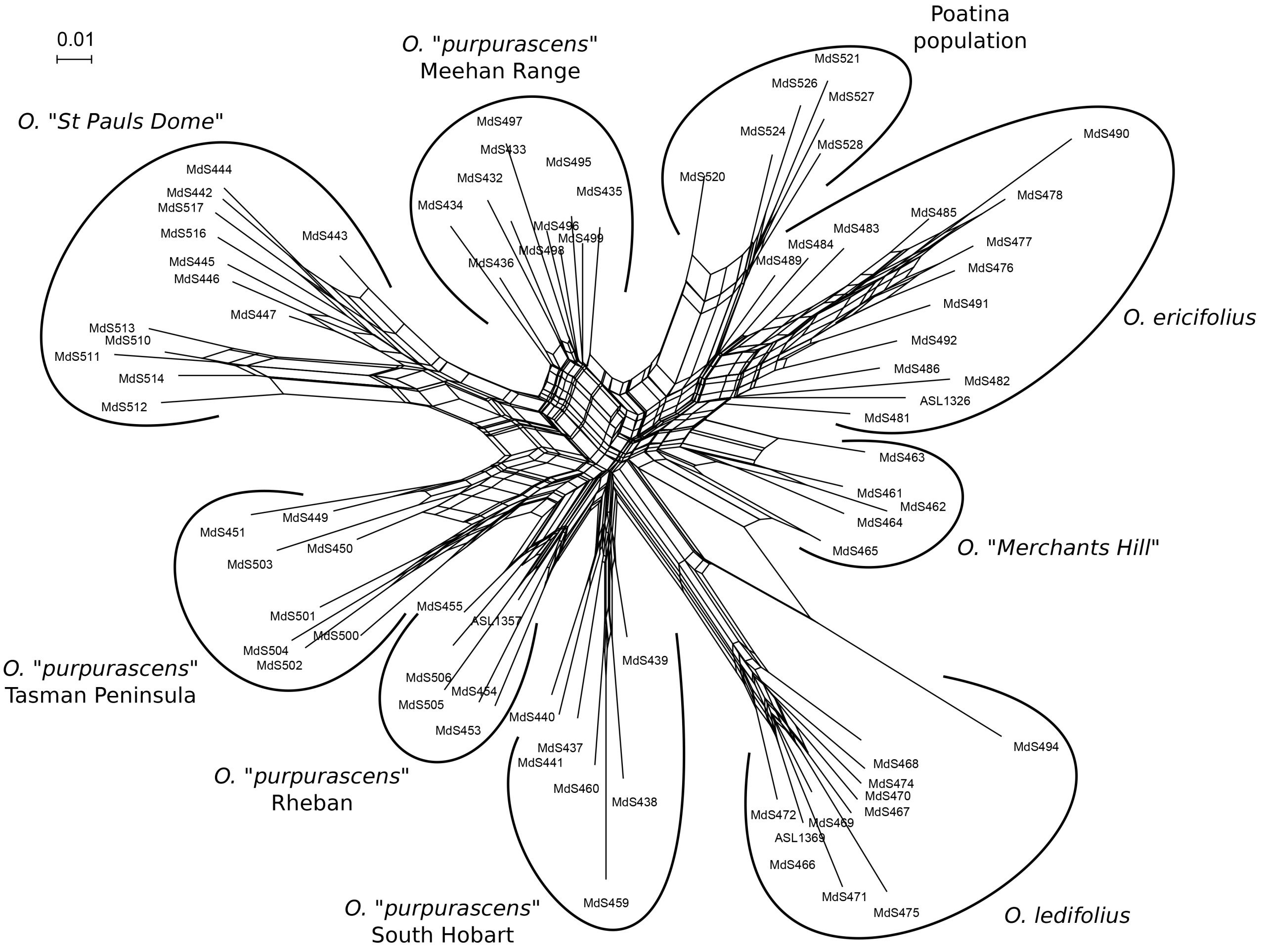

FIGURE 3. NeighborNet graph of SNP data for 80 samples of the *Ozothamnus ledifolius* complex.

Network analysis:—The centre of the network (Fig. 3) showed a high degree of reticulation. *Ozothamnus* "St Pauls Dome" and *O. ledifolius* appear as the most distinctive of the putative species. *Ozothamnus ericifolius* showed a strong degree of reticulation with the Poatina population. *Ozothamnus purpurascens* did not form a single cluster but was divided into four clusters situated between *O.* "St Pauls Dome" and the remaining samples. *Ozothamnus* "Merchants Hill" was connected to *O. ericifolius* and to a lesser degree to *O. ledifolius*.

3D ordination:—Classification by non-hierarchical clustering using PATN (K=6) produced distinct clusters for *Ozothamnus ledifolius* and *Ozothamnus* "St Pauls Dome" (Fig. 4 A,B) that showed no overlap with the other taxa analysed. Specimens identified *a priori* as *Ozothamnus ericifolius* formed a cluster that also included most of the specimens of *O.* "Merchants Hill", although the ordination shows this cluster clearly divided into two smaller sub-clusters that corresponded to each *a priori* taxon. Specimens identified *a priori* as *Ozothamnus purpurascens* (SE Tasmanian populations) formed one large, loose cluster (group 1). All the specimens from the Poatina population clustered as a distinct group (group 6), except for one specimen (MFS 524) that clustered with group 3 (*O. ericifolius* and *O.* "Merchants Hill"). One very young plant of *O.* "Merchants Hill" (with larger than adult foliage) clustered as its own distinct group (group 4), though the difference between this individual and the rest of the population was concentrated into a single axis (Fig. 4 B).

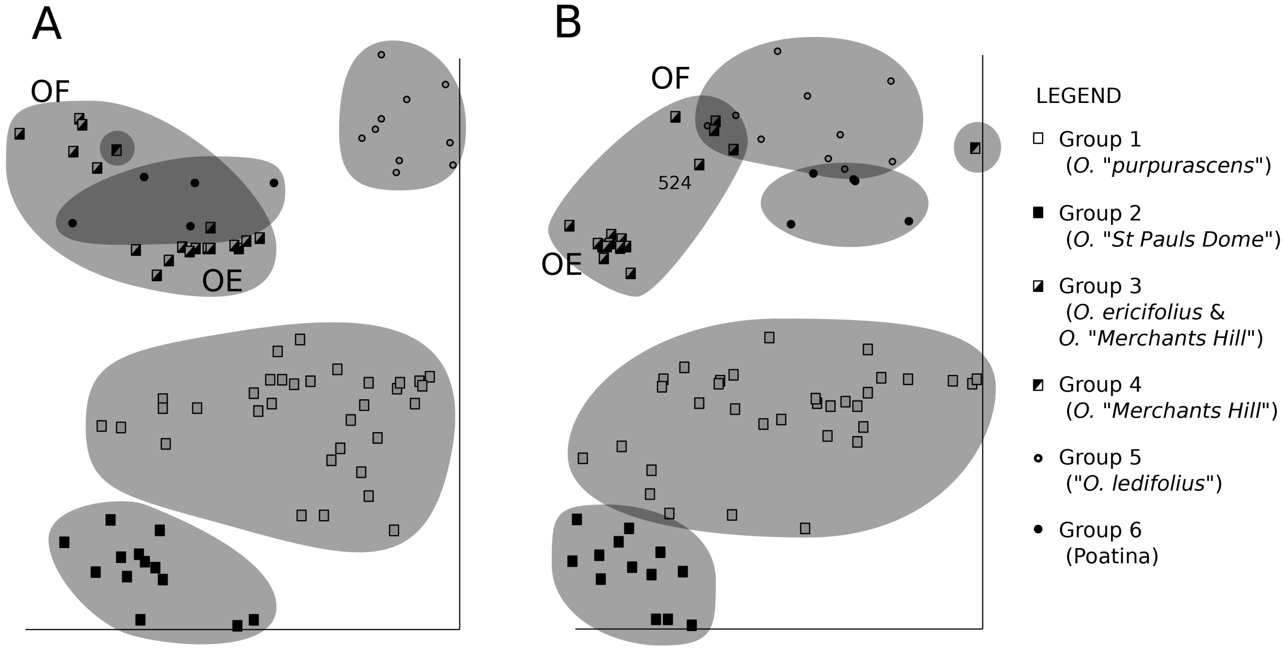

FIGURE 4. Non-hierarchical clustering analysis of 80 samples of Tasmanian *Ozothamnus,* using K=6 and *a priori* identifications. Grey shading is used to indicates discrete analysis clusters. Group 1 corresponds with south-eastern lowland populations of *O. 'purpurascens'* (*sensu auct. non* DC.); Group 2 with north-eastern highland populations of *O.* "St Pauls Dome"; Group 3 is comprised of *O. ericifolius* and *O.* "Merchants Hill" (note separate subclusters EO and OF, denoting *O. ericifolius* and *O.* "Merchants Hill", respectively); Group 4 was a single, juvenile outlier of *O.* "Merchants Hill"; Group 5 corresponds with *O. ledifolius*, and Group 6 with the Poatina cluster of identified *a priori* as *O. aff. ledifolius* and *O. aff. purpurascens*. (A) View of axes 1 and 2. (B) View of axes 2 and 3.

Re-analysis of the morphological dataset using a K value of K=5 (not shown) assigned the morphologically divergent *O.* "Merchants Hill" specimen (group 4 under K=6) to the Poatina cluster, and assigned one of the Poatina cluster individuals to the group containing both *O. ericifolius* and *O.* "Merchants Hill" (group 3 under K=6), but was not notably different otherwise. Re-analysis using higher K values (K=7, K=8, not shown) split *O. purpurascens* further into various sub-groups.

Ecological differentiation:—Principal Coordinates Analysis of selected environmental data for 348 specimens of the study group showed several clusters that corresponded with sthose found by morphological and genetic analysies (Fig. 5). *Ozothamnus* "St Pauls Dome" was clearly separated from all other groups, while *O. ledifolius* and *O. ericifolius* were separated from each other. *Ozothamnus ledifolius* and *O. purpurascens* were mostly separated but showed some overlap of specimens from the eastern face of Mount Wellington. *Ozothamnus purpurascens* was divided into two clusters comprising specimens from the South Hobart / Meehan Range area and the east of Tasmania, respectively. On the other hand, despite their geographic separation *Ozothamnus* "Merchants Hill" could not be separated ecologically from *O. purpurascens*, and specimens from Poatina were not well separated from *O. ericifolius*.

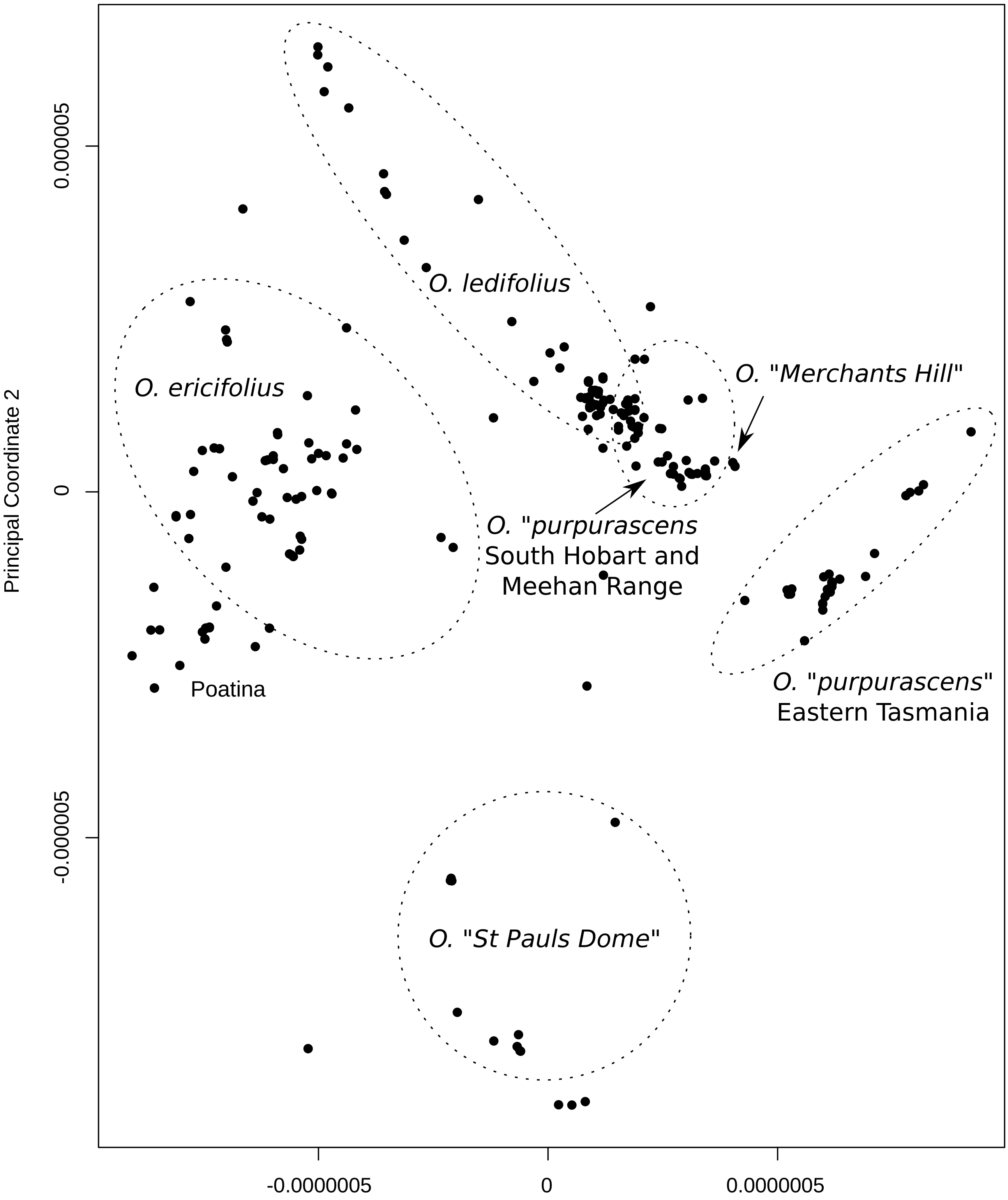

FIGURE 5. Principal Coordinates Analysis of selected environmental (soil and climate) data for collecting localities of 348 specimens of the *Ozothamnus ledifolius* complex from Australia's Virtual Herbarium.

Discussion

The integrative approach employed in this study managed to resolve the Tasmanian *Ozothamnus ledifolius* complex into consistently distinguishable taxa.

The combination of morphological, genotyping and environmental niche analyses carried out in this study allow for the resolution of more taxa within the complex than the three currently recognised species. Analyses of morphology, genotyping and environmental data (Figs 2–5) showed this complex to be a typical example of a taxonomically complex group *sensu* Naciri & Linder 2015, with incomplete speciation obscuring the exact relationship between its populations. The contrast in the make-up of clusters derived from morphological and genetic analyses suggest that not all morphologically distinctive populations of this group are reproductively isolated from each other, and that morphological and genetic differentiation have not necessarily advanced in lockstep (de Queiroz 2005, 2007).

Taxa well supported by all analyses:—Two taxa are consistently different and relatively isolated from the rest of the complex in the genotyping, ecological and morphometric analyses, and also occupy distinct ecological niches. *Ozothamnus ledifolius* forms a cluster that is morphologically and genetically distinct and distinguishable from other putative taxa using both methods. It shows little admixture in the form of potentially hybrid individuals (Figs. 2–4). Although analysis of soil and climate data shows ecological overlap between specimens of *O. purpurascens* and *O. ledifolius* found by the PCA (Fig. 5), this is almost certainly spurious, and most likely reflects a lack of geographic precision in environmental data along a steep altitudinal gradient. The eastern face of Mount Wellington is very precipitous, with high vertical cliffs. Specimens from only a short horizontal distance apart may have been collected at elevations differing by as much as 800 m, and on different underlying substrates. The two species are clearly separated in the field as they occur at different elevations and underlying geologies. Our results clearly support the ongoing taxonomic recognition of *O. ledifolius* at specific rank.

Equally distinctive in all analyses are collections from north-eastern Tasmania, which form a similarly tight cluster that is well supported in all our analyses with little or no admixture. We describe this taxon below as *O. buchananii* de Salas & Schmidt-Leb.

Taxa showing some admixture or a lower degree of differentiation:—*Ozothamnus ericifolius* has a very large and morphologically homogenous population widely spread through the Central Plateau, with a very dense population centred around Great Lake. It is possibly the most abundant taxon in the complex. Towards the extreme margins of the Central Plateau and especially on the higher peaks around its eastern and northern edge, it is gradually replaced by larger-leaved forms that morphologically start to resemble *O. ledifolius* and *O. purpurascens* (the latter name as applied at the start of this study) in morphology. Despite this, the morphotaxon *O. ericifolius* showed no appreciable admixture from other taxa, and formed a distinct cluster in the environmental niche analysis (in which it only overlaps with *O. purpurascens*). Based on this we have chosen to also recognise this taxon as a separate species.

The south-eastern Tasmanian lowland populations of the complex (to which the name *O. purpurascens* has hitherto been misapplied, see below) are variable in their morphology, genetics, and environmental niche. There is appreciable genetic differentiation into several main clusters (Figs. 2–4). Genetic clusters from the western shore of the River Derwent (South Hobart area), the eastern shore of the Derwent (Meehan Range) and the east coast (Tasman Peninsula and Rheban, Figs. 2, 3) do not coincide with distinct morphotypes. Populations from Rheban are morphologically consistent with those on the western shore of the River Derwent, and eastern shore populations are morphologically closest to those in the coastal Tasman Peninsula area, rather than their closest neighbours. Burbidge (1958) used the morphological distinctiveness of the populations from the Tasman Peninsula to justify the erection of a separate subspecies as *Helichrysum ledifolium* subsp. *reflexum*, while treating the South Hobart populations as *H. ledifolium* subsp. *purpurascens*.

There are three main options when treating a cluster such as this one: the chosen taxonomy may reflect the morphology, reflect the genetic clusters, or treat the group as one single, variable taxon. Given that genetic and morphological data are contradictory, and each method's clusters are not supported by the other, we have chosen the latter approach, and retained this group as one single, variable species. The variability of south-eastern Tasmanian populations of the *O. ledifolium* complex may be a good example of an ochlospecies sensu Cronk (1998), especially given that other ochlospecies have been identified in Australian Gnaphaliae, for example the *Chrysocephalum apiculatum* / *C. semipapposum* complex (Wilson 2016). The inconsistencies between analyses may alternatively reflect a group that is at an early stage of the process of differentiation, with incomplete reproductive isolation. The identity of the type specimen of *Ozothamnus purpurascens* has now been clarified (see below) and it is not conspecific with the south-eastern taxon which we recognise here at species rank as *O. reflexus* (N.T. Burb.) de Salas & Schmidt-Leb.

Morphologically distinctive taxa that are less well supported genetically:—The small and distinctive population in the Cygnet area in the south-east (*O.* "Merchants Hill") forms a cluster that is morphologically distinctive. Although the non-hierarchical clustering (Fig. 4) places it within the same cluster as *O. ericifolius*, it is evident from this figure that specimens of this population form a distinct sub-cluster. Ecologically and geographically this population is distinct and isolated from the rest of *O. ericifolius*, and much closer to *O. reflexus* (Fig. 5). It grows on sandstone, near sea level, instead of on dolerite at high elevations. The morphotaxon is mostly supported by the genotyping analyses (Figs. 2, 3) which finds the Cygnet population to be closest to *O. ericifolius*, perhaps with some introgression of *O. reflexus* (Fig. 3). It is likely that this small but distinctive population is a result of an ancient hybridisation event between these two species. In spite of the potentially hybrid origin of this taxon, its population is morphologically stable and distinctive enough to be recognised at specific rank, which we describe below as *O. floribundus spec. nov*.

On the type locality of *Ozothamnus purpurascens* DC.:—The geographic origin of the type of *Ozothamnus purpurascens* had been a mystery until this study. The high degree of morphological similarity between taxa in this complex makes understanding the origin of the holotype essential to clarify nomenclature within the group.

The holotype of *Ozothamnus purpurascens* (G-DC G00461399) was collected by R.C.Gunn (as No. 281), and forwarded to Lindley in 1833. It is important to note that Gunn used taxon numbers rather than specimen numbers, and so there are many Gunn 281 collections at HO and other herbaria, collected at multiple locations over a long span of time. In her attempt to typify this taxon, Burbidge (1958) was unable to determine the type locality, as she could not find other specimens of Gunn 281 that were contemporaneous with the type, and later-collected specimens were all from Mt Wellington and conspecific with *O. ledifolius*.

Gunn sent the future holotype to Lindley in 1833, who then forwarded some of this material to de Candolle in 1834. The type in the DC herbarium is annotated as "*env. par Lindley 1834*", presumably abbreviating "*envoyé par Lindley 1834*": 'sent by Lindley 1834' (Fig. 6). It was finally described as *Ozothamnus purpurascens* DC., and the protologue (de Candolle 1838) makes no mention of the type locality.

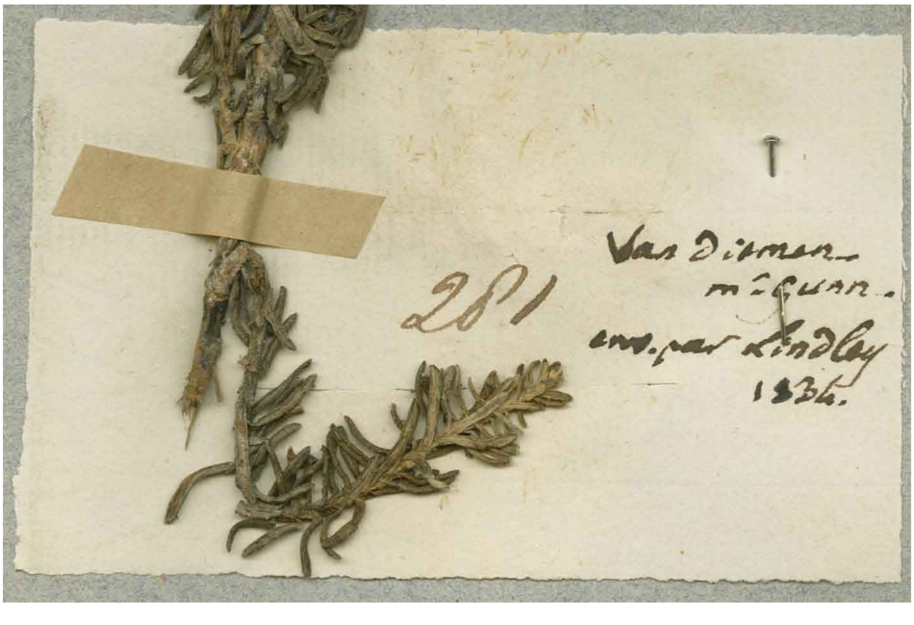

FIGURE 6. Label detail from GDC027277, R.C.Gunn 281, the holotype of *Ozothamnus purpurascens*, which is annotated: "Van Dieman—mr Gunn. env.par Lindley 1834".

Fortunately, there is no need to find other contemporaneous, annotated specimens of Gunn 281 in order to establish the type locality of de Candolle's *O. purpurascens* holotype. Gunn forwarded only one parcel of plants to Lindley in 1833, which Lindley partly distributed to other botanists. Later instances of Gunn 281 were collected too late to have been forwarded by Lindley to de Candolle by 1834. Gunn's letter accompanying this parcel is still extant in the Lindley Library at the Royal Horticultural Society in London. In this letter, Gunn detailed the specimens he had forwarded to Lindley and their origin. He stated that he had extended his numbers "from 127 to 443", indicating that the 'Gunn 281' specimen he enclosed was his first use of his taxon number 281. He also states that he collected numbers "…273 to 286 inclusive…" while "…on the mountains for two or three days…" (Gunn 1833). At the time, Gunn was residing in Launceston, in northern Tasmania, and he did not travel to southern Tasmania during this collecting period (Buchanan 1988). Although there is no specific locality in the specimen tag attached to the type, Gunn did list the locality for various other individual specimens collected during this same trip (and within this numbering series) as "Western tier of mountains, about 4000 f^t. high" [i.e. Great Western Tiers, above the modern town of Cressy].

Gunn's collection is indeed morphologically consistent with other, modern collections from this area, such as the Poatina specimens used in our analyses. These populations are genetically and morphologically distinct from the low-elevation, south-eastern Tasmanian *O. purpurascens auct. non* DC. (and also combinations under *Helichrysum*), and correspond instead to the morphologically distinctive but genetically unsupported taxon still present along the Central Plateau margins. The name *Ozothamnus purpurascens* has therefore been misapplied to south-eastern Tasmanian populations of the complex by every author since de Candolle.

Taxonomic status of *Ozothamnus purpurascens*:—The populations of *O. purpurascens* DC., which occur on the fringes of the Central Plateau, are taxonomically more problematic than the rest of the complex. Collections from the higher peaks along the eastern and northern margins of the Plateau as well as sporadically along the western margin are morphologically reminiscent of *O. ledifolius*. They are distinct enough that non-hierarchical clustering analysis of morphological traits isolated them into a separate cluster (Fig. 4). Plants from these populations have higher floret numbers per capitulum than *O. ericifolius* and larger leaves stained with pale yellow-green exudate (compared to the bright yellow exudate of *O. ledifolius*). However, the genotyping analyses showed little significant differentiation between these populations and *O. ericifolius* from the rest of the Plateau (Figs. 2, 3), and transitional morphotypes occur between core *O. ericifolius* and the morphtype of *O. purpurascens* DC. (i.e. *Moscal 689*: HO 40197).

The genetic clusters that contain the taxon to which the name *O. ericifolius* is currently applied thus also contain morphologically divergent samples from the same broad geographic area (Figs. 1, 2, 3, 5). In particular the specimens of *O. purpurascens* (sensu DC.) from Poatina had been identified *a priori* as several different species, but molecular analyses consistently placed them as closest to or indistinguishable from *O. ericifolius*. This could be explained by relatively recent morphological differentiation that is not yet clearly observable in the genomic analysis, or alternatively reflect ancient introgression of a different species, such as *O. ledifolius*, along the margins of the Central Plateau. In this case, populations that potentially arose from a historic introgression may have become genetically incorporated within *O. ericifolius* due to asymmetric gene flow from the overwhelmingly larger nucleus of population of the latter species throughout the rest of the Plateau. The main populations of *O. ericifolius* and *O. purpurascens* straddle the watershed of the Tasmanian Central Plateau in such a way that the most likely refugia of each taxon at the height of the last glacial period would have been widely separated. Ecologically, our analysis could not distinguish between the two taxa (Fig. 5). We have chosen to give priority to the significant morphological differentiation of this taxon and recognise *O. purpurascens* as a distinct species.

The SNP data used in the present study are likely to represent predominantly non-coding parts of the genome. It is possible that local selection on a limited number of genes underlying ecologically relevant characters (e.g. leaf indumentum, leaf size and orientation, exudate) constrains the morphology and physiology of a population even as other, neutral parts of the genome are swamped by *O. ericifolius*. In such a case, the 'genic view' of species (Wu 2001) would suggest species delimitation reflecting the maintenance of such ecologically relevant genes and characters as opposed to delimitation reflecting clear reproductive isolation. However, too little is currently known about the genomics of the *Ozothamnus ledifolius* complex to make an informed decision on the applicability of the genetic view of speciation.

Alternatively, it has been hypothesised that introgression can provide an avenue for species to exploit marginal habitats through increased fitness (Choler *et al.* 2004), while hybrid fitness is potentially reduced in typical habitat, reducing the chance of encountering hybrid individuals within the rest of the Plateau area and increasing their occurrence along the margins. This process may have played a significant role in the speciation of both *O. floribundus* and *O. purpurascens*.

Some specimens in the Tasmanian Herbarium, collected from the higher peaks in far north-eastern Tasmania (Mt Victoria, Mt Albert, Mt Young) are also morphologically consistent with *O. purpurascens*. Unfortunately, fresh material could not be obtained in time for inclusion in our analyses and their genetic affinity remains unknown. We have tentatively assigned them to *O. purpurascens*.

fastSTRUCTURE and populations of putative hybrid origin:—Interestingly, fastSTRUCTURE showed virtually no admixture for any of its clusters, even in the case of the Cygnet population inferred by STRUCTURE to be heavily admixed for the same number of clusters. Although fastSTRUCTURE, as implied by its name, enables extremely time-efficient analyses and identifies clusters comparable to those identified by its slower predecessor, this behaviour may limit its utility for the study of hybridisation zones.

Single Nucleotide Polymorphism data from Genotyping-by-Sequencing provided thousands of loci. Despite high amounts of missing data, they proved useful in resolving boundaries even with a limited number of samples from some of the putative entities, confirming their utility at the species level (Narum *et al.* 2013). Given in particular the ease with which they can be generated even for poorly known taxa and analysed in ways (e.g. STRUCTURE) that allow direct comparison with cluster analyses of morphological and environmental data, future studies in integrative taxonomy may benefit from a wider use of this marker system (Nicotra *et al.* 2016).

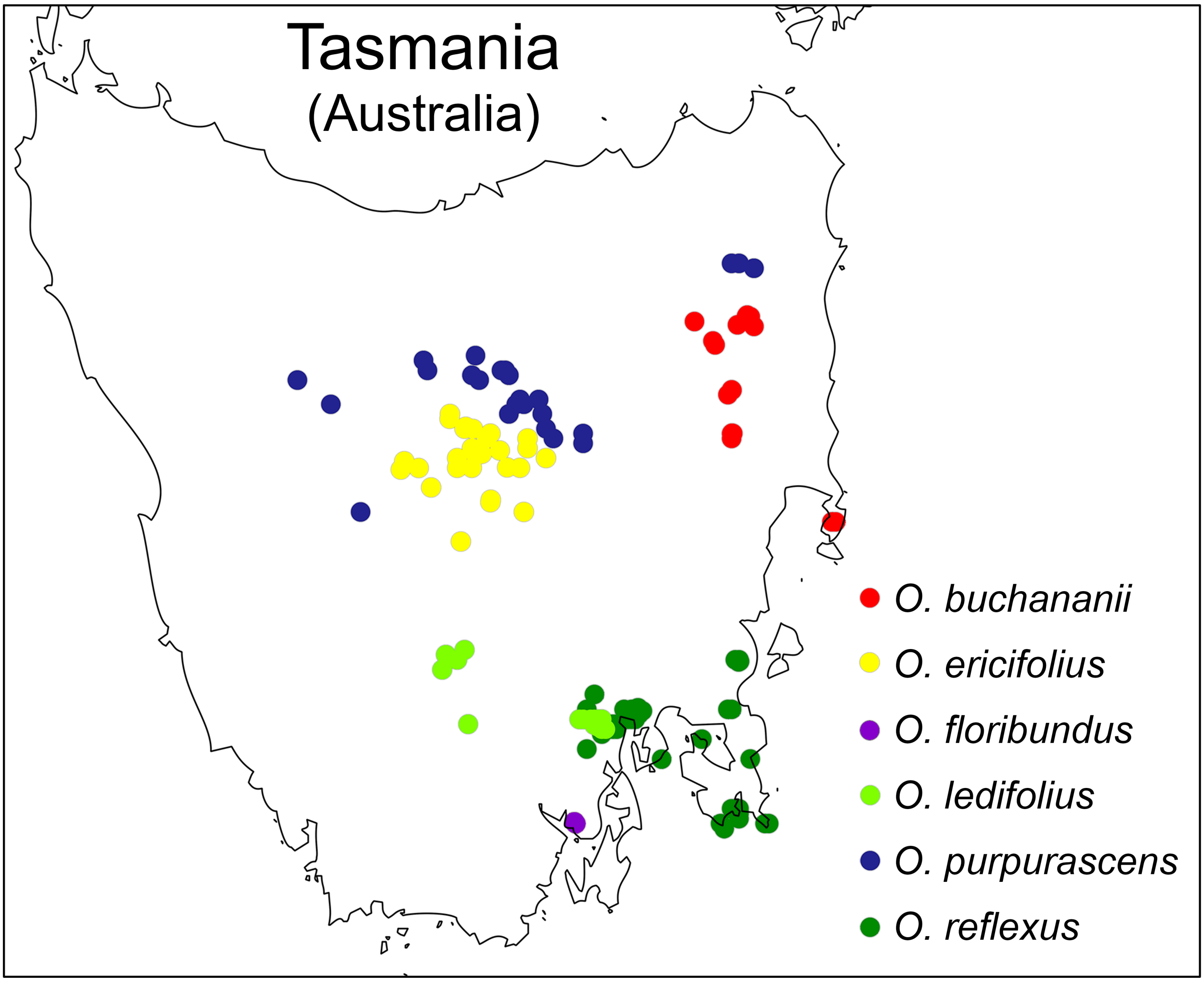

FIGURE 7. Distribution of collections in the *Ozothamnus ledifolius* complex in Tasmania, after revision and redetermination of available specimens.

The study of taxonomic boundaries within the genus *Ozothamnus* is complicated by the propensity that its species have for producing hybrids. During the course of work carried out for this study several such hybrids were encountered in the field and in the lab, including putative F1 hybrids of *O. ericifolius* × *O. hookeri* Sonder (1853: 509) (Miena, by Great Lake, 3 Jan 1972, M.R.K. Lambert 755 (HO)), *O. ledifolius* × *O. hookeri* (Track to Thark Ridge, LH side. Mt Wellington, 9 Feb 2005, R.P. Minchin s.n. (HO)), *O. buchananii* × *O. hookeri* (Dukes Marshes, W margin. M Road, 1 Mar 2007, M. Visoiu 301 (HO)), *O. purpurascens* × *O. hookeri* (Poatina Road. Uppermost switchback, at the start of the dirt road to the top of the pipeline., 27 Jan 2014, M.F. de Salas 531 (HO)) and *O. purpurascens* × *O. antennaria* (de Candolle 1838: 164) Hooker (1856: 203) (Poatina Road. Dirt road to top of pipeline, approximately 1 km southeast of the uppermost switchback on Poatina Road. 27 Jan 2014, M.F. de Salas 519, 523 (HO)). Among these, F1 hybrids between a parent in the *O. ledifolius* complex and *O. hookeri* have been described under the name *Helichrysum hookeri* var. *expansifolium* Sieber ex Morris & Willis (1942: 87) and are currently treated as *O.* × *expansiolius* (Sieber ex P.Morris & J.H.Willis) Anderberg (1991: 89) (Ohlsen *et al.* 2010).

Our genetic data show that historical hybridisation events such as these may have given rise to both *O. floribundus* and *O. purpurascens*, both of which at present are morphologically stable populations. The case is clearer for *O. floribundus*, which shows genetic introgression from its two putative parents, than for *O. purpurascens*. The chance that the latter has arisen as a result of the geographic separation, as well as the expansion and contraction of suitable habitat during Pleistocene glaciations cannot be discounted. Our use of both morphological and molecular tools to classify the Tasmanian populations of this complex has highlighted that some of the complex is most likely still not fully reproductively isolated, and some populations (*O. ledifolius*, *O. buchananii*) are further along the path of isolation than others (*O. reflexus*, *O. purpurascens*), as shown by the possibility that the latter may have arisen through the remaining ability of closely-related species to exchange genetic material.

In addition to the populations examined in this study, the Australian species *Ozothamnus rogersianus* (Willis 1967: 158) Anderberg (1991: 89) and *O. alpinus* are most likely part of the same complex. Although their examination was outside the scope of this study, it would be desirable to re-visit their taxonomy in light of this revision.

Figure 7 plots the taxonomic identity of specimens in the HO collection at the completion of this study. Populations in the complex are distributed into neat and well-defined geographic areas, contrasting with the situation that was uncovered at the beginning of the project (Fig. 1). Unlike in previous treatments and revisions of the group (Bentham 1867; Rodway 1903; Morris & Willis 1942; Burbidge 1958; Curtis 1963), our use of a combination of morphological, ecological and genotyping analyses has enabled the resolution of the *O. ledifolius* complex into taxa with a high degree of confidence.

Taxonomic treatment

Key to the species in the Tasmanian *Ozothamnus ledifolius* complex

NOTE: There is some significant intraspecific variation in characters such as leaf size and floret number. It is therefore advisable to consider the descriptions as a whole when attempting to differentiate between taxa.

Key

1. Florets per capitulum 9 or more .... 2.
\- Florets per capitulum less than 8 .... 3.
2. Compact shrub, with corymbose branching habit. Leaves with bright yellow exudate. Habitat montane .... *O. ledifolius*
\- Erect columnar shrub, rarely compact. Leaves with colourless exudate. Habitat middle and low elevation dry woodland, or heathland and scrub near the coast .... *O. reflexus*
3. Leaves revolute almost to the midvein, ranked in distinct spiralling rows; adaxial surface with a moderate indumentum of crisped hairs; abaxial surface densely cottony with crisped hairs; exudate colourless. North-east highlands and Freycinet .... *O. buchananii*
\- Leaves almost flat or slightly recurved, not in distinct ranks; indumentum lanate, or slightly cottony, appressed; exudate pale greenish yellow. Central Plateau and southern Tasmania 4
4. Lamina 5–11 mm long, narrowed slightly at the base, widest near the apex; abaxial indumentum curly, cottony. Outer mountains and margins of the Central Plateau .... *O. purpurascens*
\- Lamina to 6 mm long, linear or oblong, not wider near apex; abaxial indumentum appressed, lanate, rarely curly. Plains area of Central Plateau, and Huon Valley .... 5.
5. Lamina 1.0–1.5 mm wide. Capitula 1.4–2.0 mm diameter. Montane habitats in the Central Plateau .... *O. ericifolius*
\- Lamina 0.6–0.9 mm wide. Capitula 1.1–1.6 mm diameter. Low elevation habitats in the Huon Valley .... *O. floribundus*

Ozothamnus ledifolius (A.Cunn. ex) Hooker (1856: 204)

Basionym:—*Cassinia ledifolia* A.Cunn. ex de Candolle (1838: 155). Type:—AUSTRALIA. Tasmania: “more elevated parts of mount Wellington near Hobart town, Van Diemen’s Land”, Jan 1819, *A . Cunningham 103*, (holotype G-DC G00461559 [photo!]).

≡ *Helichrysum ledifolium* (A.Cunn. ex DC.) Bentham (1867: 630).

≡ *Helichrysum rosmarinifolium* var. *ledifolium* (A.Cunn. ex DC.) Tovey & Morris (1922: 211).

Compact shrub to 1 m tall, with a corymbose branching habit. Younger stems and leaves covered in bright yellow exudate, sweetly aromatic, especially in warm weather; older stems with persistent leaf bases. Leaves crowded, petiolate, spreading, with older ones reflexed and often encrusted in black fungi; lamina linear to narrowly oblong, widest near the middle, (4.5–)5.5–11.0(–14.2) mm long, (1.0–)1.3–2.2(–2.9) mm wide; adaxial surface thinly to moderately lanate-tomentose, dark green with midrib slightly sunken; abaxial surface obscured by cottony indumentum, stained yellow by exudate in younger leaves with midrib raised, not glabrescent; base tapering slightly; margin entire, slightly recurved but abaxial lamina still visible; apex obtuse and rounded. Inflorescence a corymbose panicle, terminal, with yellow-stained tomentose branches; bracts scarious, ovate, stained dark yellow with margins fimbriate and apex apiculate. Involucre turbinate to campanulate, 5–7 mm long, (2.1–)2.5–3.1(–3.3) mm diameter, often suffused dark pink; outer involucral bracts with scarious margins, lightly tomentose, viscid with yellow exudate; inner involucral bracts 4.5–5 mm long, spathulate, with a long claw or petiole, and a spreading white lamina. Florets (8–)9–12(–14). Achenes papillose-pubescent; pappus barbellate, with ends somewhat clavate. Flowers Jan.–Feb.

Distribution and habitat:—Wellington Range, Mt. Field and the Snowy Range, found primarily at elevations above approximately 1000 m above sea level and exclusively on Jurassic dolerite-derived soils. North of Mt. Field, and particularly around the eastern and western margins of the Central Plateau, this taxon can intergrade with *O. ericifolius.* See discussion under *O. purpurascens*.

Remarks:—Recognised by its larger leaf size, more compact habit, and leaves with bright yellow exudate and abundant, appressed tomentose indumentum. It commonly has 9–12 florets per capitulum.

Selected specimens:—AUSTRALIA. Tasmania: Mount Wellington, 19 Jan 1902, *R. Helms s.n.* (NSW); Collins Bonnet, 14 Feb 1911, *L. Rodway s.n.* (HO); Mt. Wellington, 15 Jan 1915, *J.B. Cleland s.n.* (AD); Mount Wellington, 07 Feb 1922, *R.A. Black s.n.* (MEL); Mt. Wellington, 22 Jan 1928, *J.B. Cleland s.n.* (AD); Mt. Wellington side, 23 Jan 1928, *E.H. Ising s.n.* (AD); Mount Wellington, above springs, 12 Apr 1931, *[unknown] 4791* (NSW); Mt Wellington, 17 Jan 1932, *F.H. Long 1106* (HO); Mount Wellington, 17 Jan 1932, *O. Rodway s.n.* (HO); Pinnacle, Mount Wellington, 30 Jan 1937, *G.L.R. Davis & H.C.F. Davis s.n.* (NSW); Mount Wellington, 31 Jan 1937, *A.M. Olsen s.n.* (HO); Mt Wellington, 27 Feb 1942, *H.D. Gordon s.n.* (HO); Fern Tree track below Springs, Mount Wellington, 31 Mar 1945, *Gordon s.n.* (HO); Fern Tree, 07 Nov 1945, *Burnett s.n.* (HO); Mount Wellington, near turn off to Collins Bonnet Track, 08 Feb 1947, *J. Somerville s.n.* (HO); Mt Wellington, 19 Jan 1949, *N.T. Burbidge 3187* (CANB); Middle slopes of Mount Wellington, 19 Jan 1949, *N.T. Burbidge s.n.* (HO); Mt. Wellington, 02 Mar 1951, *E. Gauba TAS 412* (CBG); Mount Wellington, 25 Jan 1952, *W.M. Curtis s.n.* (HO); Mount Wellington, 25 Jan 1952, *W.M. Curtis s.n.* (HO); Foot of Mount Wellington, 10 Dec 1952, *R. Melville 2273* (MEL); Mount Wellington, 06 Dec 1959, *W.M. Curtis s.n.* (HO); Mount Wellington, near Hobart, 06 Dec 1959, *W.M. Curtis s.n.* (MEL); Mount Wellington, 28 Dec 1959, *W.A. Tobias s.n.* (HO); Mt. Wellington, on slopes, 09 Nov 1960, *M.E. Phillips 431* (CBG); *M.E. Phillips s.n.* (CBG); Mt. Wellington, at summit, 16 Jan 1962, *M.E. Phillips s.n.* (CBG); Mount Wellington, 24 Jan 1962, *D.V. Curtis s.n.* (MEL); Mt. Wellington, Hobart, 03 Jan 1963, *P.J. Darbyshire 1070* (CANB); Mt. Wellington, at junction of road & dolerite sill, 28 Nov 1965, *M.E. Phillips s.n.* (CBG); Mt Wellington plateau, 27 Jan 1968, *J.H. Hemsley 6518* (HO); Mt. Field National Park (Lake Belcher track), 02 Feb 1969, *E.M. Canning 2254* (CBG); Mt Field East, 10 Jan 1978, *J.M.B. Smith 378* (HO); K Col, Mt Field National Park, 19 Jan 1979, *A.M. Buchanan 12* (HO); Mt Wellington, 14 Jun 1980, *I. Boyer s.n.* (HO); Mount Wellington, 14 Jun 1980, *I. Boyer s.n.* (HO); The Lectern, Mount Wellington, 13 Jan 1981, *A. Brown 95* (HO); Collins Cap Track near Big Bend. Mount Wellington, 13 Jan 1981, *A. Brown 116* (MEL); Mt Wellington, 31 Dec 1982, *C. Totterdell s.n.* (CANB); Mt Wellington road, 1 km uphill from The Springs, 26 Nov 1988, *R. Burns 69* (CBG); Mt Wellington, 02 Dec 1988, *R.W. Purdie 3553* (CBG); Mt. Wellington, 9 km NNW along Pinnacle Road from junction with Huon Highway, 12 Jan 1989, *F.E. Davies & P. Ollerenshaw 759* (AD); Mount Field National Park. Rocky slope between Clemes Tarn and Naturalist Peak, 15 Feb 1989, *P.S. Short 3433* (MEL); 2km ENE of Nevada Peak, 24 Feb 1990, *P.A. Collier 4582* (HO); Mt Wellington, near Big Bend, start of Collin Gap track, 28 Dec 1995, *C.F. Puttock 101* (CANB); Mt Wellington, near Big Bend, 0.4 km along Collin Gap track, 28 Dec 1995, *C.F. Puttock 103* (CANB); *C.F. Puttock 104* (CANB); Between The Springs and Chalet, Mt Wellington, 28 Dec 1995, *C.F. Puttock 105* (CANB); Dead Island, Mt Wellington, 07 May 1996, *A.M. Buchanan 14151* (HO); Old cable tower near Maydena, 20 Dec 1999, *B. French BF388* (HO); Summit of Mt Wellington, 5km W of Hobart. In and around summit viewing area, 20 Jan 2000, *R.J. Bayer 11* (HO); Dead Island, Mt Wellington, 06 Feb 2000, *A.C. Rozefelds 1622* (HO); Rocking Stone Track, Mt Wellington (Wellington Park), 19 Apr 2007, *M. Visoiu 330* (HO); Mount Wellington, 05 Mar 2012, *A.N. Schmidt-Lebuhn 1369* (CANB); Mt Wellington, 09 Jan 2014, *M.F. de Salas 466* (HO); *M.F. de Salas 467* (HO); *M.F. de Salas 468* (HO); *M.F. de Salas 469* (HO); *M.F. de Salas 470* (HO); *M.F. de Salas 471* (HO); *M.F. de Salas 472* (HO); *M.F. de Salas 473* (HO); *M.F. de Salas 474* (HO); *M.F. de Salas 475* (HO); Mount Wellington, 1 Jan 1893, *R.C. Gunn s.n.* (HO); Mount Wellington, 7 Jan 1841, *[unknown] s.n.* (NSW); Near Fern Tree Inn, Huon Road, 31 Dec 1877, *A. Simson 839* (HO); Top [of] Mount Wellington, 2 Jan 1888, *W.A. Weymouth 20* (MEL); Mount Wellington, 31 Dec 1890, *E. Oakden 213* (MEL); Waterworks, Hobart, s.d., *[unknown] 4781* (NSW); Mount Wellington, s.d., *R.A. Black s.n.* (MEL); Mount Wellington, s.d., *E. Cheel s.n.* (NSW); Mount Wellington, s.d., *A. Cunningham s.n.* (MEL); Mt Field East, Jan 1944, *W.M. Curtis s.n.* (HO); Mount Wellington, Oct 1934, *W.M. Curtis s.n.* (HO); Mt Wellington, above springs, s.d., *W.M. Curtis s.n.* (HO); Mt. Wellington, above "The Springs", s.d., *W.M. Curtis? s.n.* (CBG); Seagers Lookout, Mount Field, s.d., *A.J. Ewart s.n.* (MEL); Mount Wellington, s.d., *W. V. Fitzgerald s.n.* (NSW); Mt Wellington, near summit, s.d., *A.M. Gray s.n.* (CANB); Mount Wellington, s.d., *T.A. Gulliver & B. Gulliver 30* (MEL); Mount Wellington, s.d., *V. Jacobs 73* (MEL); *V. Jacobs 75* (MEL); Wombat Moor, Mt Field National Park, s.d., *G. Kantvilas s.n.* (HO); Mount Wellington, s.d., *A. H.S. Lucas s.n.* (NSW); Mount Field East, s.d., *J.H. Maiden* *s.n.* (NSW); Mount Wellington, s.d., *J.H. Maiden s.n.* (NSW); Mount Wellington, s.d., *J.H. Maiden & R.H. Cambage s.n.* (NSW); Mt. Wellington, s.d., *C.F. Puttock 9* (CANB); Springs, Mt Wellington, s.d., *L. Rodway 403* (HO); Mount Wellington, s.d., *L. Rodway s.n.* (HO); Mount Wellington, s.d., *H.M.R. Rupp s.n.* (MEL); Top of Mount Wellington, s.d., *A. Simson s.n.* (MEL); Mount Wellington, s.d., *C. Stuart s.n.* (MEL); Mount Wellington, s.d., *Sullivan & Coates s.n.* (MEL); Mount Wellington, Jan 1981, *G.C. Wade s.n.* (HO); Mt Wellington, s.d., *J.B. Williams s.n.* (NE); Huon Road, May 1894, *L. Rodway s.n.* (HO); Huon Road, 1879, *L. Rodway s.n.* (HO).

Ozothamnus purpurascens de Candolle (1838: 165).

Type:—AUSTRALIA. Tasmania: "Western tier of mountains" [Great Western Tiers] *R.C.Gunn 281* (holotype: G-DC G00461399 [photo!]). See discussion for more information on its geographic origin.

≡ *Helichrysum ledifolium* subsp. *purpurascens* (DC.) Burbidge (1958: 270).

≡ *Helichrysum purpurascens* (DC.) Curtis (1963: 334).

Columnar to compact shrub to 1.5 m tall, with a corymbose branching habit. Stems and leaves covered in pale yellowish-green exudate, sometimes sweetly aromatic; older stems with persistent leaf bases; leaf density variable, moderately crowded. Leaves narrowed somewhat at the base, spreading, with older ones reflexed and often blackened; lamina linear to oblanceolate, widest near the apex, (3.9–)4.8–10.9(–13.1) mm long, (0.8–)0.9–1.7(–2.3) mm wide; adaxial surface mid-green, moderately lanate-tomentose, the tomentum obscured by greenish exudate in younger leaves, midrib sunken; abaxial surface densely cottony, often stained pale yellowish-green by resinous exudate with midrib darker, glabrescent; base tapering slightly in the wider-leaved forms only; margin entire, almost flat to slightly recurved, with abaxial lamina clearly visible; apex obtuse, rounded. Inflorescence a corymbose panicle, terminal, with branches tomentose, often stained yellowish-green; bracts ovate, resinous, tomentose, with margins laciniate and apex acute. Involucre variable, narrowly cylindrical to narrowly conical or campanulate, 4–5 mm long, (1.2–)1.5–2.3(–2.6) mm diameter, often suffused with pink; outer involucral bracts with scarious margins, lightly tomentose, viscid with pale yellowish-green exudate; inner involucral bracts 4–5 mm long, spathulate, with a long claw or petiole, and a spreading white lamina. Florets (4–)5–8(–9). Achenes papillose-pubescent; pappus barbellate, with ends somewhat clavate. Flowers Jan.–Feb.

Distribution and habitat:—On Jurassic dolerite along the northern and eastern escarpment of the Central Plateau of Tasmania, occasionally also along the western margin. Populations are also known from Triassic sandstone horizons below the dolerite boundary but these usually contain abundant dolerite talus.

Remarks:—Some *Ozothamnus purpurascens* populations intergrade with *O. ericifolius*, for example Moscal 689, and some specimens can be difficult to identify. While *O. purpurascens* groups with *O. ericifolius* consistently in analyses of genetic data, its type form is morphologically similar to *O. ledifolius*, from which it can be distinguished by its relatively flat leaves that have a pale yellowish-green exudate (rather than yellow) and a lower floret number per capitulum. We consider *O. purpurascens* to be of hybrid origin, with parentage likely to include *O. ericifolius* and *O. ledifolius*. Its modern distribution and morphology may represent historical introgression of the latter along the margins of the Plateau. The name *Ozothamnus purpurascens* DC. and the majority of its combinations have been consistently misapplied to south-eastern Tasmanian *O. reflexus* which is both genetically and morphologically distinct.

Selected specimens:—AUSTRALIA. Tasmania: Liffey Crossing, Projection Bluff, 20 Jan 1960, *T.E. Burns 292* (HO); Liffey Crossing, Projection Bluff, 20 Jan 1960, *T.E. Burns s.n.* (CBG); 4-1/2 miles [7 km] from Cradle Mt., at Pencil Pine River, 13 Nov 1965, *M.E. Phillips TAS 178* (CBG); 5 miles [8 km] from Poatina on Western Tier, 06 Dec 1965, *M.E. Phillips s.n.* (CBG); Poatina - Great Lake Road, 04 Jan 1966, *T.E. Burns 646* (HO); Sandstone escarpment above Poatina, 15 Jan 1969, *T.E. Burns 715* (HO); Top of Poatina, penstock pipeline, 01 Jan 1976, *A.V. Ratkowsky s.n.* (HO); Poatina Penstock pipeline, top, 01 Jan 1976, *D.A. Ratkowsky s.n.* (HO); Mt Victoria, 18 Apr 1980, *M.G. Noble 29243* (HO); Poatina Hill, at the last hair-pin bend, going up the road, 07 Jan 1981, *A.M. Buchanan 428* (HO); Flexmore Creek near Arthurs Lake, 16 Feb 1981, *A. Moscal 689* (HO); Billop Bluff. N of Arthurs Lake on Western Tiers, 16 Feb 1981, *A. Moscal 637* (HO); Drys Bluff, summit, 16 Feb 1981, *A. Moscal 667* (AD); Millers Bluff, Great Western Tiers, 20 Mar 1981, *A. Moscal 746* (HO); (Mount) Rufus Canal Road, 07 Dec 1982, *A. Moscal 1159* (MEL); Douglas Creek, Old Pelion Hut (copper mine), 25 Jan 1983, *A. Moscal 1485* (HO); Drys Bluff, 14 Dec 1984, *A.M. Buchanan 4992* (HO); Mt Young, in pine plantation, 19 Dec 1984, *W.F. Pataczek 700* (HO); Mt Albert, 13 Mar 1985, *M.J. Brown 851* (HO); 1 km W of Warners Track, 14 Feb 1986, *A. Moscal 12259* (HO); Quamby Bluff, upper N slope, 2 km SW of Golden Valley, 06 Mar 1986, *A. Moscal 12570* (HO); Nells Bluff, 14 Mar 1986, *A. Moscal 12730* (HO); Drys Bluff, 31 Mar 1986, *A. Moscal 12819* (HO); Western Tiers, Quamby Bluff, c. 1 km north-east of summit, 12 Feb

1989, *N.G. Walsh 2270* (CBG); Mount Blackwood, 22 Mar 1989, *A. Moscal 17358* (MEL); Millers Bluff, 27 Feb 1990, *A. Moscal 18931* (HO); Western Creek track, Western Tiers, 15km S of Mole Creek, 14 Jan 1991, *P.A. Collier 5139* (HO); Parson and Clerk Mtn, 29 Mar 1991, *P.A. Collier 5189* (HO); Pine Lake, 23 Jan 1993, *C.F. Puttock 27* (CANB); Poatina Road, 27 Jan 2014, *M.F. de Salas 520* (HO); *M.F. de Salas 521* (HO); *M.F. de Salas 524* (HO); *M.F. de Salas 526* (HO); *M.F. de Salas 527* (HO); *M.F. de Salas 528* (HO); Needles Station, s.d., *[unknown] 4784* (NSW); Western Mountains (Great Western Tiers, above Formosa), s.d., *R.W. Lawrence 290* (HO); Near Drys Bluff, May 1997, *H. Staubmann s.n.* (CANB).

Ozothamnus ericifolius Hook.f in Hooker (1847: 119).

Type:—AUSTRALIA. Tasmania: "Marlborough, 7ft high, 5.i.1841, *Gunn 1163/1842*" (holotype: K 000910492 [photo!]; isotype: BM 000603643 [photo!]).

≡ *Helichrysum pleurandroides* Mueller (1866: 200).

≡ *Ozothamnus rosmarinifolius* var. *ericifolius* Rodway (1903: 89).

≡ *Helichrysum ledifolium* subsp. *ericifolium* (Hook.f.) Burbidge (1958: 272).

≡ *Helichrysum ericeteum* Curtis (1963: 334) *nom. illeg.*, *nom. superfl.*

≡ *Ozothamnus ericeteus* (W.M.Curtis) Anderberg (1991: 89) *nom. illeg.*, *nom. superfl.*

Erect, floriferous columnar shrub to 2.5 m tall. Stems and branches tomentose, indumentum closely appressed and often stained greenish yellow by a resinous exudate, strongly, sweetly aromatic; older stems with rough bark, leaf bases inconspicuous. Leaves crowded, linear, spreading to reflexed, older ones strongly reflexed and often appressed to stem, rarely encrusted with black fungi; lamina linear to oblong, (1.7–)2.5–5.8(–6.9) mm long and (0.7–)1.0–1.5(–1.8) mm wide; adaxial surface moderately tomentose, mid-green with midrib sunken; abaxial surface with abundant pale indumentum and midrib darker; both surfaces resinous in younger leaves; base hardly or not narrowed; margins parallel, recurved, but density of abaxial tomentum making the leaves appear flat; apex obtuse, rounded. Inflorescence a corymbose panicle, terminal, soon overtopped by lateral branches arising from axillary buds; bracts ovate to lanceolate, with margins scarious, ciliate-fimbriate, and apex acute. Involucre narrowly cylindrical-conical, 4–5 mm long, (1.2–)1.4–2.0(–2.1) mm diameter, often suffused pink; outer involucral bracts tomentose, margins scarious, viscid; inner involucral bracts 4.5–5 mm long, spathulate, with a long claw or petiole, and a spreading white lamina. Florets (5–)6–8(–9), most commonly 6 or 7. Achenes papillose-pubescent; pappus barbellate, with ends somewhat clavate. Flowers Jan.–Feb.

Distribution and habitat:—On Jurassic dolerite and Tertiary basalt substrates on the Central Plateau of Tasmania, from the northern and eastern escarpments to approximately Lake St. Clair to Lake Augusta in the west, and the Dee Lagoon / Bronte Park area in the south.

Remarks:—Characterised by its very small leaf size, commonly having 6–8 florets per capitulum, and the yellowish-green exudate on its leaves. Towards the margins of the Plateau it gradually merges into *O. purpurascens*.

Selected specimens:—AUSTRALIA. Tasmania: 6 miles SW of Great Lake on Bronte Rd, 27 Jan 1949, *N.T. Burbidge 3418* (CANB); Near Great Lake, 08 Mar 1951, *E. Gauba TAS 542* (CBG); 10 miles [16 km] N. of Bronte Park, 24 Jan 1962, *M.E. Phillips 380* (CBG); Great Lake, between Miena & Bronte, 05 Dec 1965, *M.E. Phillips 1091* (CBG); Between Great Lake & Bronte, 15 Jan 1970, *W.M. Curtis s.n.* (HO); Arthurs Lake, 30 Dec 1973, *A.V. Ratkowsky & D.A. Ratkowsky 1066* (NSW); Great Lake, 18 Dec 1975, *A. Hewer s.n.* (HO); Near Dee Lagoon, 10 Jan 1976, *D.A. Ratkowsky s.n.* (HO); Near Lake Augusta, 20 Jan 1980, *G.C. Wade s.n.* (HO); Liawenee Canal Road, 19 Mar 1980, *I. Boyer s.n.* (HO); Monpeelyata Canal, near Ouse River, 08 Jan 1981, *A.M. Gray 539* (HO); Arthurs Lake, Brazendale Island, 16 Feb 1981, *A. Moscal 700* (HO); Little Pine Lagoon, N end, 06 Apr 1981, *A. Moscal 754* (HO); Monpeelyata Road, Rushcroft Creek, 20 Feb 1984, *A. Moscal 6308* (HO); River Ouse. Map: Shannon, 24 Feb 1984, *A. Moscal 6500* (CANB); Unnamed hill, 1.5 km S of Tea-tree Bay on Arthurs Lake, 27 Feb 1984, *A. Moscal 6537* (AD); Great Lake at Marlborough Highway, 08 Mar 1984, *D.I. Morris s.n.* (HO); Haddens Bay, Great Lake at G. Wades shack, 08 Mar 1984, *D.I. Morris & W.M. Curtis s.n.* (MEL); Marlborough Highway, S of Little Pine Lagoon, 02 Apr 1986, *R. Burns ANBG 628* (CBG); 2.2 km S of Interlaken along Dennistoun Road to Bothwell, 16 Jan 1989, *F.E. Davies 921* (CBG); Central Highlands region, 2.2 km S of Interlaken along Dennistoun road to Bothwell, 16 Jan 1989, *F.E. Davies & P. Ollerenshaw FED 921* (PERTH); in small quarry on road alongside Liawenee Canal, between Great Lake and Lake Augusta, 29 Jan 1990, *R. Burns 146* (CBG); Lake Highway 25.5km N of Bothwell, 08 Jan 1992, *A.M. Gray G756* (HO); Ouse River 1.5km downstream of Waddamana, 23 Mar 1994, *A.M. Buchanan 13703* (HO); Western end of Miena on Lake Highway, 02 Mar 1995, *P.C. Jobson 3424* (CANB); Sevenpound Bay, Arthurs Lakes, 06 Jun 1996, *A.M. Buchanan 14183* (HO); Tods Corner, Great Lake, 09 Dec 1997, *A.M. Buchanan 15008a* (HO); *A.M. Buchanan 15008b* (HO); Below Pine Tier Lagoon, 02 Feb 2000, *B. French BF450* (HO); Waddamana - Bothwell - Osterley intersection, 02 Feb 2007, *M. Visoiu 279* (HO); Transmission line easement at intersection of Waddamana Road and Bashan Road, 20 Feb 2009, *J. Wood 83* (HO); Skullbone Plains, Tasmanian Land Conservancy property, 27 Feb 2012, *A.N. Schmidt-Lebuhn 1282* (CANB); *A.N. Schmidt-Lebuhn 1326* (CANB); St Patricks Plains, 12 Jan 2014, *M.F. de Salas 476* (HO); *M.F. de Salas 477* (HO); *M.F. de Salas 478* (HO); *M.F. de Salas 479* (HO); Miena, 12 Jan 2014, *M.F. de Salas 481* (HO); *M.F. de Salas 482* (HO); *M.F. de Salas 483* (HO); *M.F. de Salas 484* (HO); *M.F. de Salas 485* (HO); Liawenee, 12 Jan 2014, *M.F. de Salas 486* (HO); *M.F. de Salas 491* (HO); *M.F. de Salas 492* (HO); Lake Augusta, 12 Jan 2014, *M.F. de Salas 489* (HO); *M.F. de Salas 490* (HO); Pine River, Marlborough, 7 Jan 1837, *R.C. Gunn 1163* (NSW); Great Lake, Feb 1894, *L. Rodway s.n.* (HO); Gr[eat] Lake, s.d., *A. Simson 2336* (MEL); Great Lake, s.d., *A. Simson s.n.* (HO); Great Lake, Feb 1982, *D. Wade s.n.* (HO).

Ozothamnus reflexus (N.T.Burb.) de Salas & Schmidt-Leb., *comb. & stat. nov*.

Type:—AUSTRALIA. Tasmania: "Sea cliffs at Remarkable Cove, 3 mile S. of Safety Cove, Tasman Peninsula", 18 Dec 1925, *R. Melville 2500*, (holotype: K; isotypes HO 27070!, P 00698478 [photo!])"

≡ *Helichrysum ledifolium* subsp. *reflexum* Burbidge (1958: 270).

≡ *Helichrysum ledifolium* subsp. *purpurascens* (DC.) Burbidge (1958: 270), *non O. purpurascens* DC.

≡ *Helichrysum purpurascens* (DC.) Curtis (1963: 334) *non Ozothamnus purpurascens* DC.

≡ *Ozothamnus purpurascens auct*. *non* DC.

Compact to erect, floriferous shrub to 2 m tall. Branching habit corymbose to columnar. Younger stems and leaves covered in colourless exudate, or exudate not evident, slightly aromatic; older stems with persistent leaf bases. Leaves crowded, petiolate, reflexed or sometimes spreading when young, not normally encrusted with black fungi; lamina linear to narrowly oblong to oblanceolate, widest near the apex, (2.5–)4.9–10.7(–18.1) mm long, (0.6–)0.9–1.7(–2.5) mm wide; adaxial surface moderately tomentose, dark green with midrib sunken; abaxial surface densely tomentose, including the midrib which is not or hardly glabrescent; both surfaces with exudate either not apparent or colourless; base tapering slightly; margins entire, recurved; apex obtuse, rounded. Inflorescence a corymbose panicle, terminal; bracts scarious, ovate, tomentose, apex acute. Involucre campanulate, 4–6 mm long, (1.5–)1.8–2.6(–2.9) mm diameter, normally suffused with pink (especially near the coast); outer involucral bracts with margins scarious, tomentose, viscid with colourless exudate; inner involucral bracts 4.5–5 mm long, spathulate, with a long claw, and a spreading white lamina. Florets (5–)8–12(–14), most commonly 10–12. Achenes papillose-pubescent; pappus barbellate, with ends somewhat clavate. Flowers Dec.–Jan.

Distribution and habitat:—On Permian mudstone and Triassic sandstone in South-eastern Tasmania, from sea level to middle elevations (approximately 500 m above sea level). The main populations are on the foothills of Mt Wellington, the Meehan Range, Rheban/Wielangta area and Tasman Peninsula.

Remarks:—Characterised by its longer leaf size (to 18 mm long), colourless exudate on the leaves, commonly having 8–12 florets per capitulum, and cottony-tomentose indumentum. The name *Ozothamnus purpurascens*, as well as its combinations under *Helichrysum*, have been consistently misapplied to this taxon by most authors. However, the type of *O. purpurascens* comes from montane shrubby woodland in the Great Western Tiers near Cressy (see discussion for details), whereas *O. reflexus* occurs in south-eastern Tasmania in coastal shrubland and low-elevation dry woodland. Two forms with distinct morphologies are present: a form with long, fine leaves from the Mt Wellington foothills and the Rheban / Wielangta area, and a form with shorter, broader, often highly reflexed leaves, which occurs mainly along the Meehan Range and Tasman Peninsula. However, a breakdown into two separate genetic groups is not supported by the genotyping analysis, which shows that the Rheban populations are more closely related to the Tasman Peninsula ones, and that the Meehan Range and South Hobart populations are genetically distinct.

Selected specimens—AUSTRALIA. Tasmania: Huon Road, 30 Nov 1901, *F.A. Rodway 4783* (NSW); Huon Road [Lat/Long for Port Huon], 18 Dec 1902, *L. Rodway s.n.* (MEL); Near Redgate [Red Gate], 24 Nov 1913, *R.A. Black s.n.* (MEL); Lindisfarne, 22 Nov 1936, *A.M. Olsen s.n.* (HO); Huon Road, Hobart, 01 Nov 1937, *H.D. Gordon s.n.* (HO); Strickland Avenue, Hobart, 20 Nov 1937, *A.M. Olsen s.n.* (HO); Bellerive, summit of Tunnel Hill on main road, 20 Nov 1942, *H.D. Gordon s.n.* (HO); Eaglehawk Neck, 18 Dec 1942, *W.M. Curtis s.n.* (HO); Keens Curry Hill, Hobart, 27 Oct 1945, *J. Somerville s.n.* (HO); Safety Cove, Tasman Peninsula, 28 Apr 1946, *C. Elliott s.n.* (HO); Collinsvale, 28 Oct 1948, *J. Somerville s.n.* (HO); Remarkable Cave, Tasman Peninsula, 08 Nov 1951, *W.M. Curtis s.n.* (HO); Near Bellerive, 29 Nov 1951, *A. Ashby s.n.* (HO); Remarkable Cave, S coast of Tasman Peninsula, S of Safety Cove, 18 Dec 1952, *R. Melville 2500* (HO); Huon Road, at Turnip Fields, 25 Dec 1952, *W.M. Curtis s.n.* (HO); [unknown] s.n. (HO); Near Boomer, 24 Nov 1959, *W.M. Curtis s.n.* (HO); Huon Road between Hobart and Fern Tree, 06 Dec 1959, *W.M. Curtis s.n.* (HO); Huon Road between Hobart and Fern Tree, 06 Dec 1959, *W.M. Curtis s.n.* (MEL); Near Copping, 12 Nov 1960, *M. E. Phillips s.n.* (NSW); Near Copping, on highway, 12 Nov 1960, *M.E. Phillips s.n.* (CBG); *M.E. Phillips s.n.* (CBG); Huon Road, Hobart, 31 Dec 1961, *T.E. Burns 483* (HO); Track to Remarkable Cave, 03 Feb 1962, *M.E. Phillips s.n.* (CBG); Mornington. Bellerive, 18 Jun 1969, *W.M. Curtis s.n.* (HO); Mornington. Bellerive, 18 Jun 1969, *W.M. Curtis s.n.* (MEL); Hobart area, 22 Jan 1973, *D.A. Ratkowsky 38* (CBG); Mount Faulkner, 22 Dec 1973, *D.A. Ratkowsky & A.V. Ratkowsky 1039* (NSW); Huon Road, Turnip Fields, 07 Jan 1974, *W.M. Curtis s.n.* (HO); Hutchins School, Churchill Avenue, Sandy Bay, Hobart, 05 Jan 1975, *D.A. Ratkowsky s.n.* (HO); Warrane Hills, 12 Oct 1975, *M. Allan s.n.* (HO); Wielangata, S of Rheban, 04 Jan 1976, *M. Allan s.n.* (HO); Ridgeway Reservoir, 07 Jan 1976, *D.A. Ratkowsky s.n.* (HO); Standup Point, N of West Arthur Head, Tasman Peninsula, 14 Sep 1980, *W.D. Jackson s.n.* (HO); West Arthur Head, S of Port Arthur, 19 Sep 1980, *I. Boyer s.n.* (HO); Standup Point, Tasman Peninsula, 07 Dec 1980, *I. Boyer s.n.* (HO); Crescent Bay, S of Safety Cove, 18 Dec 1980, *A.E. Orchard 5174* (NSW); Pass Road, Rokeby Hills, 14 Dec 1982, *A.M. Buchanan 1004* (HO); Near Maingon Blowhole. Map: Storm Bay, 04 Dec 1983, *A. Moscal 4618* (CANB); Wielangta, 22 Nov 1984, *M.J. Brown 473* (HO); Fitzgeralds Road (Between Mornington and Cambridge), 23 Nov 1984, *A.M. Buchanan 4537* (HO); Crescent Bay, S of Port Arthur, 05 Oct 1986, *P.A. Collier 1718* (HO); Mt Faulkner, 12 Jan 1988, *A. Moscal 15431* (HO); Remarkable Cave, 04 Apr 1988, *R. Burns 20* (CBG); Above Remarkable Cave, 4.5 km directly S of Port Arthur, 26 Jan 1989, F.E. Davies, *P. Ollerenshaw & R. Burns FED 1281* (PERTH); Chestermans Sugarloaf on Wielangta Road, S of Orford, 26 May 1990, *R. Burns 153* (CBG); Howrah, 05 Nov 1995, *D. Ziegeler 148* (HO); Arthur Highway at Boomer Road turnoff, 27 Dec 1995, *A.M. Buchanan 14043* (CANB); Near Remarkable Cave, 27 Dec 1995, *A.M. Buchanan 14045* (HO); Huon Road, behind HCC Mountain Park depot, 29 Dec 1995, *A.M. Buchanan 14050* (CANB); Tunnell Hill, Hobart, 29 Dec 1995, *C.F. Puttock 107* (CANB); Standup Point, 30 Dec 1995, *C.F. Puttock 109* (CANB); Huon Road, behind HCC Mountain Park depot, 29 Jan 1996, *C.F. Puttock s.n.* (HO); Tunnel Hill, 26 Nov 1996, *A.M. Buchanan 14341* (HO); Cape Raoul, above the columns, 19 Nov 2003, *A.M. Buchanan 16080* (HO); Wielangta Road, 15km S of Orford, 25 Nov 2004, *A.M. Buchanan 16271* (HO); Huon Road, 100m S of Hobart City Council Depot, 14 Nov 2006, *S. Yalakowski s.n.* (HO); Tasman Island, near quarters 3, 23 Sep 2007, *P.A. Tyson 435* (HO); Tasman Island, W-facing cliff tops, 28 Sep 2007, *P.A. Tyson 562* (HO); One bay S of Remarkable Cave, 31 Jan 2008, *M. Visoiu 439* (HO); Sandspit Forest Reserve, 03 Mar 2012, *A.N. Schmidt-Lebuhn 1357* (CANB); Mornington, 09 Dec 2013, *M.F. de Salas 432* (HO); *M.F. de Salas 433* (HO); Meehan Range NRA, 09 Dec 2013, *M.F. de Salas 434* (HO); *M.F. de Salas 435* (HO); Mt. Rumney, 09 Dec 2013, *M.F. de Salas 436* (HO); South Hobart, 11 Dec 2013, *M.F. de Salas 437* (HO); *M.F. de Salas 438* (HO); *M.F. de Salas 439* (HO); *M.F. de Salas 440* (HO); *M.F. de Salas 441* (HO); Remarkable Cave, 17 Dec 2013, *M.F. de Salas 449* (HO); *M.F. de Salas 450* (HO); *M.F. de Salas 451* (HO); Rheban, 17 Dec 2013, *M.F. de Salas 453* (HO); *M.F. de Salas 454* (HO); *M.F. de Salas 455* (HO); Fern Tree, 21 Dec 2013, *M.F. de Salas 459* (HO); *M.F. de Salas 460* (HO); Mornington, 14 Jan 2014, *M.F. de Salas 495* (HO); *M.F. de Salas 496* (HO); *M.F. de Salas 497* (HO); *M.F. de Salas 498* (HO); *M.F. de Salas 499* (HO); Remarkable Cave, 15 Jan 2014, *M.F. de Salas 500* (HO); *M.F. de Salas 501* (HO); *M.F. de Salas 502* (HO); *M.F. de Salas 503* (HO); *M.F. de Salas 504* (HO); Rheban, 15 Jan 2014, *M.F. de Salas 505* (HO); *M.F. de Salas 506* (HO); *M.F. de Salas 507* (HO); *M.F. de Salas 508* (HO); *M.F. de Salas 509* (HO); Lime Bay area, Tasman Peninsula, Dec 1962, *[unknown] s.n.* (HO); Port Arthur, s.d., *J. Bufton 5* (MEL); *J. Bufton 11* (MEL); *J. Bufton 14* (MEL); *J. Bufton 42* (MEL); Bellerive, Jan 1946, *W.M. Curtis s.n.* (HO); Huon Road, at Turnip Fields, s.d., *W.M. Curtis s.n.* (HO); Huon Road, at Turnip Fields, s.d., *W.M. Curtis s.n.* (HO); Huon Road, Fern Tree Bus Terminal, s.d., *W.M. Curtis s.n.* (HO); Longley, Nov 1929, *A.V. Giblin s.n.* (CANB); Mount Nelson Road, s.d., *A.V. Giblin s.n.* (HO); Longley, s.d., *A.V. Giblin s.n.* (HO); Cape Raoul, Nov 1979, *G. Kantvilas s.n.* (HO); Huon road on road to Mt. Wellington, s.d., *C.E. Lord s.n.* (CANB); Bellerive, Hobart, s.d., *A.H.S. Lucas s.n.* (NSW); Hobart, s.d., *A.H.S. Lucas s.n.* (NSW); Waterworks, Hobart, s.d., *F.A. Rodway 4780* (NSW); Mount Nelson, s.d., *F.A. Rodway* 4782 (NSW); Mt Wellington, s.d., *L. Rodway 404* (HO); Huon Road, Hobart, s.d., *L. Rodway 404a* (HO); Bellerive, Jan 1912, *L. Rodway s.n.* (HO); Cascades, Hobart, s.d., *L. Rodway s.n.* (HO); Safety Cove, Dec 1961, *J. Somerville s.n.* (HO); Half Moon Bay (Crescent Bay), near Mt Brown, Tasman Peninsula (site D5), Dec 1961, *Tasmanian University Sci. Soc., s.n.* (HO); Cascades, slope of Mount Wellington, 20 Jan 1920, *R.A. Black s.n.* (MEL).

Ozothamnus buchananii Puttock ex de Salas & Schmidt-Leb., *spec. nov*.

Type:—AUSTRALIA. Tasmania: Tower Hill. Forestry road, approximately 250 m north of Cox Road and 2.3 km northeast of Tower Hill Road intersection, 14 Dec 2013, *M.F. de Salas 446* (holotype: HO 574754; isotypes: CANB, K, PERTH).

Erect, columnar shrub, rarely compact with corymbose branching habit, to 1.5 m tall. Young stems and leaves hoary, with indumentum of crisped hairs, exudate colourless, not or hardly aromatic; older stems with cracked bark, leaf bases not persistent. Leaves somewhat crowded, arranged in spiralling ranks, antrorse to spreading; lamina linear-lanceolate, widest at the base, coriaceous, (2.6–)4.0–8.1(–11.1) mm long, (0.8–)1.0–1.6(–2.5) mm wide; adaxial surface mid to dark green, with midrib slightly sunken; abaxial surface densely cottony with midrib hardly glabrescent; both surfaces with crisped hairs; margins revolute almost to the midrib, giving the lamina a terete appearance; apex obtuse, rounded. Inflorescence a corymbose panicle, terminal; bracts lanceolate, with scarious, acute apex. Involucre conical to narrowly cylindrical, 4–5.5 mm long, (1.2–)1.4–2.0 mm diameter, often suffused with pink; outer involucral bracts with scarious margins, lightly tomentose, slightly viscid with colourless exudate; inner involucral bracts 4.5–5 mm long, spathulate, with a long claw, and a spreading white lamina. Florets (5–)6–7(–10). Achenes papillose-pubescent; pappus barbellate, with ends somewhat clavate. Flowering Dec.–Feb.

Distribution and habitat:—North-eastern Tasmania, Ben Lomond, Tower Hill, Snow Hill and St. Pauls Dome. Occurring on both Jurassic dolerite at high elevation and Silurian–Devonian sandstones and slates at middle elevations, from 500 to 1400 m above sea level.

Remarks:—Characterised by its revolute, almost terete leaves that are broadest near the base, its cinerascent appearance (from its abundant, curly indumentum), its colourless exudate and by typically having 6–7 florets per capitulum.

Etymology:—The epithet honours Alex Buchanan, former curator of Botany (1983–2009) at the Tasmanian Herbarium.

Selected specimens:—AUSTRALIA. Tasmania: On top of Mount Freycinet, Freycinet Peninsula, 27 Jan 1967, *I. Olsen 139* (NSW); Tower Hill [Plantation], 14 Dec 1970, *W.F. Pataczek s.n.* (HO); Snow Hill, summit, 30 Oct 1992, *F. Duncan s.n.* (HO); Knuckle Track, Ben Lomond, near bluffs, 25 May 1997, *A.M. Buchanan 14680* (HO); Tower Hill, 14 Dec 2013, *M.F. de Salas 442* (HO); *M.F. de Salas 443* (HO); *M.F. de Salas 444* (HO); *M.F. de Salas 445* (HO); *M.F. de Salas 446* (HO); *M.F. de Salas 447* (HO); Snow Hill, 23 Jan 2014, *M.F. de Salas 510* (HO); *M.F. de Salas 511* (HO); *M.F. de Salas 512* (HO); *M.F. de Salas 513* (HO); *M.F. de Salas 514* (HO); Tower Hill, 24 Jan 2014, *M.F. de Salas 516* (HO); *M.F. de Salas 517* (HO).

Ozothamnus floribundus de Salas & Schmidt-Leb., *spec. nov.*

Type:—AUSTRALIA. Tasmania: Merchants Hill. Channel Highway, approximately 250 m ENE of intersection with Randalls Bay Road, 8 Jan 2014, *M.F. de Salas 461* (holotype: HO 575836; isotype: CANB).

Erect, slender columnar, highly floriferous shrub to 1 m tall. Younger stems and leaves viscid with a pale yellow exudate, slightly sweetly aromatic; older stems with slightly raised, persistent leaf bases. Leaves loosely crowded, spreading, soon reflexed; lamina linear, (3.2–)3.7–6.3(–8.6) mm long, (0.5–)0.6–0.9(–1.1) mm wide; adaxial surface slightly lanate, with indumentum evident mostly on older leaves, once the exudate is lost, bright green with midrib sunken; abaxial surface cottony; midrib darker, glabrescent; margins slightly recurved; apex acute to obtuse, rounded. Inflorescence a corymbose panicle, terminal; bracts scarious, ovate to lanceolate, viscid, slightly tomentose with margins fimbriate and apex apiculate. Involucre cylindrical, 4–5 mm long, 1.1–1.6(–1.7) mm diameter, not suffused with pink; outer involucral bracts with scarious margins, slightly tomentose, viscid with pale yellow exudate; inner involucral bracts 4.5–5 mm long, spathulate, with a long claw, and a spreading white lamina. Florets 4–5(–6). Achenes papillose-pubescent; pappus barbellate, with ends somewhat clavate. Flowers Dec.–Jan.

Distribution and habitat:—Known from a single, isolated population on Triassic sandstone at approximately 150 m above sea level in the Huon Valley, near Randalls Bay.

Remarks:—Characterised by its delicate, narrow, short, flat leaves, appressed woolly indumentum, yellowish-green exudate, and low floret number (typically 4–5 per capitulum).

Etymology:—Named *floribundus* after the highly floriferous nature of this taxon, which can be covered in inflorescences so profusely that it's difficult to see the foliage underneath.

Selected specimens:—AUSTRALIA. Tasmania, Road to Cygnet turnoff to Randalls Bay, 02 Jan 1974, *M.P. Cameron s.n.* (HO); Between Gardners Bay & Garden Island Creek, 28 Dec 1995, *A.M. Buchanan 14049* (HO); Merchants Hill, 08 Jan 2014, *M.F. de Salas 461* (HO); *M.F. de Salas 462* (HO); *M.F. de Salas 463* (HO); *M.F. de Salas 464* (HO); *M.F. de Salas 465* (HO).

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