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Volume 31 (2017/18)

Contents

| | |
|--|-----|
| <i>Leptecophylla</i> in Tasmania: a reassessment of four species <i>S.J. Jarman & G. Kantvilas</i> | 1 |
| A new species of small black disc fungi, <i>Smardaea australis</i> (Pezizales, Pyronemataceae), is described from Australia <i>P.S. Catcheside, S. Qaraghuli & D.E.A. Catcheside</i> | 17 |
| <i>Tephromela baudiniana</i> sp. nov. (lichenised Ascomycetes) from Kangaroo Island <i>G. Kantvilas & J.A. Elix</i> | 27 |
| Two species of <i>Bacidia</i> De Not. with pruinose apothecia from Kangaroo Island <i>G. Kantvilas</i> | 31 |
| <i>Goodenia asteriscus</i> (Goodeniaceae), a new arid zone species from north-western South Australia and eastern Western Australia <i>P.J. Lang & R.J.-P. Davies</i> | 37 |
| <i>Pertusaria crassilabra</i> Müll. Arg. – a reinstated name for an Australasian lichen <i>G. Kantvilas</i> | 45 |
| The type of Sturt pea found <i>A.S. George</i> | 49 |
| <i>Micarea kartana</i> sp. nov. (lichenised Ascomycetes) from Kangaroo Island, South Australia <i>G. Kantvilas</i> | 55 |
| Notes on the taxonomy of Australian <i>Lindernia</i> subg. <i>Didymadenia</i> (Linderniaceae) <i>W.R. Barker</i> | 59 |
| <i>Antrelloides atroceraea</i> , a new genus and species in the Pezizaceae (Pezizales) from Australia <i>P.S. Catcheside & D.E.A. Catcheside</i> | 81 |
| The <i>Ptilotus murrayi</i> species group: synonymisation of <i>P. petiolatus</i> under <i>P. murrayi</i> and description of the new Western Australian species <i>P. unguiculatus</i> (Amaranthaceae) <i>T.A. Hammer</i> | 93 |
| CORRIGENDUM to: A new species of small black disc fungi, <i>Smardaea australis</i> (Pezizales, Pyronemataceae), is described from Australia <i>P.S. Catcheside & D.E.A. Catcheside</i> | 101 |

New taxa, names and combinations

Swainsona 31 (2017/18)

| | | |
|---|------------------------|----|
| <i>Antrelloides</i> P.S.Catches. & D.E.A.Catches. | 28 Sep. 2018 | 82 |
| <i>Antrelloides atroceraea</i> P.S.Catches. & D.E.A.Catches. | 28 Sep. 2018 | 82 |
| <i>Bacidia brigitteae</i> Kantvilas | 15 June 2017 | 34 |
| <i>Goodenia asteriscus</i> P.J.Lang | 24 Nov. 2017 | 37 |
| <i>Leptecophylla oxycedrus</i> (Labill.) Jarman | 15 June 2017 | 1 |
| <i>Leptecophylla parvifolia</i> (R.Br.) Jarman | 15 June 2017 | 7 |
| <i>Lindernia</i> subg. <i>Didymadenia</i> W.R.Barker | 2 May 2018 | 61 |
| <i>Lindernia</i> sect. <i>Didymadenia</i> (W.R.Barker) W.R.Barker | 2 May 2018 | 64 |
| <i>Lindernia</i> sect. <i>Hemiarrhena</i> (Benth.) W.R.Barker | 2 May 2018 | 71 |
| <i>Lindernia</i> sect. <i>Heterandrae</i> W.R.Barker | 2 May 2018 | 70 |
| <i>Lindernia</i> sect. <i>Prolatae</i> W.R.Barker | 2 May 2018 | 61 |
| <i>Lindernia</i> sect. <i>Scapigerae</i> W.R.Barker | 2 May 2018 | 67 |
| <i>Lindernia acrandra</i> W.R.Barker | 2 May 2018 | 77 |
| <i>Lindernia atrata</i> W.R.Barker | 2 May 2018 | 62 |
| <i>Lindernia brennanii</i> W.R.Barker | 2 May 2018 | 74 |
| <i>Lindernia calliandra</i> W.R.Barker | 2 May 2018 | 78 |
| <i>Lindernia cyanoplectra</i> W.R.Barker | 2 May 2018 | 63 |
| <i>Lindernia dierythra</i> W.R.Barker | 2 May 2018 | 63 |
| <i>Lindernia dunlopii</i> W.R.Barker | 2 May 2018 | 74 |
| <i>Lindernia enypniastina</i> W.R.Barker | 2 May 2018 | 77 |
| <i>Lindernia leucochroa</i> W.R.Barker | 2 May 2018 | 69 |
| <i>Lindernia lucrusmiana</i> W.R.Barker | 2 May 2018 | 76 |
| <i>Lindernia mitrasacmoides</i> (O.Schwarz) W.R.Barker | 2 May 2018 | 71 |
| <i>Lindernia murfetiana</i> W.R.Barker | 2 May 2018 | 63 |
| <i>Lindernia petrensis</i> W.R.Barker | 2 May 2018 | 65 |
| <i>Lindernia porphyrodinea</i> W.R.Barker & M.D.Barrett | 2 May 2018 | 67 |
| <i>Lindernia prolata</i> W.R.Barker | 2 May 2018 | 62 |
| <i>Lindernia pronanthera</i> W.R.Barker | 2 May 2018 | 77 |
| <i>Lindernia pustulosa</i> W.R.Barker | 2 May 2018 | 72 |
| <i>Lindernia robyniae</i> W.R.Barker | 2 May 2018 | 78 |
| <i>Lindernia scopularis</i> W.R.Barker | 2 May 2018 | 65 |
| <i>Lindernia scutellata</i> W.R.Barker | 2 May 2018 | 71 |
| <i>Lindernia thyridostoma</i> W.R.Barker | 2 May 2018 | 70 |
| <i>Lindernia tiwiensis</i> W.R.Barker | 2 May 2018 | 68 |
| <i>Lindernia venustula</i> W.R.Barker | 2 May 2018 | 76 |
| <i>Micarea kartana</i> Kantvilas & Coppins | 11 Apr. 2018 | 56 |
| <i>Ptilotus unguiculatus</i> T.Hammer | 28 Sep. 2018 | 96 |
| <i>Smardaea australis</i> P.S.Catches. & D.E.A.Catches. | 15 June 2017 | 19 |
| <i>Tephromela baudiniana</i> Kantvilas & Elix | 15 June 2017 | 28 |

The online publication date is indicated before the page number.



Leptecophylla in Tasmania: a reassessment of four species

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Abstract: The occurrence of *Leptecophylla juniperina* (J.R.Forst. & G.Forst.) C.M.Weiller in Tasmania is reviewed. Two subspecies of this taxon are re-instated to specific rank: *L. oxycedrus* (Labill.) Jarman *comb. nov.* and *L. parvifolia* (R.Br.) Jarman *comb. nov.* *Leptecophylla juniperina* itself is excluded from the Tasmanian flora. Tasmanian plants previously identified as *L. juniperina* are mostly either *L. oxycedrus* or the newly described *L. pogonocalyx* subsp. *decipiens* Jarman *subsp. nov.* An identification key is provided for Tasmanian species of *Leptecophylla*.

Keywords: *Leptecophylla*, taxonomy, change of status, new subspecies, Tasmania

Introduction

The genus *Leptecophylla* was first described by Weiller (1999) for a group of 12 closely related species formerly included in *Cyathodes* Labill. or *Styphelia* Sm. in the Epacridaceae, a family which has since been submerged in the Ericaceae (Kron *et al.* 2002). The transfer of these species to the new genus serves to highlight the close affinities within the group and is widely accepted by botanists. However, within *Leptecophylla*, relationships among several taxa are more problematic. This present study focusses on the taxa included in Weiller's (1999) study as *L. juniperina* subsp. *juniperina*, *L. juniperina* subsp. *oxycedrus*, *L. juniperina* subsp. *parvifolia* and *L. pogonocalyx*. Our treatment proposes major nomenclatural changes, with the reinstatement to specific rank of both of the subspecies *oxycedrus* and *parvifolia*, the exclusion of *L. juniperina* from the Tasmanian flora, and the description of a new subspecies of *L. pogonocalyx*. A detailed discussion of the evidence supporting these changes is provided.

Materials

Taxonomic interpretation of all Tasmanian species was based primarily on fresh material, although the large collection of *Leptecophylla* specimens at the Tasmanian Herbarium (HO; over 800 sheets) was also consulted extensively. The New Zealand species, *L. juniperina*, was examined only as dried specimens held at HO or on loan from the National Herbarium of Victoria (MEL), Auckland Museum Herbarium (AK), Allan Herbarium, Landcare Research Manaaki Whenua, Lincoln (CHR), Museum of New Zealand Te Papa Tongarewa Herbarium, Wellington (WELT), and the Natural History Museum, London (BM).

Type material of *L. juniperina* and *L. parvifolia* was examined via loans from BM. Labillardière's specimens of *L. oxycedrus* held at Florence were viewed there by one of us (GK), as well as via digital images supplied by the Herbarium Universitatis Florentinae (FI-W). Other historical specimens collected in the late 18th and early 19th centuries were viewed as digital images on *JSTOR Global Plants* or on the individual websites of herbaria in Britain, Europe or America.

Taxonomic discussion

- 1. *Leptecophylla oxycedrus* (Labill.) Jarman, *comb. nov.***
Styphelia oxycedrus Labill., *Nov. Holl. Pl.* 1: 49, t. 69 (1805). — **Type:** in capite Van-Diemen, J.J.Labillardière (holo: FI009077!). *Cyathodes oxycedrus* (Labill.) R.Br., *Prodr.* 540 (1810).
For detailed synonymy, see Weiller (1999, p. 205), under *Leptecophylla juniperina* subsp. *oxycedrus*.

The first known European collections of *Leptecophylla oxycedrus* (Fig. 1) were made by Jacques Julien de Labillardière, naturalist with Bruni D'Entrecasteaux's expedition in the *Recherche* and *Esperance* which sailed from France in 1791 in search of the missing navigator Jean-Francois de La Perouse. The expedition visited Van Diemens Land (Tasmania) in April–May 1792, and January–February 1793 (Labillardière 1800). Material from the expedition was widely distributed, with the main plant collections being held in the Webb Herbarium in Florence.

Labillardière's precise collecting sites are not known, with the location on all his specimens simply indicating 'In capite Van-Diemen' (Van Diemens Land). However, his stay in Tasmania was confined to the south-east and south of the island, with the main anchorages being



Fig. 1. *Leptecophylla oxycedrus*, collected in Van Diemens Land (Tasmania) by J.J. Labillardière in 1792/1793. (Image courtesy of Herbarium Universitatis Florentinae.) Inset: magnified segment of the main image.

in Recherche Bay in the far south. The ships sailed through the D'Entrecasteaux Channel and around the northern tip of Bruny Island, with landings made in several places (Labillardière 1800). Based on the known distribution of *Leptecophylla oxycedrus*, the species is most likely to have been collected from around Recherche Bay, where it would have been one of the first species encountered after landfall in April 1792. The first description of the plant appeared in 1805 in Labillardière's *Novae Hollandiae Plantarum Specimen*.

Leptecophylla oxycedrus was originally classified in the genus *Styphelia* (Labillardière 1805) and later in *Cyathodes* (Brown 1810). It remained as a distinct species until 1868, when Bentham, in *Flora Australiensis*, synonymised it with *Cyathodes acerosa* R.Br. (= *Leptecophylla juniperina* (J.R.Forst. & G.Forst.) C.M.Weiller), a New Zealand species. Bentham's interpretation was followed by many botanists (e.g. Rodway 1903 and Curtis 1963 dealing with the Tasmanian flora; Ewart 1930, Willis 1973 and Albrecht 1996 with the Victorian flora; Cheeseman 1906, 1925 and Allan 1961 with the New Zealand flora). A dissenting view was held by Sleumer (1963), who retained the two separately within the genus *Styphelia*. In the most recent taxonomic treatment of *Leptecophylla* (Weiller 1999), the two taxa, together with *L. parvifolia*, are given subspecific rank within *L. juniperina* and all three subspecies are included in the Tasmanian flora.

Separation of *L. oxycedrus* from *L. juniperina*

Evidence from both floral and vegetative characters indicates that *Leptecophylla oxycedrus* should retain its original status as a distinct species, separate from

L. juniperina. Weiller (1999) comments that all species in *Leptecophylla* are 'apparently functionally dioecious', and refers to the presence of 'apparently hermaphrodite and male-sterile flowers on separate plants, with only male-sterile flowers setting fruit'. In *L. oxycedrus*, dioecy is clearly evident in the dimorphic flowers, with separate plants producing either flowers with large, pollen-producing anthers or small empty anthers. Typically, the corolla tube of pollen-producing flowers is much longer than in female plants (Figs 2, 3) and is exerted well beyond the calyx. The lobes are almost always less than half the length of the tube and often less than one-third to one-quarter. In shape, the tube is slightly barrel-shaped (Fig. 3) or narrowly urceolate. In dried material, the tube often appears cylindrical to very narrowly campanulate. In female flowers, the length of the tube is shorter, but still clearly remains exerted beyond the calyx.

Dioecy occurs in *L. juniperina* (Fig. 4; Gardner 2011) but is not as obvious as in *L. oxycedrus* because of the smaller size difference between pollen-producing and female flowers. The corolla tube is shorter than in *L. oxycedrus* (cf. Figs 3, 4) and, at the shorter end of the range, can be equal to or less than the length of the calyx, a condition not encountered in *L. oxycedrus*.

Critical vegetative characters that separate *L. oxycedrus* from *L. juniperina* are related to the seasonal production of leaves and to leaf shape and venation. In the genus as a whole, leaves are produced in a single flush each year. They are pre-formed in an annual 'parcel' enclosed by bracts which are brown, scarios and increase in size from the minute lowermost bracts up to the last large bracts that reach approximately the length of the first

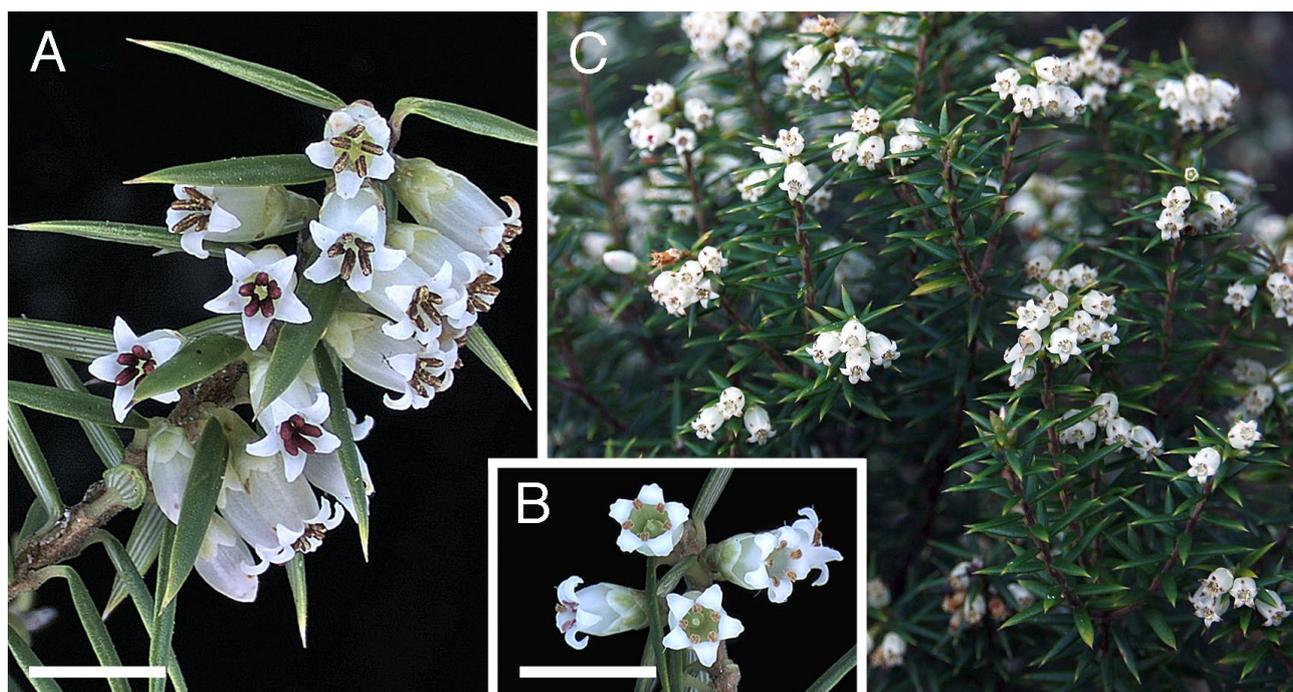


Fig. 2. *Leptecophylla oxycedrus* from Recherche Bay, Tasmania, the most likely Type locality of J.J. Labillardière's species collected in 1792/93. **A** Pollen-producing flowers; **B** female flowers with poorly formed anthers; **C** general aspect of the plant. Scale = 5 mm.

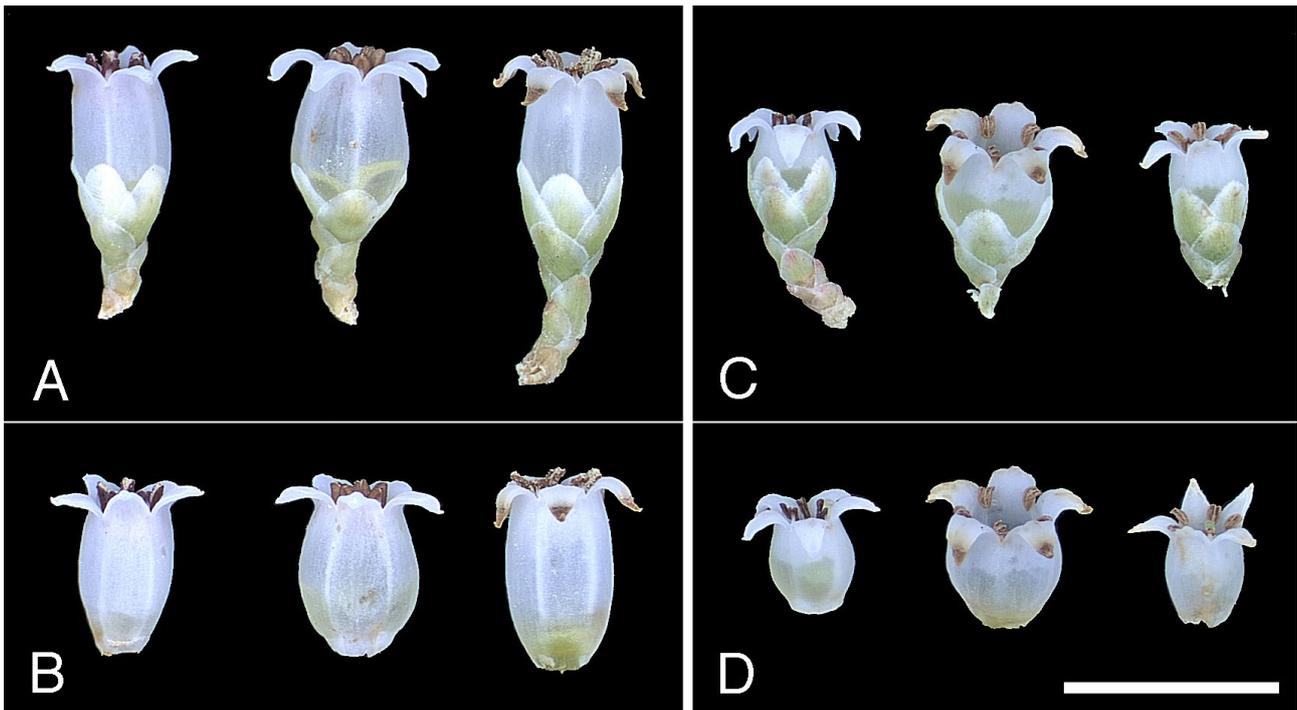


Fig. 3. Flowers of *Leptecophylla oxycedrus* from Recherche Bay. **A** Pollen-producing flowers from three different plants; **B** corolla of flowers shown in A. **C** Female flowers from three different plants; **D** corolla of flowers shown in C. Scale = 5 mm.

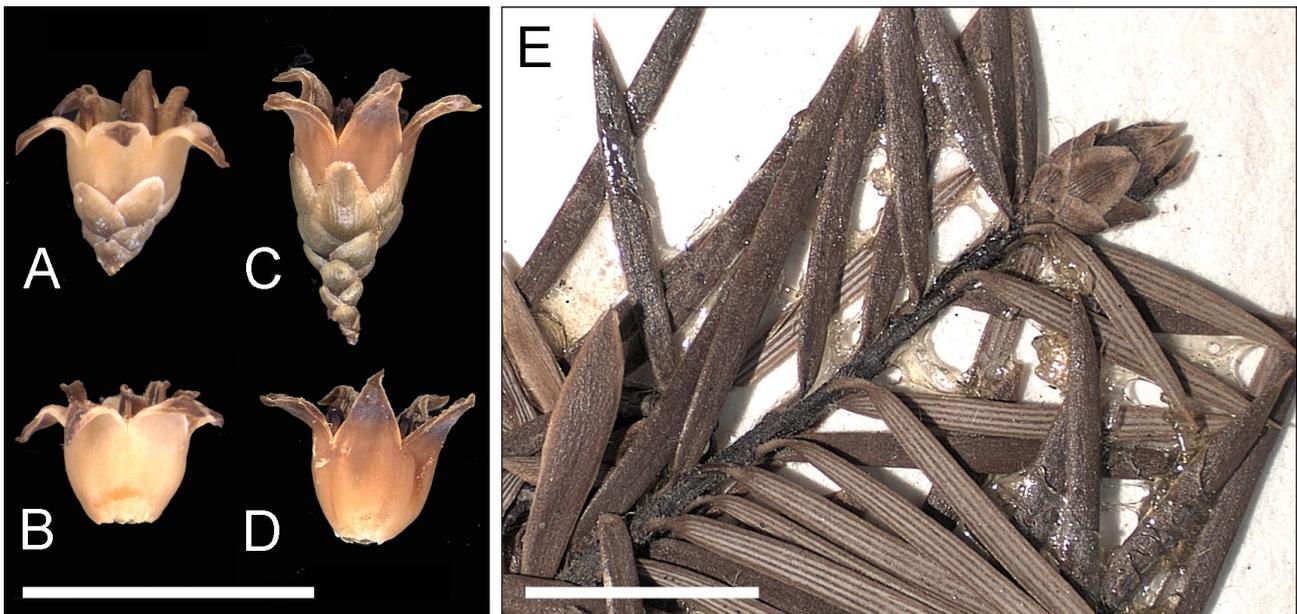


Fig. 4. Flowers of *Leptecophylla juniperina*. **A** Reconstituted flower from dried material (AK258766; dissection undertaken with permission); **B** corolla from A. **C** Reconstituted flower from HO583393; **D** corolla from C. **E** Partially opened flower on the lectotype, photographed from BM000797781. Scale = 5 mm.

leaves (e.g. Fig. 5). There is a zone between the last totally scarios bract and the first properly formed leaf where there are a number of 'transition' leaves that differ in shape from both the bracts and the properly formed leaves. They have abaxial venation that is composed of finely branched veins, which, although essentially parallel, do not have the distinctly striate appearance seen in typical leaves. Much of the 'transition' leaf comprises green photosynthetic tissue.

In the 'transition' leaves of *Leptecophylla oxycedrus*, the hyaline or scarios part of the margin towards the tip is quite broad but rolls towards the undersurface as the young shoot expands. As a result, the transition leaves more-or-less resemble the typical leaves in outline (Figs 6A, 6B) and blend inconspicuously among them (Fig. 7A). They are most easily recognised by checking the leaf undersurface for the rolled margin in the upper part of the leaf, and the finely branched venation



Fig. 5. Seasonal production of leaves in *Leptecophylla*. Scale = 5 mm.

(Fig. 6A). Except for a few tiny bracts at the very base of the branchlets, all of the bracts and many of the transition leaves fall by the time the branchlet reaches its ultimate size for that year's growth. By the second year of growth, although some of the uppermost transition leaves may remain, they are uncommon and essentially indistinguishable from the fully formed mature leaves when viewed from their upper surface.

In the transition leaves of *L. juniperina*, the hyaline or scarious portion towards the apex is quite narrow and is not or only scarcely rolled under, giving the transition leaves an oblanceolate shape (Figs 6C, 7B). The finely branched venation of these leaves is clearly visible on the undersurface (Fig. 6C). The 'transition' leaves persist and are held across several years' growth (Fig. 7B) and, because of their different shape and venation, and their frequency and persistence, they give a subtle but distinctive aspect to the plant. There is also a difference in the shape of normal leaves, which tend to be more linear in *L. juniperina* (Fig. 6D) than in *L. oxycedrus* (Fig. 6B). The tendency for the major veins to branch, particularly towards the leaf apex, also persists into the true leaves to a greater extent in *L. juniperina* than in *L. oxycedrus*.

The branching venation on the underleaf of *L. juniperina* has been commented upon by earlier botanists, including Robert Brown, who, in 1810, observed that the Tasmanian *Cyathodes* (*Leptecophylla*) *oxycedrus* differed from the New Zealand *C. acerosa* (*Leptecophylla juniperina*) in the branching of the veins towards the leaf extremities. Hooker (1853), in the *Flora of New Zealand*, makes the comment about *C. acerosa*:

'There is a tendency in the leaf (very variable in amount) to become broader towards the tip, whence the outer nerves branch to supply the increased surface, which I do not observe in the following species [*C. oxycedrus*]; this character Mr Brown detected, and applied in distinguishing them.'

These vegetative differences in venation, and shape and level of persistence of transition leaves are accompanied by important floral differences between the two species (see above), which have proved to be consistent wherever the appropriate floral stages have been available for checking.

Our assessment that *L. juniperina* and *L. oxycedrus* are separate species is not novel, with botanists such as Brown (1810), Sprengel (1824), de Candolle (1838), Hooker (1853, 1859) and, more recently, Sleumer (1963), treating the two separately, albeit acknowledging their close affinities.

Descriptions of *L. oxycedrus* are given in Ewart (1930, as *Cyathodes acerosa* R.Br.) and Albrecht (1996, as *Cyathodes juniperina* (J.R.Forst. & G.Forst.) Druce), and are not repeated here.

Notes. In recent works (Weiller 1999; Crowden & Duretto 2013), the presence of sparse, rigid hairs on the corolla of *L. oxycedrus* has been used as a key identification character. However, corolla hairiness does not appear to be a reliable taxonomic character in this species and its close relatives.

Labillardière (1805) described the corolla as scarcely hairy and the hairs on the corolla limb as rare ('corollae limbo ... vix piloso', and 'Corollae limbus pilis raris'). In the illustration accompanying Labillardière's work, it is difficult to see any sign of hairs on the corolla, although admittedly the floral drawing is rather small. Labillardière himself is unlikely to have seen many flowers, either on a single plant or across the population, because his visits to Tasmania were well outside the peak flowering times for *L. oxycedrus* (August–October). We have collected flowering material from the area most likely to be the Type locality of Labillardière's specimens (Recherche Bay), where plants are still plentiful. In an examination (dissecting microscope) of 60 plants (three flowers/plant) encompassing two populations at Recherche Bay, approximately two-thirds of the plants were found to have a glabrous corolla. The remaining third had hairs present on the corolla, but these were sometimes as few as one or two. Hairs were mostly in

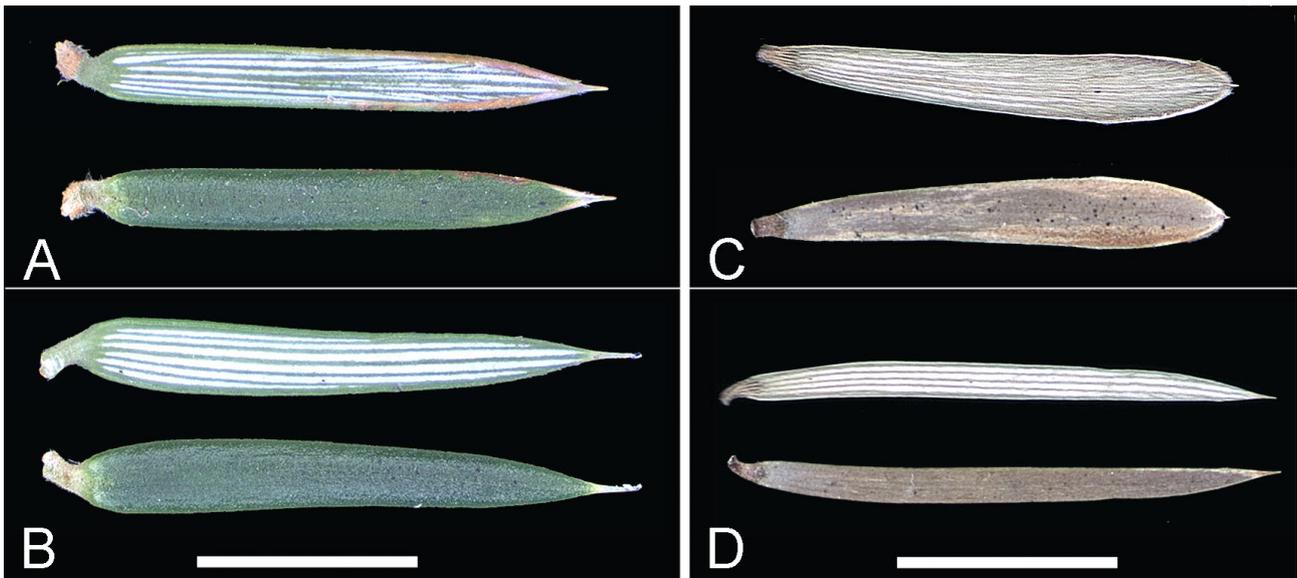


Fig. 6. Leaves of *Leptocophylla oxycedrus* from Recherche Bay (**A, B**) and *L. juniperina* from New Zealand (**C, D**, Auckland area, HO504556). **A, C** Transition leaf, showing shape and venation on the upper and lower surface. **B, D** Typical leaf from mid-season's growth, showing shape and venation on upper and lower surface. Scale = 5 mm.

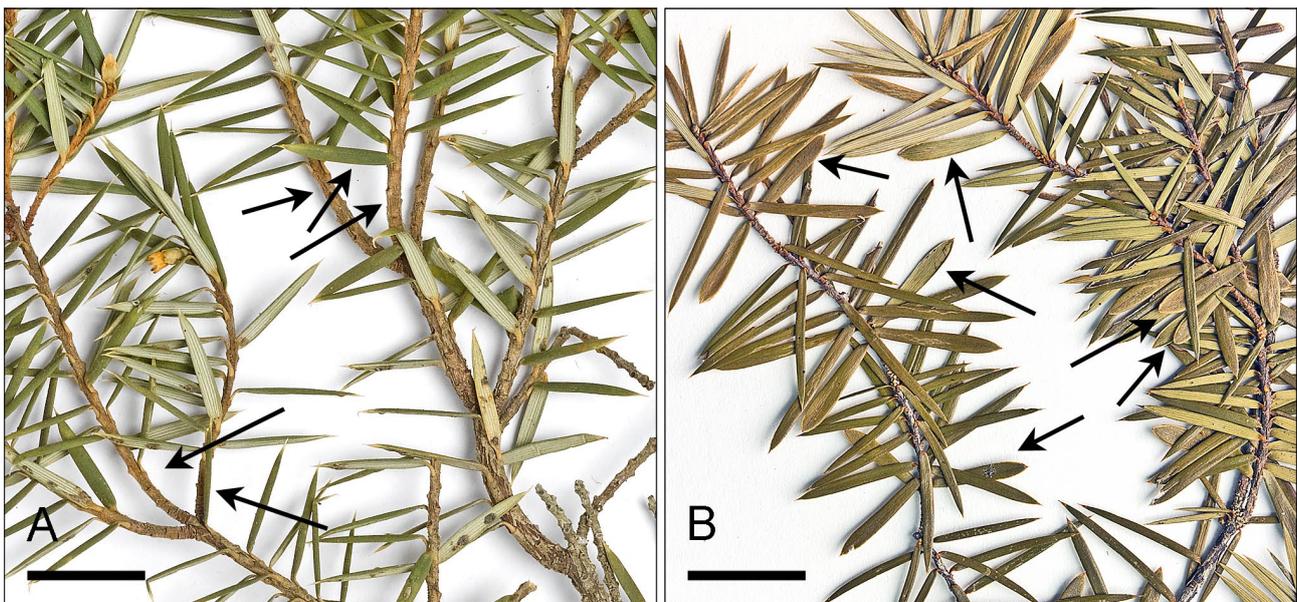


Fig. 7. *Leptocophylla oxycedrus* (**A**) from Recherche Bay, the probable Type locality, and *L. juniperina* (**B**) from New Zealand (Auckland area, HO504556). Arrows show the position and/or shape of transition leaves (fallen or scarcely discernible among the typical leaves of *L. oxycedrus*; readily distinguished in *L. juniperina*). Scale = 1 cm.

the tube near the base of the anthers, but occasionally one or a few hairs also occurred on the lobes.

Populations in the southern half of Tasmania, on the south-eastern, southern and western coasts, typically have a glabrous corolla or one with so few hairs that, for identification purposes, it can be considered glabrous. Further north, on the Bass Strait Islands and in the far north-west (also in southern Victoria), the populations seem to be more variable (as indicated by collections at HO), and a greater proportion of plants have hairs present on the corolla. In those plants, the hairs, though sparse, are often more numerous on individual

flowers than seen in southern plants. In an examination of 25 plants from Slaves Bay (north-western Tasmania), all plants had one to a few hairs on the tube near the anthers, and about half (13/25) had at least one or two hairs on the limb.

The presence of sparse hairs on the corolla is clearly a variable character within and between populations of *L. oxycedrus*. Two other species that normally have a glabrous corolla (*L. juniperina* and *L. pogonocalyx*) have also been observed occasionally with sparse hairs on the upper surface of the lobes and at the top of the corolla tube.

Distribution. The stronghold of *Leptecophylla oxycedrus* is in Tasmania but the species also occurs in southern Victoria (Ewart 1930; Willis 1973; Albrecht 1996). It has been reported from New Zealand (Hooker 1853; Cheeseman 1906, 1925; Allan 1961), where it has mostly been treated as a variety of *L. juniperina*. However, we very much doubt its occurrence in that country. Although *Leptecophylla juniperina* exhibits a high level of morphological variability (as observed from loan material), none of the variants we have seen can be ascribed to *L. oxycedrus*.

Selected specimens examined

TASMANIA: Walkers Hill, Flinders Island, 20.x.1976, *M.Allan* (HO27696); King Island, 24.iv.1802, *R.Brown* (BM000797755, BM000797756); Kent Group, Bass Strait, 12–19.xii.1803, *R.Brown* (BM000797757); Nye Bay, 8.i.1986, *A.M.Buchanan* 7702 (HO97763); Observatory site, Bennetts Point, Recherche, 11.ix.2003, *A.M.Buchanan* 16054 (HO523632); Nettley Bay Road, 11.i.2003, *L.H.Cave* (HO583395); Maria Island, Bishop and Clerk, 14.xii.2011, *L.H.Cave* 1395 (HO564872); Mt Munro, Cape Barren Island, 7.x.1988, *P.A.Collier* 3550 (HO118374); Strzelecki summit, Flinders Island, 27.x.1990, *R.K.Crowden* & *Y.Menadue* (HO536147); Marrawah, v.1948, *W.M.Curtis* (HO53463); Surprise Bay, 6.iii.2003, *H.J.Elliott* (HO583396); Old rehabilitated mine tailings near Grassy, King Island, 26.x.2005, *A.M.Gray* 1590 (HO535658); Emu Bay Road, 21.viii.1838, *R.C.Gunn* 714 (HO4071); South Hummock, Three Hummock Island, 5.x.1995, *S.Harris* & *J.Balmer* (HO445082); Balt Spur, Tasman Peninsula, 26.x.1979, *J.Jarman* (HO31368); Slaves Bay, 13.x.2003, *J.Jarman* & *G.Kantvilas* (HO583399); D'Entrecasteaux's Watering Place in Recherche Bay, 17.i.2004, *J.Jarman* & *G.Kantvilas* (HO583400); Gillams Beach in Recherche Bay, 4.ix.2014, *J.Jarman* & *G.Kantvilas* (HO583401); Macquarie Heads, 19.ix.2014, *J.Jarman* & *G.Kantvilas* (HO583402); Road to Redbill Point, Port Dalrymple, 12.ix.2015, *J.Jarman* & *L.A.Thorne* (HO583403); Track to Cape Raoul, 19.xi.2003, *G.Kantvilas* (HO583404); Coxs Bight, 31.xii.1982, *D.I.Morris* 8285 (HO68182); Maatsuyker Island, viii.1976, *A.Moscal* (HO32384); Point Hibbs, 23.i.1984, *A.Moscal* 5863 (HO401591); Boat Harbour, 17.xi.2002, *M.R.* & *M.H.Stanton* (HO583397); Mt Leventhorpe, summit, Flinders Island, 3.iv.2007, *P.Tyson* (HO583398); Tasman Island, downhill of quarters, 25.ix.2007, *P.A.Tyson* 485 (HO545837).
VICTORIA: Cape Woolami, Phillip Island, 8.ix.1981, *A.Opie* & *S.Van Berkel* (HO58969).

2. *Leptecophylla parvifolia* (R.Br.) Jarman, comb. nov.

Cyathodes parvifolia R.Br., *Prodr.* 540 (1810). — **Type:** [Tasmania: Mount Wellington (Table Mountain), near River Derwent], *R.Brown*, Feb–May 1804 (as *Styphelia erythrocarpa*) (holo: BM000802314! Bennett No. 2416). For additional notes and a detailed synonymy, see Weiller (1999, p. 204) under *Leptecophylla juniperina* subsp. *parvifolia*.

Leptecophylla parvifolia was first collected from Mt Wellington (Table Mountain) by Robert Brown in

1804 during his nine-month sojourn in southern Tasmania. Brown named the plant *Cyathodes parvifolia* (Fig. 8) and described it in his *Prodrum florae Novae Hollandiae*, published in 1810. He commented on its similarity to *C. oxycedrus* (= *Leptecophylla oxycedrus*) which he had seen growing on the Bass Strait Islands but observed that it was easily distinguished by its small size. Since Brown's initial description, *L. parvifolia* has generally been accepted at specific rank (e.g. by de Candolle 1838; Hooker 1859; Bentham 1868; Rodway 1903 and Curtis 1963). However, Sleumer (1963) considered it a subspecies of *Leptecophylla oxycedrus* (as *Styphelia oxycedrus* Labill. subsp. *parvifolia* (R.Br.) Sleum.) and, more recently, Weiller (1999) treated it as a subspecies of *L. juniperina*.

Leptecophylla parvifolia and *L. juniperina*

Several morphological characters readily separate *Leptecophylla parvifolia* from *L. juniperina*. The corolla shape and size is different (Fig. 9 compared to Fig. 4), as well as leaf size, shape and venation, and the level of retention of the transition leaves. *Leptecophylla parvifolia* loses most of its transition leaves promptly and the ones remaining are superficially similar to the typical leaves. Even in the very oldest transition leaves, the shape is more elliptical than oblanceolate, in contrast to the persistent oblanceolate-shaped transition leaves of *L. juniperina*.

Leptecophylla parvifolia and *L. oxycedrus*

In floral morphology, *L. parvifolia* is similar to *L. oxycedrus*, except that the flowers are slightly smaller (Fig. 9 compared to Fig. 3), and the lobes of *L. parvifolia* are somewhat longer and narrower in relation to the tube compared to those of *L. oxycedrus*. Leaves of the two species may be similar in shape, but those of *L. parvifolia* are distinctly shorter and narrower, and they may be elliptical to oblong as well as lanceolate.

In its typical form, *L. parvifolia* grows as a compact rounded shrub, about 50–100 cm tall and often wider than high, with many branches from ground level. Even in dense understoreys at its lowest elevation, it rarely exceeds 2 m in height. On the other hand, *L. oxycedrus* typically occurs as a tall shrub greater than 3 m in height, and has been reported as a small tree reaching 10 m (Curtis 1963, as *Cyathodes juniperina*). In extreme coastal environments, it can occur as a dense wind-pruned, low to medium shrub, but in such situations, its overall appearance is very different from that of *L. parvifolia*. Where living plants are growing in their natural habitat there is little likelihood of confusion between these two species.

The two species differ in ecology and distribution. *Leptecophylla parvifolia* is widespread in Tasmania, and abundant in the southern, central and north-eastern highlands. It occurs in heathy vegetation or in open forest dominated by various *Eucalyptus* species, and can also be associated with high-altitude *Nothofagus cunninghamii* forests. It is particularly abundant on



Fig. 8. *Leptocophylla parvifolia*. Holotype collected by Robert Brown from Mt Wellington (Table Mt) in Van Diemens Land (Tasmania) in 1804.

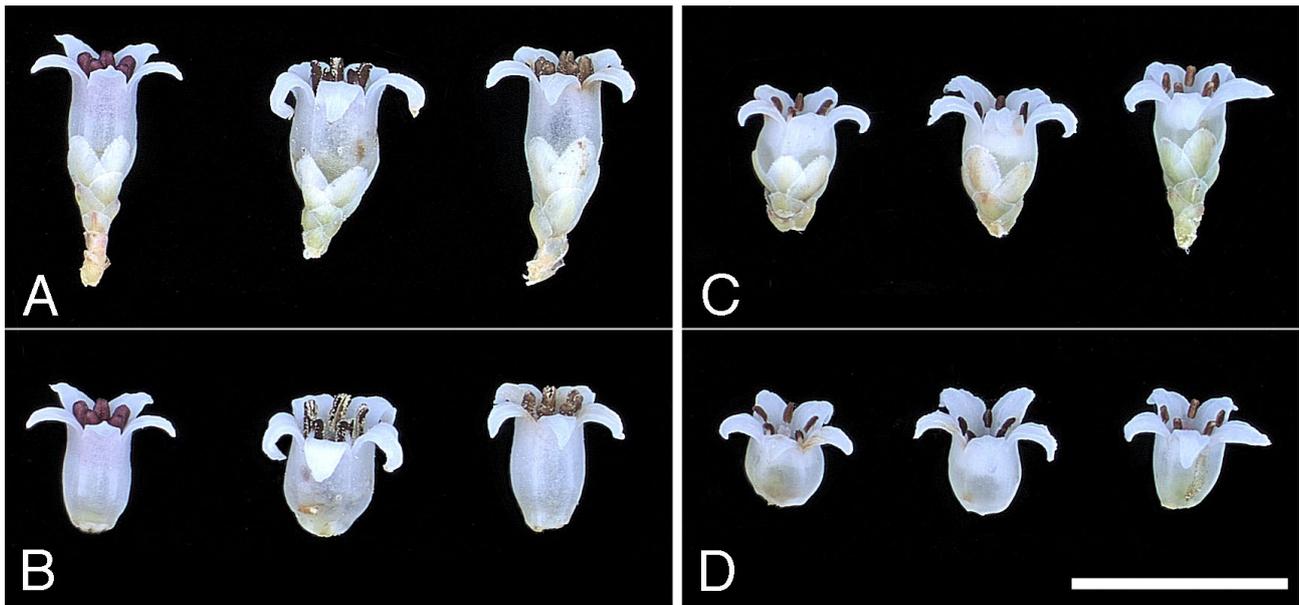


Fig. 9. Flowers of *Leptecophylla parvifolia* from Mt Wellington, the Type locality. **A** Pollen-producing flowers from three different plants; **B** corolla of flowers shown in A. **C** Female flowers from three different plants; **D** corolla of flowers shown in C. Scale = 5 mm.

the Central Plateau, where it occurs in broad expanses as a dominant or subdominant low shrub in the understorey (e.g. Fig. 10). It is found most commonly above 500–600 m, ascending to over 1200 m, but can occur at lower elevations especially where it has dispersed from higher ground nearby. In contrast, *L. oxycedrus* occurs in lowland coastal areas, where it

mostly grows as a medium to tall shrub in wet eucalypt forest or coastal scrub, but may also form a small tree (Fig. 11). Hooker (1859) records *Cyathodes oxycedrus* (= *L. oxycedrus*) as ascending to 3000 ft, but this is possibly an error resulting from confusion with *Leptecophylla pogonocalyx* which, until the work of Weiller (1999), remained unrecognised in the Tasmanian flora. The



Fig. 10. *Leptecophylla parvifolia* dominating the low heathy layer in eucalypt forest on Tasmania's Central Plateau.

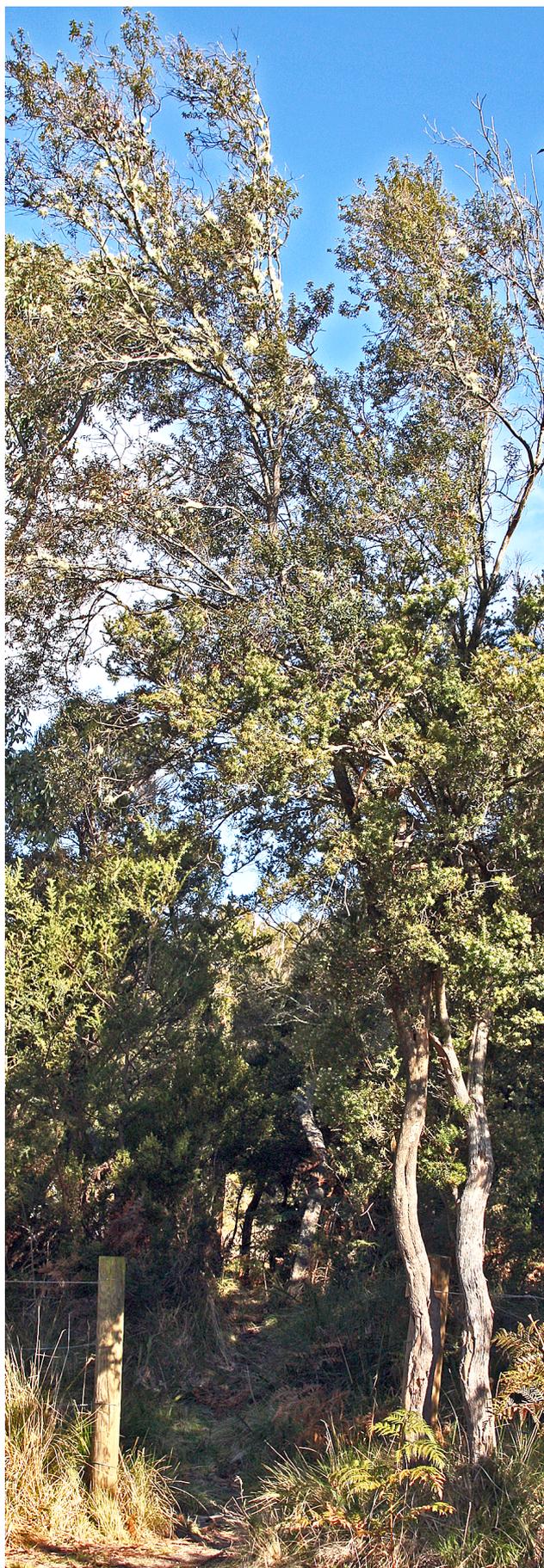


Fig. 11. *Leptecophylla oxycedrus* forming a small tree at Recherche Bay. The fence post (scale) is c. 1.2 m tall.

highest elevation for *L. oxycedrus* known at present is 750 m on Mt Strzelecki on Flinders Island; the highest on the Tasmanian mainland is 400 m on Mt Raoul on the Tasman Peninsula. Its furthest recorded distance from the coast is about 10 km on Mt Leventhorpe, also on Flinders Island, but this, and other inland sites, are likely to be subjected to strong maritime influences. *Leptecophylla parvifolia* is restricted to the Tasmanian mainland whereas *L. oxycedrus* extends to the Bass Strait Islands and is also recorded from southern Victoria.

Taxonomic status

Morphological differences between *L. parvifolia* and the New Zealand *L. juniperina* are such that there is no justification in uniting the two. The situation is less straightforward between *L. parvifolia* and *L. oxycedrus*. However, the widespread distribution of *L. parvifolia* in Tasmania, its abundance across very large areas, its retention of small leaves across a range of ecological conditions and, typically, its very different aspect from *L. oxycedrus*, are strong arguments in favour of separating the two. This view supports that of Brown (1810), who described the species, and others who worked on the Tasmanian flora such as Hooker (1859), Rodway (1903) and Curtis (1963).

Descriptions of *L. parvifolia* are given in Bentham (1868), Rodway (1903) and Curtis (1963), all as *Cyathodes parvifolia* R.Br., and are not repeated here.

Selected specimens examined

TASMANIA: Bradys Lake, 17.x.1975, *M.Allan* (HO572582); Western Mountains, Western Tiers, i.1848, *W.H.Archer* (HO4131); south slope of Mt Maurice, 9.xii.1979, *A.M.Buchanan* 76 (HO32182); north ridge of Mt Mangana, South Bruny Island, 9.xi.1984, *A.M.Buchanan* 4264 (HO407859); Mt Barrow, 27.xii.1959, *T.E.Burns* 231 (HO4116); Lyell Highway, east of turnoff to Rufus Canal, 12.i.2003, *L.H.Cave* (HO583004); N ridge of Millers Bluff, 25 km W of Campbell Town, 8.xii.1990, *P.Collier* 4976 (HO126290); Mt Faulkner, 26.ix.1954, *W.M.Curtis* (HO4122); MacKenzies Tier, c. 3 km SSW of dam on Little Pine Lagoon, 21.ii.2014, *M.F.de Salas* 626, *M.L.Baker* & *G.Kantvilas* (HO575139); Snow Hill Marshes, 29.iv.1986, *F.Duncan* & *M.Brown* 83 (HO507457); Herringback, summit, 1.xii.2006, *A.Gray* 1756 (HO538694); Poatina Highway, SW of Poatina, 17.xi.2002, *J.Jarman* (HO583006); Murchison Highway, near Belmont Road turnoff, 12.x.2003, *J.Jarman* & *G.Kantvilas* (HO583007); Bruny Island, Lockleys Road, 2.ix.2015, *J.Jarman* & *G.Kantvilas* (HO583008); Cathedral Rock, 1.xii.2013, *G.Kantvilas* (HO583005); Quoin Mountain, near summit, 20.iv.1986, *A.Moscal* 12887 (HO410253); Cathcart Bluff, 11.i.1990, *A.Moscal* 18371 (HO144597); Ben Lomond National Park, at treeline near Ranger's Headquarters, 18.xii.1979, *M.G.Noble* (HO74451); One O'Clock Hill, Murderers Marsh, Mt Dromedary, 20.i.1981, *A.E.Orchard* 5277 (HO40863); Lake Fenton area, Mt Field National Park, 10.v.1986, *J.M.Powell* 2153 (HO307760); Lake Sorell, xi.1908, *L.Rodway* 496 (HO4079); Breona, Great Lake, 14.xi.1947, *J.Somerville* (HO53458); Collinsvale, 13.x.1934, *V.V.Hickman* (HO4125).

3. *Leptecophylla juniperina* (J.R.Forst. & G.Forst.)

C.M.Weiller

Muelleria 12: 200 (1999); *Epacris juniperina* J.R.Forst.

& G.Forst., *Char. Gen. Pl.* 20, t. 10 (1776). —

Type: [New Zealand], *sine loco*, Forster, G.Forster's Herbarium (lecto, fide Weiller 1999: BM00079771!); Herb. Pallas (isolecto: BM00079772!).

For a detailed synonymy, see Weiller (1999, p. 203).

Leptecophylla juniperina (Figs 4, 12) was first described as *Epacris juniperina* in 1776 from material collected by Johann and Georg Forster in New Zealand during James Cook's second Pacific Voyage in the ships *Resolution* and *Adventure* (Forster & Forster 1776). The same species was described 15 years later by Joseph Gaertner as *Ardisia acerosa* (Gaertner 1791), again based on material from New Zealand, but this time from specimens collected by Joseph Banks and Daniel Solander on Cook's earlier voyage in the *Endeavour* in 1769. For many years, the specific epithet *acerosa* was the one used most commonly for the species (*Cyathodes acerosa* or *Styphelia acerosa*), with the earlier name given by the Forsters generally being ignored. However, Sleumer (1963) and Curtis (1963) reverted to the name *juniperina* and, thereafter, the epithet has been applied widely.

Leptecophylla juniperina (as *Cyathodes acerosa*) was included in the Tasmanian flora at least as early as 1819, when Roemer & Schultes (1819) indicated it occurred 'In insulae Van Diemen'. The source of their information is not clear and was possibly due to a misinterpretation of Brown's (1810) comments in his *Prodromus florae Novae Hollandiae*, where he noted the close similarities between *Cyathodes oxycedrus* and *C. acerosa*. Another possible explanation is that the information came from an examination of early collections of plant material from Tasmania. Some of Robert Brown's specimens of *C. oxycedrus* from Bass Strait collected in 1802 (BM00797756 from King Island) and 1803 (BM000797757, Kents Group) carry the name *C. acerosa*, but this was probably a temporary field name used by Brown until further information came to hand. Having the use of Joseph Banks' library and herbarium (Vallance *et al.* 2001), Brown would have seen Banks and Solander specimens of *C. acerosa* from New Zealand before his Australian trip commenced in 1801. He was also unlikely to have had access at that time to Labillardière's Tasmanian specimens of *Styphelia* (*Cyathodes*) *oxycedrus*, a species that was not published until 1805. By the time Brown published his *Prodromus* in 1810, he was apparently satisfied that *C. oxycedrus* and *C. acerosa* were different, and that only one of them, *C. oxycedrus*, occurred in Tasmania.

In spite of the distribution given by Roemer & Schultes (1819), most of the early botanical references after Robert Brown omitted *C. acerosa* from the Tasmanian flora (e.g. de Candolle 1838; Hooker 1859). However, in 1868, in *Flora Australiensis*, Bentham synonymised the Tasmanian *C. oxycedrus* with *C. acerosa* under the latter name. Through this synonymy, *C. acerosa* (under various names) has continued to be listed as a

Tasmanian plant by many botanists, with the notable exception of Sleumer (1963).

Exclusion of *L. juniperina* from the Tasmanian flora

The close relationship between *Leptecophylla juniperina* and Tasmanian members of the genus is immediately apparent from the general appearance of the plants, which have narrow, sharply pointed leaves that are striate and glaucous below. In spite of these similarities, *L. juniperina* can be separated from all Tasmanian species using vegetative characters and from most using floral characters.

Important vegetative characters involve leaf shape and venation, and persistence of transition leaves (see above under *L. oxycedrus*). *Leptecophylla abietina* is the only Tasmanian species that has any tendency to produce persistent, oblanceolate transition leaves. However, it is probably the most distinctive of all Tasmanian *Leptecophylla* species and is very easily separated from *L. juniperina* by a broad array of characters, including the densely hairy corolla lobes, long corolla tube and horizontally orientated trichomes between the veins on the leaf undersurface.

In terms of floral morphology, *L. juniperina* differs from all Tasmanian species except *L. pogonocalyx* in its relatively short, broad corolla tube. However, the two can be easily separated on the basis of leaf characters (venation, subtleties of leaf shape, and differences in shape and retention of transition leaves).

We have examined specimens of *Leptecophylla juniperina* collected by the Forsters (lectotype: BM000797781, Fig. 12; isolectotype: BM000797782) and Banks and Solander (BM000802315, BM000802316) and compared them with numerous specimens of *Leptecophylla* from widely dispersed locations in Tasmania. Comparisons have also been made with material of *L. juniperina* on loan from New Zealand. On this basis, we do not consider *L. juniperina* to be a Tasmanian species, and formally exclude it from the Tasmanian flora. Plants previously identified as *L. juniperina* in Tasmania are mostly either *L. oxycedrus* or a newly described subspecies of *L. pogonocalyx*.

Selected specimens examined

NEW ZEALAND, NORTH ISLAND: Cascade Park, Waitakere Range, Waitemata City, Auckland, 11.ix.1974, S.J.Astridge & L.R.Stemmer (CHR259266); Tairua State Forest, 24.iv.1956, I.L.Barton (AK213083); Jacks Bay, Bay of Islands, 3.viii.1967, R.Belcher (AK117922); Hauraki Gulf, Ponui (Chamberlins) Island, 28.viii.1978, E.A.Brown (AK151185); north Waikawau Bay, 26.ix.2002, E.K.Cameron (AK258766); Waitangi, Manukau County, 3.x.1900, H.Carse (CHR332679); Woodhill, West Coast, Waitemata County, 12.vii.1921, H.Carse (CHR332677); summits of hills at Mangaroa, xi.1826, A.Cunningham[?] (MEL685918); W. of Mt Messenger, N. Taranaki, iii.1978, A.P.Druce (CHR323871); Pokai Reserve, S. Mamaku Plateau, x.1978, A.P.Druce (CHR325967); Mt William, Pokeno, 27.x.1972, R.O.Gardner



Fig. 12. Lectotype of *Leptecophylla juniperina* (BM000797781) collected by the Forsters in New Zealand. Inset: magnified segment of the main image.

(CHR258390); Whangaparapara Bay, Great Barrier Island, ix.1964, *B.L.Gee & M.S.Reid* (AK263286); Little Barrier Island, 1.ix.1963, *P.Hynes* (AK98692); Forestry Department area, Woodhill, 17.viii.1968, *P.Hynes* (AK118807); Northcote, Kauri Glen, 18.ix.1943, *D.L.Knowlton* (AK132300); Hapuakohe Range, Waiti Road above Ohinekaua Stream, 6.vii.1991, *P.J. de Lange 856 & G.M.Crowcroft* (HO504556, ex CHR473442); Birkenhead, in Le Roys Bush, 14.vii.1982, *D.Lewis* (AK271068); Hunua Ranges, Mangatangi Track, Auckland, 13.ix.2003, *T.J.Martin* (HO583394); Birkdale, Auckland, 18.viii.1924, *H.B.Mathews?* (AK105578); Little Barrier Island, 26.vi.1947, *H.R.McKenzie* (AK211747); Whangarei, 1957, *T.W.Mellor* (AK50410); Cascades, Waitakere Ranges, 30.i.1983, *J.M.Powell 2074* (HO584244); Baie des Iles, 1843, *M.Raoul* (MEL685965); Wairata Forest Farm, Wairata, Opotiki, x.2014, *A.Redpath* (HO583393); c. 3 km SW of Waiwera, 26.x.1980, *P.Scofield 29* (AK154355); Mt Manganui, Tauranga, i.1960, *A.G.Simpson* (AK266216); c. 2 km SW of Waiwera, 3.x.1981, *G.Straka 336* (AK155408); Mamaku, x.1941, *M.R.Woodhead* (AK151817); Auckland (MEL2380635).

SOUTH ISLAND: Opuragi, Totaranui, 5–15.xi.1769, *J.Banks & D.Solander* (BM000802315, BM000802316).

4. *Leptecophylla pogonocalyx* C.M.Weiller

Muelleria 12: 206 (1999). — **Type citation:** above Lake Dove, Cradle Mountain, eastern slopes, 21.xi.1985, *C.M.Mihaich 5*. **Type sheet:** From the eastern slopes above Lake Dove, Cradle Mountain–Lake St Clair National Park, 21.xi.1985, *C.M.Mihaich 5* (holo: HO521873!).

Leptecophylla pogonocalyx was segregated by Weiller (1999) from what had been known until then as *L. juniperina*. Distinguishing characters are a short corolla tube and pubescent calyx and bracteoles (Weiller 1999). The species is very widespread in the south-west and west of Tasmania and is now known to cover a much broader altitude range than when first reported, occurring from sea level to alpine elevations.

In the present study, the circumscription of *L. pogonocalyx* is broadened to include a new subspecies, *L. pogonocalyx* subsp. *decipiens*. In their typical form, subsp. *pogonocalyx* (Fig. 13) and subsp. *decipiens* (Figs 13, 14) can be distinguished unambiguously by the degree of hairiness of the sepals and floral bracts (glabrous vs hairy), and this distinction applies across much of the area they occupy: subsp. *pogonocalyx* in southern and western areas; subsp. *decipiens* in north-western areas. However, where their distribution patterns converge (north-western parts of the Central Plateau, parts of the West Coast), it becomes increasingly difficult to assign plants to one or other subspecies with certainty because of the intergrading level of hairiness and the absence of any other diagnostic character.

Leptecophylla pogonocalyx subsp. *decipiens* Jarman, subsp. nov.

A *L. pogonocalyx* subsp. *pogonocalyx* C.M.Weiller sepalis glabris differt.

Type: slopes of Mt Leslie, 12.xi.2015, *J.Jarman & G.Kantvilas* (holo: HO583888; iso: MEL, CANB, AK, CHR, WELT).

Medium to tall shrub up to c. 4 m; branchlets pubescent, with short stiff hairs. Leaves alternate, spreading or reflexed, narrow-ovate to narrow elliptical-lanceolate, tapering to a pungent point, 8–17 (–23) mm long (including pungent point), 1.2–1.6 mm wide; upper surface convex, green; lower surface glaucous, striate with 3–5 (–7) unbranched parallel veins; margin smooth or scabrous above; petiole short, c. 1 mm long, glabrous or with short hairs on the upper surface; apex acute, with a stiff sharp point, c. 1 mm long. Flowers white, solitary, mostly in the upper axils, on straight or recurved pedicels, 1–3 mm long; bracts glabrous or with minute, inconspicuous hairs at the tip, ovate-oblong to broadly triangular, margin ciliolate, apex obtuse, upper bracts imbricate, decreasing in size to the lower bracts, lower bracts imbricate or distant; sepals glabrous or with a small patch of minute, inconspicuous hairs at the apex, ovate-oblong, apex obtuse, margin ciliolate; corolla tube 1.5–2.5 (–3) mm long, 2–3 mm wide, bulbous in the middle, exerted beyond the calyx or equal to it, corolla lobes spreading or reflexed, 1–1.5 mm long, shorter than the tube, glabrous or rarely with sparse hairs. Anthers half-exserted. Ovary 5-locular; disk of five scales or lobes. Fruit a drupe, pink to red, 7–10 mm diam. **Figs 13D–F, 14.**

Etymology. The epithet *decipiens*, from the Greek participle meaning ‘deceiving’, refers to the general appearance of the subspecies, which is so like that of several other Tasmanian *Leptecophylla* species that the taxon has been overlooked or misidentified in the past.

Distribution and ecology. *Leptecophylla pogonocalyx* subsp. *decipiens* is the typical *Leptecophylla* occurring throughout north-western Tasmania, from the lowlands to over 1000 m elevation. It is known as far south as the Pieman River and extends onto the northern and north-western rim of the Central Plateau. It has not been recorded from southern parts of Tasmania. It commonly grows as a tall understorey shrub in wet eucalypt forest. However, like other tall-growing Tasmanian *Leptecophylla* species, it matures as a small plant and can be found flowering at heights below 1 m in open situations, at high elevations, or along margins of roadsides and other disturbed areas. Peak flowering time is October–November, with later flowering at higher elevations.

Selected specimens examined

TASMANIA: Bowry Creek, Savage River, 9.vi.1993, *A.M.Buchanan 13378* (HO409926); south ridge of St Valentines Peak, 13.1.1986, *P.A.Collier 1165* (HO116892); Baretop Ridge, 29.i.2015, *M.F. de Salas 1140 & M.L.Baker* (HO578612); Mt Bertha, near summit trig point, 5.ii.2015, *M.F. de Salas 1354 & M.L.Baker* (HO578425); Murchison Highway 7.7 km N of Waratah and Guildford Roads junction, 10.x.1978, *A.M.Gray 281* (HO28100); near mouth

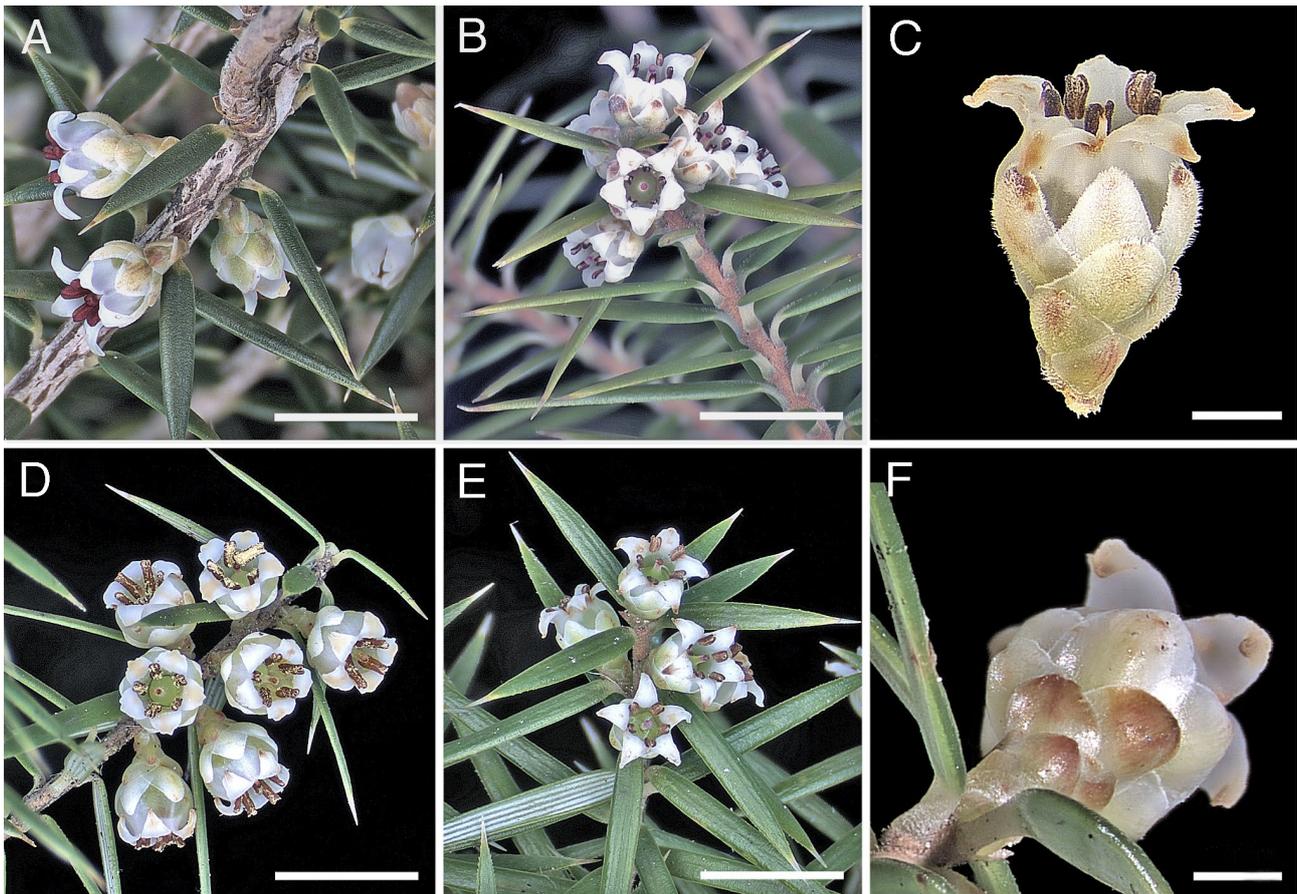


Fig. 13. *Leptecophylla pogonocalyx* subsp. *pogonocalyx* (A–C) and *L. pogonocalyx* subsp. *decipiens* (D–F). **A, D** Pollen-producing plant; **B, E** female plant; **C** flower showing hairy calyx; **F** flower showing glabrous calyx. Scale A, B, D, E = 5 mm; C, F = 1 mm.

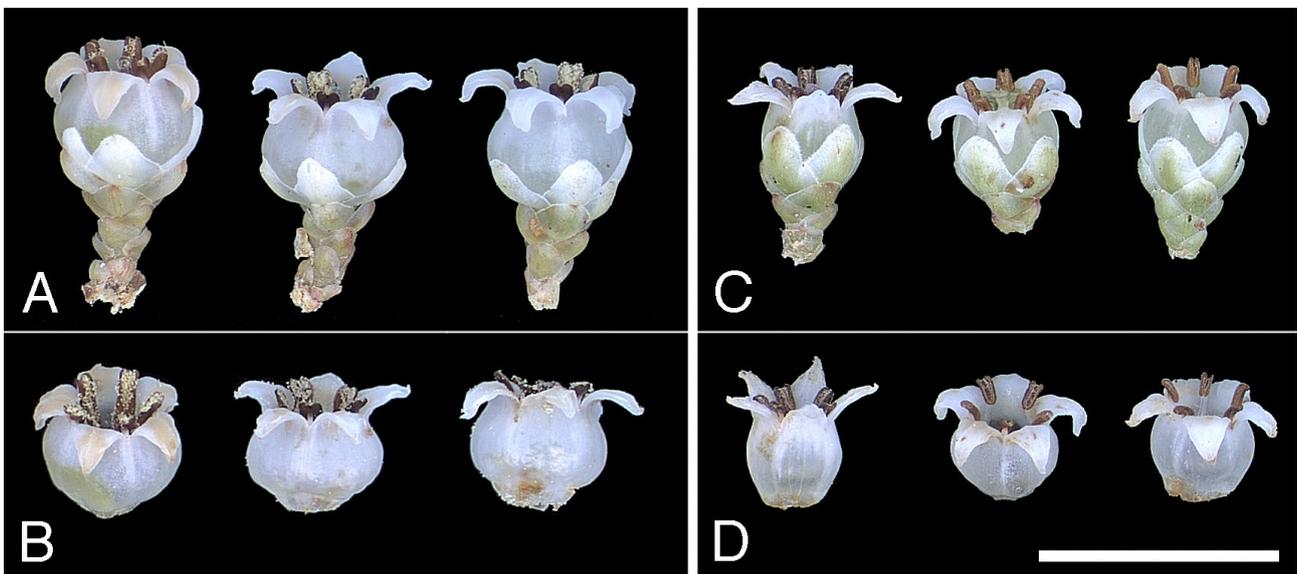


Fig. 14. *Leptecophylla pogonocalyx* subsp. *decipiens*. **A** Pollen-producing flowers from three different plants; **B** corolla from flowers shown in A. **C** Female flowers from three different plants; **D** corolla from flowers shown in C. Scale = 5 mm.

of Pieman River, 15.i.1954, *W.D.Jackson 136* (HO4096); Wandle River, 16.xi.2014, *J.Jarman* (HO584431); Loyatea Peak, 19.x.2001, *J.Jarman & G.Kantvilas* (HO584432); Black Bluff Track, 19.x.2001, *J.Jarman & G.Kantvilas* (HO584433); Savage River Pipeline Road, 27.xi.2003, *J.Jarman & G.Kantvilas* (HO584434); Murchison Highway,

near Belmont Road turnoff, 28.xi.2003, *J.Jarman & G.Kantvilas* (HO584435); Blackwater Road near spur 5, 10.xi.2015, *J.Jarman & G.Kantvilas* (HO583890); Norfolk Road near the junction with Sumac Road, 10.xi.2015, *J.Jarman & G.Kantvilas* (HO583891); Henrietta, 12.xi.2015, *J.Jarman & G.Kantvilas* (HO583892); Bonds

Range, 25.xi.1982, *A.Moscal 1044* (HO68368); The Clump, 9.xii.1983, *A.Moscal 4666* (HO79821); Frankland Creek, 18.xii.1983, *A.Moscal 5003* (HO111287); Providence Creek, Arthur River, 28.iii.1984, *A.Moscal 7166* (HO121900); Trowutta Arch, 7.iv.1984, *A.Moscal 7434* (HO92140); Mother Cummings Peak, 20.ii.1986, *A.Moscal 12368* (HO402240).

Composition of *Leptecophylla* in Tasmania

On the basis of this study, the genus *Leptecophylla* comprises six species in Tasmania, one of which has two subspecies. These include *L. abietina* (Labill.) C.M.Weiller, *L. divaricata* (R.Br.) C.M.Weiller, and *L. pendulosa* (Jarman) C.M.Weiller, in addition to the taxa documented herein. An identification key to these species is provided (below).

Acknowledgements

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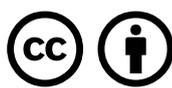
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Key to Tasmanian species of *Leptecophylla**

1. Flowers with a short, broad corolla tube: in pollen-producing flowers, the length of the tube equal to or less than the diameter at the widest point; tube bulbous in shape (e.g. Fig. 14)
 2. Sepals pubescent on the outer surface ***L. pogonocalyx* subsp. *pogonocalyx***
 - 2: Sepals glabrous on the outer surface ***L. pogonocalyx* subsp. *decipiens***
- 1: Corolla tube relatively long in relation to its diameter: in pollen-producing flowers, at least 1.5 times as long as the width; tube barrel-shaped or cylindrical (e.g. Figs 3, 9)
 3. Style long, at least twice the height of the ovary
 4. Corolla lobes with long straggling hairs; bracts distant, bracteoles scarcely reaching the sepals. ***L. divaricata***
 - 4: Corolla lobes glabrous, rarely with one or two hairs; bracts and bracteoles overlapping ***L. pendulosa***
 - 3: Style short, less than twice the height of the ovary
 5. Leaves longer than 7 mm
 6. Inside of corolla lobes densely hairy ***L. abietina***
 - 6: Inside of corolla glabrous or with scattered sparse hairs. ***L. oxycedrus***
 - 5: Leaves shorter than 7 mm ***L. parvifolia***

* *Leptecophylla juniperina* is excluded from the Tasmanian flora.

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A new species of small black disc fungi, *Smardaea australis* (Pezizales, Pyronemataceae), is described from Australia

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Abstract: A new species, *Smardaea australis* P.S.Catches. & D.E.A.Catches. (Ascomycota, Pezizales, Pyronemataceae) is described and illustrated. This is the first record of the genus in Australia. The phylogeny of *Smardaea* and *Marcelleina*, genera of violaceous-black discomycetes having similar morphological traits, is discussed.

Keywords: Fungi, discomycete, Pezizales, *Smardaea*, *Marcelleina*, Australia

Introduction

Small black discomycetes are often difficult or impossible to identify on macro-morphological characters alone. Microscopic examination of receptacle and hymenial tissues has, until the relatively recent use of molecular analysis, been the method of species and genus determination.

Between 2001 and 2014 five collections of a small black disc fungus with globose spores were made in South Australia. Initially the fungus was identified as *Marcelleina atroviolacea* Brumm., since it conformed in all respects with a fungus previously collected in 1964 from Anglesea, Victoria, by Gordon Beaton. This collection had been sent by Beaton to the Royal Botanic Gardens, Kew, and described by Rifai (1968) as *M. atroviolacea*.

No other species of *Marcelleina* Brumm., Korf & Rifai has been recorded in Australia, nor of other possibly confusing genera such as *Smardaea* Svrček and *Otidea* (Pers.) Bonord, although species of the latter genus have been found in New Zealand (Atlas of Living Australia, ALA). There are no records of any species of *Smardaea* in the ALA or Australia's Virtual Herbarium (AVH). Those in the ALA and AVH of *Marcelleina atroviolacea* are of the collections from South Australia covered in the present study and of Beaton's collection from Victoria. The ALA also records *M. atroviolacea* as being in New Zealand, but these collections had been misidentified and were *Pseudoplectania affinis* M.Carbone, Agnello & P.Alvarado (P. Johnston, pers. comm.; NZFungi2 2016). *Pseudoplectania* Fuckel also

has dark coloured apothecia and globose ascospores, but differs morphologically from *Smardaea* in having dark hairs on the excipulum.

Marcelleina and *Smardaea*

Four genera of small black discomycetes with purple pigmentation, *Greletia* Donad., *Pulparia* P.Karst., *Marcelleina* and *Smardaea*, had been separated by characters in part based on distribution of this purple pigmentation, as well as on other microscopic characters. Their relationships have been much discussed (Donadini 1984; Pfister 1985; Moravec 1987; Haffner 1995; Perić 2001; Benkert 2005), but Korf & Zhuang (1991) followed Donadini (1979) in accepting two genera: *Marcelleina* (with *Pulparia* as a synonym) and *Smardaea* (with *Greletia* as a synonym).

The generic name *Marcelleina* was proposed by van Brummelen, Korf and Rifai in 1967 (Brummelen 1967; Rifai 1968; Moravec 1987) in honour of Mme Le Gal, an eminent French mycologist who specialised in discomycetes. The genus *Smardaea* was proposed by Svrček in 1969, named after František Šmarda, a Czech botanist.

Species in the genera *Marcelleina* and *Smardaea* have small, cupulate to saucer-like, sessile or subsessile, glabrous apothecia with violaceous-brown hymenium. The receptacle tissue of both is similar: ectal excipulum of globose or angular cells (*textura globulosa* or *textura angularis*) and medullary excipulum of interwoven septate hyphae (*textura intricata*). Asci are cylindrical and their apices do not turn blue in Melzer's reagent. Paraphyses are septate and contain purple granules.

The two genera differ in that all *Marcelleina* species have globose spores, the paraphyses are usually unbranched and, though the sterile tissue and paraphysis contents have purple pigmentation, the asci and ascospores are not necessarily purple. The spores of *Smaradæa* may be globose or ellipsoid, paraphyses are usually branched and there is purple pigment in asci, ascospores, paraphyses and excipula (Benkert & Moravec 1986; Moravec 1987; Hansen & Knudson 2000).

Nine species of *Smaradæa* are presently recognised (Index Fungorum), four of which have globose spores. Of these only *S. planchonis* (Dun. ex Boudier) Korf & W.Y.Zhuang has smooth spores; *S. reticulosperma* (Donadini, Rioussset & G. Rioussset) Benkert has reticulate spores, those of *S. verrucispora* (Donadini & Monier) Benkert are warty and *S. marchica* (Benkert & J. Moravec) Benkert has subglobose, coarsely warty spores.

Eleven species of *Marcelleina* are listed in Index Fungorum. Seven of these have ornamented spores with ornamentations ranging from warty-tuberculate, ridged or partially to completely reticulate. Of the four smooth-spored species, *M. benkertii* J. Moravec, *M. chopraiana* (L.R. Batra) S.C. Kaushal, *M. parvispora* E. Rubio, Tabarés & M.A. Martínez and *M. atroviolacea*, only the latter has purple colour in all tissues and structures. The generic position of *M. parvispora* will be discussed later in this paper.

Korf & Zhuang (1991) synonymised *Marcelleina atroviolacea* and *Smaradæa planchonis* and erected the new combination *Smaradæa planchonis*.

Distribution and habitat of *Smaradæa planchonis*

Smaradæa planchonis, albeit under its various synonyms, is widespread in the northern hemisphere (Rifai 1968; Perić 2001). The type locality is France and it has been found in a number of countries in central and southern Europe (Boudier 1887; Lagarde 1911; Donadini 1984; Moravec 1987; Marchetti & Franchi 1993; Haffner 1995; Perić 2001; Benkert 2005; Martin 2005; Cuesta & Ribes 2006; Lantieri *et al.* 2009), the U.S.A. (Pfister 1985), Bermuda (Seaver 1928) and has been reported in Argentina in the southern hemisphere (Gamundi 1960; Rifai 1968).

Smaradæa planchonis is reported as growing in mostly sandy soil, often amongst moss and under Cupressaceae. For example, in Tuscany it has been found under *Cupressus sempervirens* L., *C. glabra* Sudw., *Juniperus oxycedrus* subsp. *macrocarpa* (Sibth. & Sm.) Ball and *J. phoenicea* L. (Marchetti & Franchi 1993). Benkert (2005), in his discussion on the distribution and ecology of *S. planchonis*, reported its presence under *Juniperus horizontalis* Moench., *J. chinensis* “plumosa aurea” and *Chamaecyparis obtusa* (Siebold & Zucc.) Endl. In the U.S.A. Pfister (1985) recorded it under *Yucca*. The Argentinian collections were from a

park in the inland city of Mendoza, on moist soil in sandy groves.

Materials and methods

Habitat and associated plant communities were noted in the field. Collection locations were recorded by GPS, geodetic datum WGS84/GDA94 (Garmin GPS12) and *in situ* photographs taken (Nikon 4500). Macroscopic characters were described directly from fresh material. Colours are designated using the Royal Botanic Gardens Edinburgh Colour Chart (1969) and given as colour descriptor and number, e.g. “rust 13”, and in general terms. Fresh material was dried in a food dehydrator at 35°C for 24 h (Hydraflo 1000FD).

Sections of fresh material and dried specimens were hand-cut and mounted in various media. For the amyloid reaction, fresh material was stained with Melzer’s reagent and dried material was rehydrated in 5% NH₄OH before staining. Water mounts were used to determine colour of context, 5% KOH and 5% NH₄OH were used to determine reaction to alkali, and 5% H₂SO₄ to determine the acid reaction.

Measurements were made using an Olympus BH-2 microscope at ×400 or ×1000 with a calibrated ocular micrometer. Spore dimensions are given as: length range × width range (n = 40) and Q ratio (spore length/spore width). Dimensions of asci are given as length range × width range (n = 20). A Nikon 4500 camera was used to photograph microscopic characters.

Descriptions of *Smaradæa australis* are based on the type collection, P.S. Catcheside 4079 (AD-C 58765), with outlying measurements for other collections given in brackets. Photographs of fruit bodies and microscopic characters are from the type collection. All South Australian collections have been accessioned into the State Herbarium of South Australia (AD). AD numbers (AD-C nnnnn) are given in the Taxonomy section together with the Collector’s number (PSC nnnn); in other sections only the Collector’s number is used.

DNA Extraction, amplification and processing were as described in Catcheside *et al.* (2016). To place species of interest in the Pyrenomataceae, sequences of the ribosomal RNA large subunit gene were aligned with those of representatives of each of the currently recognised families and lineages chosen from those used by Hansen *et al.* (2013). Sequences were manipulated with the Geneious 8.1.9 suite of programmes using Muscle for alignment and, for tree building, either neighbour joining (Fig. 8) or MrBayes (Fig. 9) using the HKY85 substitution model, 4 heated chains for 1,100,000 iterations including a burn-in of 100,000. Correlation between genetic and physical distance between collections was examined using the Pearson product-moment test in R.

Taxonomy

Smaradæa australis P.S.Catches. & D.E.A.Catches. sp. nov.

Holotype: South Australia. Sleaford Bay, Coffin Bay National Park, on low sand dune, 34° 51' 12.8"S, 135° 44' 6.4"E, alt. c. 5 m, amongst moss with *Leucopogon parviflorus* (Andrews) Lindl., *Melaleuca* sp. and *Acacia longifolia* subsp. *sophorae* (Labill.) Court, 21 July 2014, P.S. Catcheside PSC 4079 & D.E.A. Catcheside (AD-C 58765).

Mycobank number: MB819607.

Apothecia scattered to gregarious, sessile; (3–) 5–15 mm diameter, (1–) 3–8 mm high (Fig. 1). *Disc* more or less circular, concave to flat; margin initially slightly inrolled, later becoming plane, entire to crenate, often becoming eroded; fuscous-black 36, violaceous-black 38, blackish-purple; smooth, sometimes slightly pitted, waxy. *Receptacle* saucer- to cup-shaped; sessile; concolourous with disc; smooth to finely scurfy; attached to substrate by a small central soil pad (Fig. 2: Section through hymenium and excipulum; Fig. 3: Hymenium showing asci, ascospores and paraphyses). *Flesh* 1–1.5 mm thick; dark brown, purplish. *Ectal excipulum* 50–100 µm thick (Fig. 4). The outer layer composed of thick-walled globose, subglobose, sometimes polygonal cells (*textura globulosa*), cells 15–30 µm across; walls purple-brown; clumps of cells aggregated to give receptacle a slightly scurfy

appearance. Inner layer of thinner-walled, cylindrical-subglobose cells to 40 µm long, arranged with long axis at right angles to surface of receptacle; colour of cells ranging from colourless to purple to red-purple in NH₄OH, pale purple to deeper or red-purple in KOH, more strongly purple/red-purple in water, orange-red in H₂SO₄. *Medullary excipulum* of interwoven, septate, branched hyphae 4–10 µm diameter (*textura intricata*), with similar colour reactions as cells of the ectal excipulum. *Subhymenium* of more compacted hyphae. *Hymenium* 200–250 µm thick. *Asci* 8-spored; cylindrical-clavate, (160–) 170–225 × 8.5–12.5 µm (Fig. 5); amyloid; attenuating towards base; base forked, arising from croziers (Fig. 6). Immature asci with purple colouration in alkali and water, red in acid, no colour in fully mature asci. *Ascospores* globose (7.5–) 8.0–10.5 (–11.5) × (7.0–) 8.0–10.0 (–11.5) µm diameter; Q = 1–1.08 (–1.09); smooth; uniseriate; in upper portion of the ascus; hyaline, subhyaline; often with one large globule and several smaller ones. Immature ascospores with purple colouration in alkali and water, red in acid, no colour in fully mature spores. *Paraphyses* slender, filiform (Fig. 7); slightly longer than asci; straight or slightly curved; sparsely septate; tips slightly swollen 2–7 µm diameter; with granular contents which are more densely concentrated at tips; granular contents purple to purple-brown in water and alkali, becoming browner with age of apothecium; paraphyses branching especially near base; often nodulose.



Fig. 1. *Smaradæa australis*. Apothecia in situ. Scale = 10 cm.



Fig. 2. *Smardaea australis*. Section through hymenium and excipulum. In water. Scale = 100 μ m.

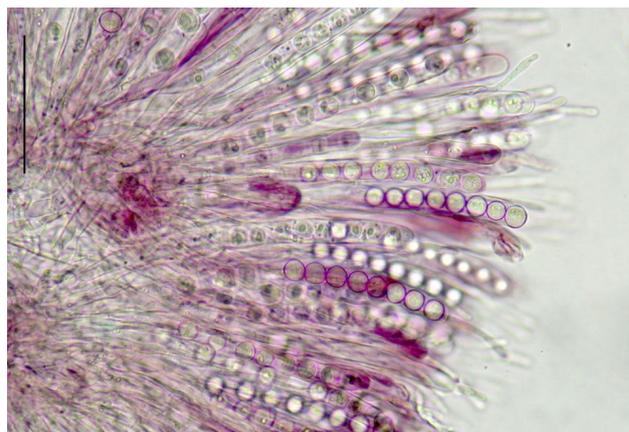


Fig. 3. *Smardaea australis*. Hymenium showing asci, ascospores, paraphyses. In water. Scale = 100 μ m.

Additional specimens examined.

VICTORIA. Two miles West of Anglesea, terrestrial between road and dunes, 38° 25' 48.44"S, 144° 8' 40.14"E, 5 July 1964, as *Marcelleina atroviolacea* Brumm., G.W. Beaton (MELU F 121706a).

SOUTH AUSTRALIA. Flinders Ranges National Park below Bunyeroo Gorge car park, on surface of mostly bare clay soil amongst stones, 31° 25' 00"S, 138° 33' 29"E, alt. c. 300 m, on the bank of creek bed colonised by moss protonema, near *Callitris glaucophylla* Joy Thomps. & L.S.A. Johnson and *Eucalyptus camaldulensis* Dehnh., 10 Aug. 2001, P.S. Catcheside PSC 1020 & D.E.A. Catcheside (AD-C 51219); Mambray Creek, Mount Remarkable National Park, in soil amongst moss, 32° 49' 17"S, 138° 03' 37"E, alt. c. 200 m, in dry woodland near *C. glaucophylla*, *E. camaldulensis*, *Leucopogon* sp. and *Acacia* sp., 9 Aug. 2011, P.S. Catcheside PSC 3637 & D.E.A. Catcheside (AD-C 57291); Wilpena Pound, Flinders Ranges National Park, on surface of mostly bare clay soil, 31° 33' 03"S, 138° 35' 22"E, alt. c. 540 m, amongst *C. glaucophylla*, 16 July 2014, P.S. Catcheside PSC 4043 & D.E.A. Catcheside (AD-C 58766); Lincoln National Park, Eyre Peninsula, in soil and amongst moss, 34° 52' 12"S, 135° 52' 38"E, alt. c. 40 m, on raised bank at side of road, sandy dune heath, *L. parviflorus*, *Melaleuca* sp. and *A. longifolia* subsp. *sophorae*, 22 July 2014, P.S. Catcheside PSC 4080 & D.E.A. Catcheside (AD-C 58767).

Etymology. From the Latin *australis*, meaning southern. Referring to the geographic distribution of the species in the southern hemisphere.

Note. The nuclear ribosomal sequences of each of the five collections, PSC 1020 (GenBank KY067461), PSC 3637 (GenBank KY067462), PSC 4043 (GenBank KY067463), PSC 4079 (GenBank KY067464) and PSC 4080 (GenBank KY067465), differ (Fig. 8), with PSC 1020 and PSC 4043 being heterozygous at single nucleotide positions in ITS2 and ITS1, respectively. There are ten variable sites in ITS1 (5.7%), eight in ITS2 (4.1%) and a further six in the ~960bp of the ribosomal RNA large subunit gene that was sequenced. This degree of intraspecific divergence in ITS sequence is high for ascomycetes (Nilsson *et al.* 2008). However, there is no significant correlation of sequence divergence

and distance between collection sites (Pearson product-moment $t = 1.38$, $df = 19$, $p = 0.18$) and no obvious grouping with respect to substrate or plant association. Accordingly we consider each to be strains of *Smardaea australis*.

Notwithstanding the morphological similarity of *Smardaea* and *Marcelleina* species, comparison of ribosomal RNA large subunit sequences shows they are only distantly related members of the Pyronemataceae placed in the *Otidea* lineage and Pezizaceae respectively (Fig. 9).

Discussion

With the relatively few morphological characters to distinguish between them, identification of small black discomycetes is problematic. Spore characters, ascus amyloidity, pigmentation of tissues have been and are used to help identification to genus and species levels. Since the development of molecular sequencing and phylogenetic analyses, it has become clear that macro- and micromorphological characters alone are insufficient to determine taxonomic identity and phylogenetic relationships.

Taxonomy, morphology and purple pigmentation of *Marcelleina* and *Smardaea*

The similarities of the smooth, globose-spored species of *Marcelleina* and *Smardaea* make separation on morphological characters of the two genera difficult, if not impossible. As currently understood, all species of *Marcelleina* have inamyloid asci, globose spores and partial purple pigmentation of tissues. *Marcelleina atroviolacea* was alone amongst the marcelleinas in having purple pigment in all tissues, a character that suggests it be put in the genus *Smardaea*. Svrček's concept of the genus *Smardaea* was of species having inamyloid asci, oblong-ellipsoid, verrucose spores and all tissues with violaceous colouration. When Korf & Zhuang (1991) synonymised *M. atroviolacea* and *S. planchonis*, a synonymy that the present authors accept, they extended

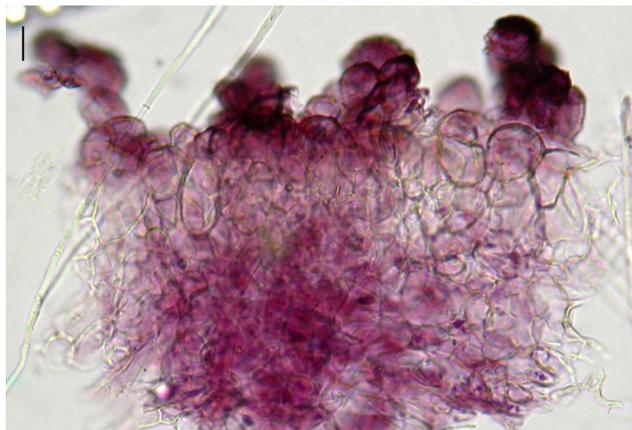


Fig. 4. *Smardaea australis*. Ectal excipulum. In water. Scale = 10 μ m.



Fig. 5. *Smardaea australis*. Asci. In water. Scale = 10 μ m.

the generic concept of *Smardaea* to include species with globose, smooth spores. Benkert (2005) commented that *S. planchonis* is the only species of *Smardaea* with such spores. *S. australis* becomes the second species in the genus with that combination of spore characters.

When Beaton identified his Victorian collection of a discomycete as *Marcelleina atroviolacea* he was following Rifai's concept of *M. atroviolacea*. Rifai documented the Australian Pezizales that had been sent to the Royal Botanic Gardens at Kew, a work that was published in 1968. The genus *Smardaea* was not erected until the following year (Svrček 1969) so Rifai's concept of *M. atroviolacea* would now place that taxon in the genus *Smardaea*. Beaton's collection of *M. atroviolacea* (MELU F 121706a) was examined and found to be similar in all respects to the South Australian collections, now named *S. australis*, based on comparison of spore and ascus measurements (Table 1), hymenial tissue, their inamyloid asci, smooth, globose spores and branched paraphyses with purple pigment.

The purple pigmentation in tissues is obviously an important character in determining genus and species, but its variability presents difficulties in interpretation. The asci and ascospores of all *Smardaea* species contain purple pigment while those of *Marcelleina* species are not necessarily purple; the paraphysis contents of both genera contain purple pigment.

In all Australian collections of *Smardaea australis* the cells and colouration of excipular tissue were similar: ectal excipulum of thick-walled, purplish-brown, globose to subglobose cells, medullary tissue of densely interwoven, purple hyphae. However, the intensity of the purple pigmentation in hymenial tissues varied in the different collections and was seemingly age-dependent. Asci, ascospores and paraphyses of collection *PSC 4043* had the most intense pigmentation, those in *PSC 4080* the least. The apothecia of *PSC 4080* were more mature than those of the other collections with almost all asci having mature ascospores. The distribution of pigmentation also varied in all collections: immature asci had distinct

purple colouration as did their ascospores. The purple granular material in the paraphysis tips was variable, some paraphyses had strongly pigmented contents while the contents of others were clear. From our observations it appears that the pigmentation fades with maturity and thus is age-dependent. All pigmented tissues became a slightly darker, duller purple in KOH and NH₄OH and red-orange in acid. The purple colour was brightest in water which was found to be the most useful medium when determining intensity and distribution of the pigmentation.

While morphologically the Australian material has some characteristics of *Marcelleina* species, the extent of purple pigmentation and sometimes branched paraphyses fit better with *Smardaea*. Morphologically our new species, *Smardaea australis*, most closely resembles the northern hemisphere *S. planchonis*, however, it differs from *S. planchonis* in having shorter asci (Table 1): the ascus length of *S. australis* ranges from 155–225 μ m, while that of *S. planchonis* is from 190–240 μ m, if the measurements of Boudier (1887) are discounted. The size of the ascospores of both species is similar. Unfortunately there are currently no molecular data for *S. planchonis*, so the two taxa cannot be compared on a molecular basis.

Phylogenetic relationships of *Marcelleina* and *Smardaea*

Recent phylogenetic studies confirm the placement of *Marcelleina* in the Pezizaceae (Hansen *et al.* 2001; Hansen *et al.* 2005; Hansen & Pfister 2006; Perry *et al.* 2007; Tedersoo *et al.* 2010; Hansen *et al.* 2013). The position of the genus *Smardaea* in the Pyrenomataceae is rather more complex. Perry *et al.* (2007) placed two species, *S. reticulosperma* (Donadini, Rioussset & G.Rioussset) Benkert and *S. amethystina* (W.Phillips) Svrček in the *Pyropyxis* clade and several species of *Otidea* in the adjacent *Otidea* clade. Tedersoo *et al.* (2013) show similar placements. Hansen *et al.* (2013) separated the *Pyropyxis* and *Otidea* lineages, while Frey *et al.* in *Engler's Syllabus of Plant Families* (2016) treat the large family Pyrenomycetaceae *s.l.* by dividing it into several groups,



Fig. 6. *Smardaea australis*. Croziers. In water. **Fig. 7.** *Smardaea australis*. Paraphyses. In water. Scale = 100 μ m. Scale = 10 μ m.

among them the family Otideaceae Eckblad, in which *Smardaea*, *Pyropyxis* and *Otidea* are included.

Ribosomal 28S sequences confirm that the Australian collections are within the genus *Smardaea* (Fig. 9) with the closest sister species being *S. reticulosperma* and *S. amethystina*. *Smardaea reticulosperma*, like *S. australis*, has globose spores but these have reticulate ornamentation. *Smardaea amethystina* has ellipsoid, warty spores. In the same clade are taxa lacking purple pigment, thus separating them from *Smardaea*: *Pyropyxis rubra* (Peck) Egger and two species of *Jafnea*, *J. fusicarpa* (W.R. Gerard) Korf and *J. semitosta* (Berk. & M.A.Curtis) Korf. *Pyropyxis rubra* has ellipsoid, smooth spores, but differs from *Smardaea* species in containing orange pigment. *Jafnea* species have ellipsoid spores, and the apothecia are brown and have hairs, another character that separates them from *Smardaea* whose apothecia are glabrous. *Otidea* species lie within the same clade. They are characterised by having apothecia which are split down one side, are yellow, brown or ochre, and have smooth, ellipsoid spores.

Thus there seems no particular morphological character that typifies members of the Otideaceae. Amyloidity of asci has been used to separate taxa such as the family Pezizaceae from the Pyronemataceae (Rifai 1968). The Pyronemataceae, which now include the Otideaceae, have inamyloid asci; the amyloid reaction of the ascus is a character associated with the Pezizaceae. Hansen *et al.* (2001) consider that amyloidity has been lost in some lineages, such as *Marcelleina*.

Marcelleina is in a lineage which is some distance from the Otideaceae (Fig. 9). The phylogenetic data of Hansen *et al.* (2013) show *Marcelleina* and *Peziza gerardii* Cooke in the *Marcelleina*/*P. gerardii* lineage in the Pezizaceae as opposed to the Pyrenomycetaceae *s.l.* in which the Otideaceae lie. They also pointed out that Schumacher & Jenssen (1992) had noted the morphological similarities between *P. gerardii* and *Marcelleina* and *Smardaea*. *Peziza gerardii* is a violaceous-brown discomycete with amyloid asci and fusoid, ribbed ascospores (Beug *et al.* 2014), thus differing from *Marcelleina* with its inamyloid asci and

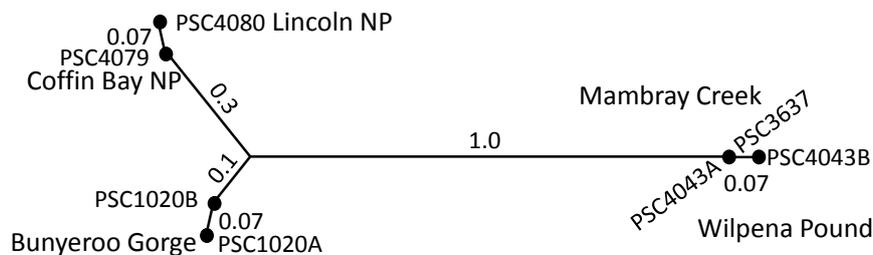


Fig. 8. *Smardaea australis* is genetically diverse. Neighbour joining tree of the sequences from five collections (~960 bp comprising 18S partial, ITS1, 5.8S, ITS2, 28S partial ribosomal RNA genes). Figures show the % divergence between sequences, names are the places of collection and A and B after the collection number refer to genotype differences between dikaryon components.

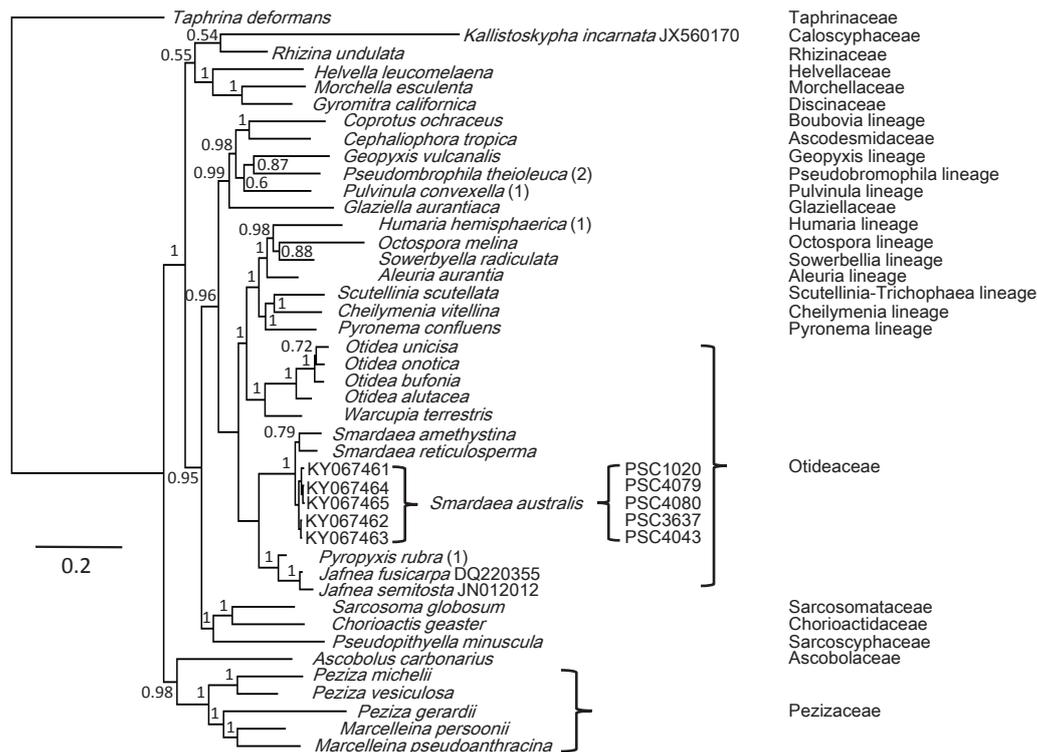


Fig. 9. Phylogeny of Pyrenomycetes showing the *Smardaea* and *Marcelleina* clades are distantly related. Sequences of the ribosomal RNA large subunit gene were aligned with those of representatives of each of the currently recognised families and lineages chosen from those used by Hansen *et al.* (2013). Tree construction used MrBayes. Figures show the posterior probability of branches (note that the support for some is less secure than those based on the combined RPB1, RPB2, EF-1 α and LSU sequences used by Hansen). GenBank accession numbers for the sequences used follow each species name.

globose spores. Although *Peziza gerardii* and species of *Marcelleina* have purple pigments they do not have these in all tissues whereas all species of *Smardaea* have purple pigments in all tissues.

The difficulties in species identification and placement within phylogenetic relationships of some of the small disc fungi is exemplified by a species described as a *Marcelleina*, *Marcelleina parvispora* E. Rubio, Tabarés & M.A.Martínez. However much earlier, in 1917, this taxon had been described as a species of *Caloscypha* Boudier: *C. incarnata* Duverney & Maine. It has a whitish to pinkish-violaceous hymenium, is found in association with *Eucalyptus* species and occurs in various parts of the world. After morphological examination and phylogenetic studies, Pfister *et al.* (2013) transferred the taxon into a new genus *Kallistoskypha* Pfister, Agnello, Lantieri & LoBuglio in the Caloscyphaceae, a family adjacent to Pezizaceae. Previously, *Caloscypha* had been included in the Pyrenomycetaceae (Pfister *et al.* 2013).

Habitat and trophic mode

Collections of *Smardaea australis* from the lower Eyre Peninsula, Port Lincoln and Coffin Bay, South Australia, and near Anglesea, Victoria, were on sandy dunes in coastal heath. Those specimens from the more northern localities in South Australia, i.e. Wilpena Pound and Bunyerroo Gorge, Flinders Ranges, and Mambray Creek, Mount Remarkable National Park, were on clay soil with river red gum, *E. camaldulensis*

(Myrtaceae), and native pine, *C. glaucophylla* (Cupressaceae). Soil and vegetation types were thus different for these similar South Australian collections. The morphologically similar *Smardaea planchonis* is reported as growing mostly in sandy soils, as did coastal collections of *S. australis* but unlike those to the north on heavier soils. The five South Australian specimens of *S. australis* were collected from sites up to 460 km apart and, although they do have divergent ITS sequences, the diversity appears consistent with a single species. Molecular sequencing of the Victorian collection was not attempted due to its age.

Healy *et al.* (2013) investigated the trophic status of a high diversity of Pezizales. Within the Otideaceae, which includes the genera *Pyropyxis*, *Jafnea*, *Otidea* and *Smardaea*, they consider that *Otidea leporina* (Batsch) Fuckel is ectomycorrhizal. Hansen *et al.* (2013) consider *S. amethystina* and *S. reticulosperma* to be saprobic and comment that this is surprising since *P. rubra* is parasitic and differs morphologically by containing orange, not purple, pigments. A species of *Jafnea*, *J. semitosta* is considered saprobic (Antonín & Moravec 2010; Kuo 2012). There are therefore ectomycorrhizal, saprobic and parasitic species within the one family of Otideaceae. The trophic mode of *Smardaea* species is still uncertain. Tedersoo *et al.* (2006) and Tedersoo *et al.* (2010) did not include *Smardaea* in their study of fungal ectomycorrhizal lifestyles, but determined *Marcelleina* to be mycorrhizal.

Table 1. Measurements of asci and spores and locality in collections of *Smardaea australis* from Australia and *S. planchonis* worldwide. n.d. = no data

| Collection/Reference | Asci Range (μm) | Mean Asci (μm) | Spore Range (μm) | Mean Spore (μm) | Spore Q Range | Mean Spore Q | Locality |
|---|-----------------------------------|-----------------------------|-------------------------------|------------------------------|---------------|--------------|-----------------|
| <i>Smardaea australis</i> in South Australia | | | | | | | |
| PSC 4079 (holotype) | 170–225 \times 8.5–12.5 | 194.75 \times 10.32 | 8.0–10.5 \times 8.0–10.0 | 9.2 \times 9.05 | 1–1.08 | 1.0175 | Eyre Peninsula |
| PSC 1020 | 190–225 \times 10–12.5(–14) | 208.4 \times 11.6 | 8.0–11.5 \times 8.0–11.5 | 10.1 \times 9.87 | 1–1.05(1.09) | 1.023 | Flinders Ranges |
| PSC 3637 | 160–190(–210) \times 9.5–12 | 177.25 \times 10.8 | 8.0–10.5 \times 7.5–10.5 | 9.03 \times 8.87 | 1–1.07(1.09) | 1.018 | Mambray Creek |
| PSC 4080 | 160–200 \times (8.5–)9–12.5 | 176.8 \times 10.32 | 7.5–9.5 \times 7.0–9.5 | 8.62 \times 8.43 | 1–1.1 | 1.02 | Eyre Peninsula |
| PSC 4043 | 155–195 \times 9.5–12 | 173.45 \times 10.37 | 8.0–11.02 \times 8.0–11.0 | 9.74 \times 9.55 | 1–1.08 | 1.02 | Flinders Ranges |
| <i>Smardaea australis</i> in Victoria | | | | | | | |
| MELU F 121706a | (160–)185–210 \times 10–12 | 192.6 \times 11 | 9.0–10.5 \times 9.0–10.5 | 9.55 \times 9.44 | 1–1.04 | 1.025 | Anglesea |
| <i>Smardaea planchonis</i> worldwide | | | | | | | |
| Boudier 1887 | 135–150 \times 10–12 | n.d. | 10–11(–12) (diam.) | n.d. | n.d. | n.d. | France |
| Cuesta & Ribes 2006 | 193.5–234 \times 8.5–12.4 | 213.7 \times 10.5 | 9.7–11.4 \times 9.4–11.2 | 10.5 \times 10.3 | 1–1.1 | 1.02 | Spain |
| Marchetti & Franchi 1993 | 190–230 \times 11–12(–15) | n.d. | 9–11(–12) (diam.) | n.d. | n.d. | n.d. | Tuscany |
| Haffner 1995 | 195–240 \times 9.7–12 | n.d. | 7.9–11.3 (diam.) | n.d. | n.d. | n.d. | Austria |
| Benkert 2005 | 200–235 \times 11–13(–16) | n.d. | 10–12 (diam.) | n.d. | n.d. | n.d. | Germany |
| Perić 2001 | 198–228(–230) \times 12–13(–15) | n.d. | 8.5–11.5 (diam.) | n.d. | n.d. | n.d. | Montenegro |
| Pfister 1985 | 215–225 \times 11–12 | n.d. | 8–10 (diam.) | n.d. | n.d. | n.d. | U.S.A. |
| Gamundí 1960 | 191–222 \times 10.7–14.5 | n.d. | None given | n.d. | n.d. | n.d. | Argentina |

Lantieri *et al.* (2009) suggested that *S. planchonis* is mycorrhizal. Collections were mostly recorded under Cupressaceae or Pinaceae, perhaps suggesting that this species is mycorrhizal with trees of those families. *Smardaea australis* cannot be mycorrhizal with conifers since there were no *Callitris* species in the Eyre Peninsula localities. The trophic status of *Smardaea* remains unresolved.

In summary

The similarities in morphology and pigmentation of the *Smardaea* and *Marcelleina* species are striking given the ancient phylogenetic divergence implied by the 28S rDNA sequences (Fig. 9) and other analyses that infer two distinct lineages (Hansen *et al.* 2001; Hansen *et al.* 2005; Hansen & Pfister 2006; Perry *et al.* 2007; Tedersoo *et al.* 2010; Hansen *et al.* 2013). These data suggest cases of convergent evolution, perhaps driven by exposure to high levels of insolation, where the intense purple pigmentation would have provided protection from ionising radiation.

In the absence of molecular data on northern hemisphere collections of *Smardaea planchonis*, it is

not possible to determine for certain, whether the Australian collections are synonymous with those from the northern hemisphere or Argentina. However, the shorter asci, variability and relative paleness of the violaceous pigmentation, absence of probably associated plant species and the distance from northern hemisphere and South American collections are consistent with the Australian collections being a new species.

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Tephromela baudiniana sp. nov. (lichenised Ascomycetes) from Kangaroo Island

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Abstract: A new lichen species, *Tephromela baudiniana* Kantvilas & Elix, is described from coastal rocks on Kangaroo Island, South Australia. It is characterised chiefly by its unique chemistry, comprising the rare metabolites, 9-*O*-methylalternariol and alternariol. The species is compared with other saxicolous species of the genus occurring in Australia.

Keywords: alternariol, biodiversity, lichens, new species, South Australia, Tephromelataceae

Introduction

This paper is a further contribution to the documentation of the lichens of Kangaroo Island, South Australia (Elix & Kantvilas 2013a, b; Kantvilas 2016; Kantvilas & Elix 2014; Kantvilas & Kondratyuk 2013; Kantvilas & van den Boom 2013, 2015; Kantvilas & Wedin 2015; McCarthy & Kantvilas 2013a, b, 2016 a, b), and describes a new species of the cosmopolitan genus *Tephromela* M.Choisy (Tephromelataceae). *Tephromela* is characterised by a crustose thallus with a unicellular, trebouxioid photobiont, apothecial ascomata, eight-spored, *Biatora*- to *Lecidella*-type asci, and simple, hyaline, non-halonate ascospores; the hymenium is invariably pigmented a diagnostic crimson, referred to as *atra*-red by Meyer & Printzen (2000). Detailed descriptions and illustrations of the genus and a discussion of its affinities are provided by Fryday (2011), Spribille *et al.* (2011), Kantvilas (2015) and many others, and are not repeated here. Species of *Tephromela* may be lichenicolous or occur free-living on a wide range of substrata, including rocks, bark and wood. They tend to be defined by thalline characters (e.g. presence or absence of soredia, etc.), apothecial anatomy and morphology, ascospore size and thallus secondary chemistry. The apothecia can be highly variable, ranging from immarginate to biatorine to “lecanorine”. The seemingly lecanorine apothecial margin, a feature of the many species ascribed to the *T. atra* group, has been interpreted by Spribille *et al.* (2011) and Kantvilas (2015) as a thalline cushion that subtends the apothecium and may envelop it at the margins.

Variation in the widespread *T. atra* group was investigated at a global scale by Muggia *et al.* (2013), who found that DNA sequence data do not support

some of the phenotypically distinct entities that have been described as species. They considered that some of the variability with respect to apothecial and ascospore size, substratum preference and thallus chemistry may be better interpreted as locally developed features that are part of the infra-specific diversity of one highly variable taxon. Subsequently, however, Cestaro *et al.* (2016) demonstrated that at least in one segregate of *T. atra*, the North American species *T. pacifica* Björk & Muggia, differences in chemical composition were underpinned by phylogenetic data. In Australia (and elsewhere), variation, particularly chemical variation, continues to be treated at species rank (see Kalb 2004, 2008; Elix 2012, 2013a, b; Elix & Kalb 2006, 2008) and its taxonomic importance requires further detailed investigation. The new species described below represents a further example of this variation.

Material and methods

The study is based on collections by the first author housed in the Tasmanian Herbarium (HO). Anatomical and morphological observations were undertaken using light microscopy, with thin hand-cut sections mounted in water, 10% KOH, 50% HNO₃, lactophenol cotton blue, ammoniacal erythrosin and Lugol's iodine, with and without pretreatment with KOH. Ascospore measurements are based on 30 observations and are presented in the format: least value–average–highest value. Chemical composition was investigated by thin-layer chromatography using standard methods (Orange *et al.* 2001; Elix 2014). Nomenclature of ascus types essentially follows Hafellner (1984) and Kantvilas (2009); that of pigments follows Meyer & Printzen (2000).

***Tephromela baudiniana* Kantvilas & Elix, sp. nov.**

Tephromelae atrae (Hudson) Hafellner similis sed 9-*O*-methylalternariolum et alternariolum, substantias chemicalias adhuc in *Tephromela* ignotas, continenti differt.

Typus: South Australia, Kangaroo Island: Rocky River Track, c. 250 m from mouth of river, 35°58'S 136°39'E, 10 m alt., on coastal rocks on the bank of a fast-flowing fresh-water stream, 25 Sep. 2015, G. Kantvilas 511/15 & B. de Villiers (holo: HO 581706; iso: AD).

Mycobank number: MB820508.

Thallus free-living, markedly rimose-areolate, whitish grey, esorediate, forming extensive, irregular, rather discontinuous patches to 10 cm or more in extent, essentially comprised of numerous irregularly circular thalli c. 10 mm wide that coalesce; individual areoles irregularly rhomboid, 0.4–1.5 mm wide, 0.7–1 mm thick, plane, verruculose or bullate; prothallus not developed, but actively expanding thallus margins often discoloured dark bluish grey at the very edge. *Apothecia* scattered, roundish, basally constricted, “lecanorine”, 0.5–1 mm wide; disc black, glossy, plane to undulate to convex, epruinose; thalline “margin” typically prominent but occasionally not developed, entire, often slightly inrolled, persistent, concolorous with the thallus, in section to 100–200 µm thick. *Proper excipulum* to 20–60 (–100) µm thick, thickest at the base, becoming excluded at the edges, pale to intense yellow-brown, K± intensifying yellow, N+ intense brownish orange. *Hypothecium* to 20–45 µm thick, hyaline to pale yellowish, thickest in the centre of the apothecium, tapering towards the margins and sometimes ± excluded. *Hymenium* 90–130 (–170) µm thick, not interspersed or with occasional oil droplets, crimson red, K+ intensifying red, N+ orange (*atra*-red), persistently coherent in water, K and N, with

an intensely *atra*-red pigmented epihymenial layer. *Paraphyses* 2–3 µm thick, stout, simple; apices not or gradually expanded to 6 µm wide, with a thick coat of gel and heavily caked and conglutinated with pigment. *Asci* clavate, 43–60 × 12–18 µm, of the *Biatora*-type: having a well-developed amyloid tholus, a masse axiale with ± parallel flanks and a rounded apex, and a darker, more intensely amyloid edge adjacent to the masse axiale. *Ascospores* hyaline, ellipsoid, 8–10.7–13 × 4.5–6.4–9 µm. *Pycnidia* not found. **Fig. 1.**

Chemistry. Thallus K+ yellow, C–, PD–, UV+ blue; containing atranorin (minor), 9-*O*-methylalternariol (major) and alternariol (minor).

Etymology. The specific epithet commemorates the French navigator Nicolas Baudin who made the second European landing on Kangaroo Island in 1802 (including just to the north of type locality) and who charted and named many of the island’s features.

Remarks. Although Muggia *et al.* (2013) questioned the rigorous application of chemical characters in the delimitation of *Tephromela* species, this criterion underpins the taxonomy of the genus in Australia where 27 species are recorded (McCarthy 2016); see Elix (2013a) for an identification key. It is the unusual secondary chemistry of the new species that distinguishes it unequivocally from other, morphologically highly similar, saxicolous species (Table 1). *Tephromela baudiniana* is chemically unique within the genus. Alternariol and 9-*O*-methylalternariol occur very rarely as major metabolites in lichens and are known as such only in *Pertusaria praecipua* A.W.Archer & Elix from Papua New Guinea (Archer & Elix 1998). This chemical character is highly significant. Alternariol is derived biosynthetically from a single, non-reduced

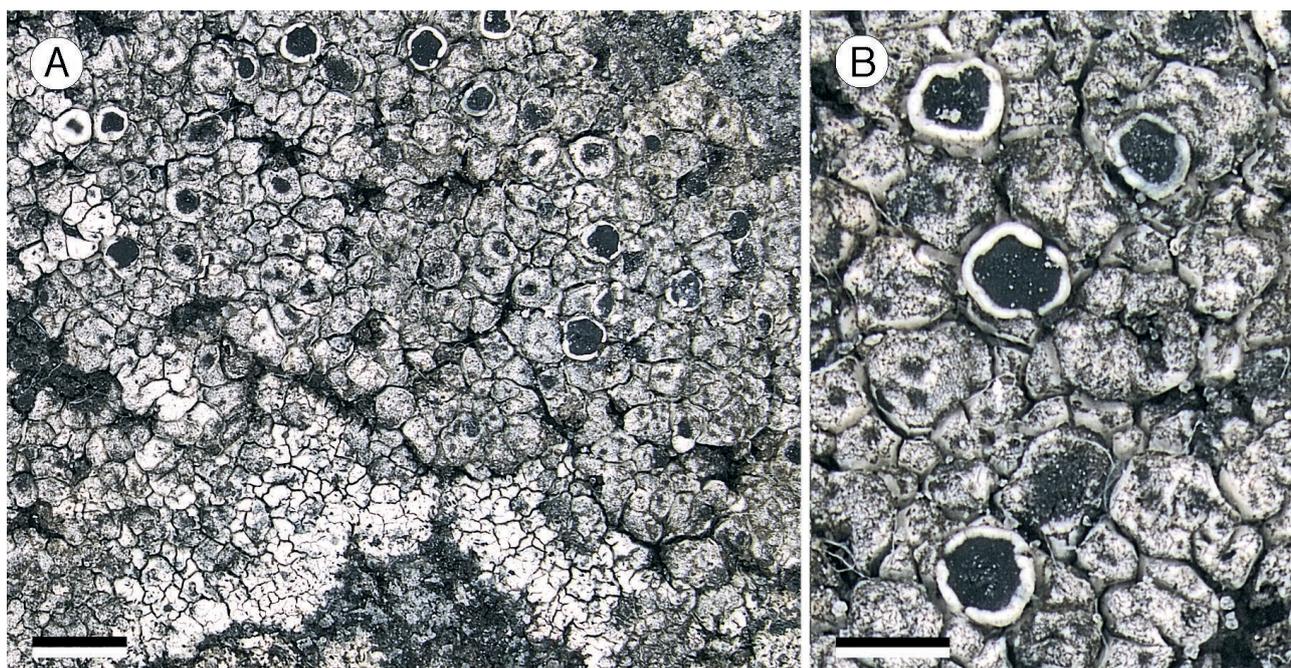


Fig. 1. *Tephromela baudiniana* (holotype). **A** Habit, scale = 2 mm; **B** Detail, scale = 1 mm.

Table 1. Salient features of saxicolous, free-living species of *Tephromela* in Australia.

| | secondary chemistry (key compounds) | asexual propagules | apothecial morphology | ascospore size | distribution |
|---|---|--------------------|-------------------------------|--------------------------------|-----------------------------|
| <i>T. arafurensis</i> Rambold | atranorin, perlatolic and glomelliferic acids | esorediate | ± immarginate to "lecanorine" | 9–14 × 5–7 µm ¹ | northern Australia (NT, WA) |
| <i>T. atra</i> (Huds.) Hafellner | atranorin, α-collatolic, alectoronic and bourgeanic (±) acids | esorediate | "lecanorine" | 11–17 × 5.5–9 µm ² | widespread, cosmopolitan |
| <i>T. baudiniana</i> Kantvilas & Elix | atranorin, alternariol, 9-O-methylalternariol | esorediate | "lecanorine" | 8–13 × 4.5–9 µm | Kangaroo Is (SA) |
| <i>T. buelliana</i> (Müll.Arg.) Kalb | atranorin, α-collatolic acid | | ± immarginate to "lecanorine" | 10–14 × 5.5–9 µm ³ | SA, Vic, Brazil |
| <i>T. granularis</i> Kantvilas | atranorin, α-collatolic, alectoronic and bourgeanic (±) acids | sorediate | "lecanorine" | 10–15 × 5–10 µm ² | Tas |
| <i>T. korundensis</i> (Räsänen) Kalb | atranorin | esorediate | ± immarginate | 6.5–12 × 6–9 µm ¹ | NE Qld |
| <i>T. lillipillensis</i> Elix | atranorin, alectoronic acid | esorediate | "lecanorine" | 7.5–14 × 6–7.5 µm ¹ | NSW, Qld |
| <i>T. promontorii</i> (Zahlbr.) Kalb | atranorin, α-collatolic and alectoronic acids | esorediate | ± immarginate | 7–13 × 5.5–7 µm ⁴ | SA, NT, Vic, South Africa |
| * <i>T. skottsbergii</i> (Darb.) Fryday | atranorin, α-collatolic and alectoronic acids | esorediate | "lecanorine" | 10–17 × 5–8 µm ¹ | Qld, NSW, Chile |
| <i>T. stenosporonica</i> Elix & Kalb | atranorin, stenosporonic acid | esorediate | "lecanorine" | 11–13 × 7–9 µm ¹ | northern Australia (NT, WA) |
| <i>T. territoriensis</i> Elix & Kalb | atranorin, physodic acid | esorediate | "lecanorine" | 7.5–8 × 5–6.5 µm ¹ | NT |

Data sources. ¹ Elix (2009); ² Kantvilas (2015); ³ Vainio (1890); ⁴ Elix (2013a).

**T. skottsbergii* is characterised further by having an hymenium interspersed with oil droplets.

polyketide chain, whereas α-collatolic and alectoronic acids, found in the widespread, morphologically similar *T. atra*, are derived from two partially reduced polyketide chains (Armaleo *et al.* 2011; Saha *et al.* 2012).

The new species has proved to be technically challenging to study. Although seemingly abundantly fertile, most apothecia sectioned proved to be devoid of mature asci or almost so, and literally dozens of sections were required to compile the observations necessary for a comprehensive description. Kantvilas (2015) noted that the ascospores of *Tephromela* may vary significantly in size, depending on their stage of development. In the present work, most measurements were of relatively young spores still within the ascus, and so their dimensions may have been underestimated. The thallus of the new species included numerous crystals detached from the rock substrate, which protrude through the upper surface or are enclosed within the medulla. We have not observed this in previous studies of the genus, even in collections from highly crystalline rocks such as granite, and it is not clear whether this is a product of the species or the substrate. No pycnidia were located, and the abundant speck-like features on the surface of the thallus proved to be mainly apothecial initials or crystalline inclusions.

Morphologically, *T. baudiniana* falls within the very broad range of variation exhibited by *Tephromela atra*, which is characterised by containing atranorin plus α-collatolic and alectoronic acids, usually together with bourgeanic acid. However, the very "chinky" rimose thallus, the absence of a prothallus and the relatively

small apothecia place it at the extreme of variation for that species.

Distribution and ecology. The new species is known only from the type locality where it was locally very abundant. It grew on dry, exposed siliceous rocks lining the course of a fast-flowing fresh water stream, but close to its mouth and therefore also subject to marine influences. Thus associated lichen species included truly littoral species such as *Caloplaca gallowayi* S.Y.Kondr., Kärnefelt & Filson, *Catillaria australilittoralis* Kantvilas & van den Boom and *Opegrapha spodopolia* Nyl., as well as species more typical of inland, non marine habitats, for example, *Xanthoparmelia australasica* D.J.Galloway and *Amandinea* spp.

Acknowledgements

We sincerely thank Dr Ernest Lacey, Microbial Screening Technologies, Smithfield, NSW, and Dr Andrew Piggott, Department of Chemistry & Biomolecular Sciences Macquarie University, NSW, for assistance with HPLC/MS analysis of an extract of this species. Dr Jean Jarman provided the photographs that illustrate this paper.

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Two species of *Bacidia* De Not. with pruinose apothecia from Kangaroo Island

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Abstract: Two species of the lichen genus *Bacidia* (Ramalinaceae) with pruinose apothecia from Kangaroo Island, South Australia, are described and illustrated: *B. septosior* (Nyl.) Zahlbr., a long-overlooked species that is widespread in south-eastern Australia, and *B. brigitteae* Kantvilas, described as new and known only from Kangaroo Island where it occurs in coastal *Melaleuca*-dominated woodland.

Keywords: taxonomy, lichens, South Australia, Ramalinaceae

Introduction

Bacidia De Not. (Ramalinaceae) is a large, cosmopolitan genus of lichens that occurs in virtually all vegetation and climatic zones of the world, ranges from sea-level to alpine elevations, and colonises a wide variety of substrata, including rock, wood, bark, soil and living leaves. The genus is well represented in Australia where 33 names in *Bacidia* have been recorded (McCarthy 2016), many based on Australian types, and all the major herbaria hold large numbers of specimens that are mostly unidentified or misidentified.

For decades, *Bacidia* in the traditional sense served as a useful “form” genus for crustose lichens with a green photobiont, biatorine or lecideine apothecia, eight-spored asci and hyaline, transversely multi-septate ascospores. However, as has occurred with most other form genera, such as *Buellia* De Not., *Catillaria* A.Massal., *Lecanora* Ach. and *Lecidea* Ach., new insights and the application of characters such as excipulum structure and, in particular, ascus type (Hafellner 1984) have led to the gradual segregation out of *Bacidia* of smaller, more natural units, sometimes classified in different families such as the Pilocarpaceae. Some of these smaller genera that occur in the Australian flora and that accommodate taxa formerly included under *Bacidia* include *Arthrorhaphis* Th.Fr. (Obermayer 2001), *Bacidina* Vězda (Vězda 1990), *Bapalmuia* Sérus. (Kalb et al. 2000), *Bryobilimbia* Fryday, Printzen & S.Ekman (Fryday et al. 2014), *Fellhanera* Vězda (Vězda 1990), *Fellhaneropsis* Sérus. & Coppins (Kantvilas & Lücking 2009), *Jarmania* Kantvilas (Kantvilas 2008), *Sarrameana* Vězda & P.James (Kantvilas & Vězda 1996) and *Scoliciosporum* A.Massal. (Kantvilas 2008).

In recent decades, there have been considerable advances in the study and delimitation of *Bacidia*, mainly in the Northern Hemisphere, and a large

body of literature pertaining to individual species or local regions now exists. Significant contributions of a broader application, and ones that assist understanding the species found in Australia, include the account for North American corticolous species (Ekman 1996), and flora treatments or keys for the Iberian Peninsula (Llop & Hladun 2002), Great Britain (Coppins & Aptroot 2009), the Sonoran Desert (Ekman 2004) and North America (B. McCune, unpublished mss). However, in Australia, the genus remains extremely poorly known and is, in some respects, the last of the “big genera” demanding detailed study and revision. It is noteworthy that since the resurgence of lichenology from the mid-20th Century onwards, the only contributions on *Bacidia* in Australasia remain the Flora account for New Zealand by Galloway (2007), and descriptions of new species by Elix (2009) and Coppins & Fryday (2007). In this author’s considered view, the many taxa listed by McCarthy (2016) represent only the very tip of a very large and complex iceberg.

For some years, the author has been gradually examining the types and reliably identified specimens of many *Bacidia* species in the major herbaria of the world, with the intention of bringing some order to those taxa that occur in southern Australia, especially Tasmania and Kangaroo Island, where most of his taxonomic studies have been focused. This work has proved to be extremely challenging due to the large numbers of species and specimens involved, and the subtle variation in critical species-level characters such as apothecial pigmentation, excipulum structure and ascospore dimensions. A comprehensive account for the region is clearly some way off, even though a few particular species have now been resolved. In this paper, two species with pruinose apothecia, a feature that is rather restricted in the genus, are treated; the work represents the first hesitant steps towards a broader study.

Material and methods

The study is based mainly on collections of the author housed in the Tasmanian Herbarium (HO), with additional material sourced from other herbaria as indicated in text. Anatomical and morphological observations were undertaken using light microscopy, with thin hand-cut sections mounted in water, 10% KOH, 50% HNO₃, Lactophenol Cotton Blue, ammoniacal erythrosin and Lugol's Iodine, with and without pretreatment with KOH. Ascospore measurements are based on at least 50 observations for each taxon and are presented in the format: 5th percentile–average–95th percentile, with outlying values given in brackets. Chemical composition was investigated by thin-layer chromatography using standard methods (Orange *et al.* 2001). Nomenclature of apothecial pigments follows Ekman (1996).

The species

Bacidia septosior (Nyl.) Zahlbr.

Catal. Lich. Univ. 4: 240 (1926); *Lecidea septosior* Nyl. in Crombie, *J. Linn. Soc., Bot.* 17: 400 (1880).

Type: [Australia, New South Wales] on bark of trees, near Port Jackson, *R. Brown* 562 (holo: BM!).

Thallus crustose, whitish grey to grey green, rather scurfy, smooth to somewhat verruculose, or, more commonly, patchy and evanescent, to 40–150 µm thick, forming irregular, undelimited patches to 15 cm wide or more; prothallus absent; photobiont chlorococcoid, with cells globose, 7–13 µm diam. *Apothecia* biatorine, 0.6–1.6 mm diam., scattered, urceolate and strongly basally constricted to almost substipitate when young, soon becoming disciform; disc plane at first, often

persistently so, or sometimes becoming convex, black to brown-black, matt, occasionally bluish grey pruinose when very young but soon becoming epruinose; proper excipulum persistent, sometimes becoming reduced in the oldest, most convex apothecia, with outer parts glossy red-brown and the upper edge intensely bluish grey pruinose when young, later becoming brown-black to black and the pruina restricted to the upper inner edge or absent, in section cupulate, 90–160 µm thick, at the upper edge red-brown to brown, K± purple-brown, N+ orange, internally ± colourless, composed of radiating, branched and anastomosing hyphae 1–1.5 µm thick in a gel matrix, lacking enlarged terminal cells, interspersed with bands of angular crystals to c. 5 µm wide that are insoluble in K. *Hypothecium* 140–200 µm thick, colourless throughout, or pale yellowish, intensifying yellowish in K and N in the upper part. *Hymenium* 120–160 µm thick, sparsely interspersed with oil droplets; epithecium grey-green, brownish green or brownish, K± intensifying greenish, N+ purple, sometimes rather fleetingly so and then fading to pale orange, also often slowly forming a precipitate of minute, dark blue crystals; paraphyses 1.5–2 µm thick, simple, not or only weakly capitate, ± separating readily in K, but with apices remaining conglutinated in epithelial pigment and sometimes expanded to 3 (–4) µm wide; asci of the *Bacidia*-type, narrowly cylindrical, with an amyloid tholus not entirely pierced by a ± non-amyloid, conical masse axiale, 90–110 × 14–20 µm. *Ascospores* arranged side-by-side or very loosely coiled in the ascus, filiform to narrowly cylindrical with rounded apices, easily fractured, (55–) 64.5–77.6–96 (–104) × 4–4.5–5.5 (–6) µm, 20–35-septate. *Pycnidia* very rare, immersed; conidia filiform, curved, aseptate, 15–20 × 0.5 (–1) µm. *Chemistry:* no substances detected by t.l.c. **Figs 1, 2B.**



Fig. 1. *Bacidia septosior* habit (Kantvilas 261/13). Note the youngest (smallest) apothecia with a characteristically pruinose inner margin. Scale = 5 mm.

Note on the type. The sheet in BM bearing Brown's type specimen also has a second collection in very poor condition, annotated in the same hand with "on the bark of tree, S. Coast of Tasmania, R. Brown".

Discussion. This highly distinctive species is characterised by the presence of crystals in the excipulum in combination with the pruinose apothecial margin and the particular suite of apothecial pigments. The pruina are best seen in young apothecia, and older apothecia may be entirely epruinose or with the pruina reduced to just the inner upper edge of the excipulum. Whilst some specimens may be dominated by black epruinose mature apothecia, careful examination will usually reveal vestiges of pruina on at least some apothecia. The crystalline inclusions in the excipulum are invariably present although rarely they may be few in number. The excipular pigment is *laurocerasi*-brown of Ekman (1996). The epithelial pigment is more variable but, in most collections, the dominant colour in water is greenish or greenish grey or greenish brown. With the addition of KOH, the pigment remains unchanged or the greenish hints intensify, whereas with HNO₃, it turns a vivid purple, then slowly fades to a pale orange; if this pigment is sufficiently concentrated, a precipitate of minute dark blue crystals may develop. The pigment appears to match *Bacidia*-green II of Ekman (1996).

Whilst this species, as defined above, is extremely clear-cut, there are herbarium collections, particularly from Tasmania, that have essentially identical apothecial pigments and ascospores, but lack both the apothecial pruina and the crystalline excipular inclusions; such

specimens are excluded from this species and require further study. The most similar species to *B. septosior* (Nyl.) Zahlbr., in that it has pruinose apothecia with crystals in the excipulum, is *B. brigittae*, which is described and discussed below. Also extremely similar is *Bacidia ceratina* (Stirt.) Hellb., described from New Zealand (lectotype in GLAM examined). This name was synonymised incorrectly with *B. laurocerasi* (Delise ex Duby) Vain. by Galloway (1985). Although *B. laurocerasi* and *B. ceratina* have some superficial features in common, the latter has crystalline excipular inclusions and occasionally pruinose apothecial margins identical to what is seen in *B. septosior*. Interestingly, neither of these features is noted in the original description of Stirton (1875). I have considered the possibility that *B. ceratina* may be an earlier name for *B. septosior*, but have declined to synonymise these taxa. Brown's Australian type of *B. septosior* matches subsequent collections of this species exactly. In contrast, the New Zealand type specimen of *B. ceratina* has a very thick, papillate-verruculose thallus that has never been observed in Australian specimens. Furthermore, no well-developed ascospores could be found in the *B. ceratina* specimen, but the hymenium is consistently thinner than that of *B. septosior*, and therefore presumably the ascospores may well be shorter.

Distribution and ecology. *Bacidia septosior* appears to be widespread in lowland, especially coastal areas of south eastern Australia (New South Wales, Victoria, Tasmania, the Bass Strait Islands and Kangaroo Island), where it occurs mostly on soft, spongy bark, such as on

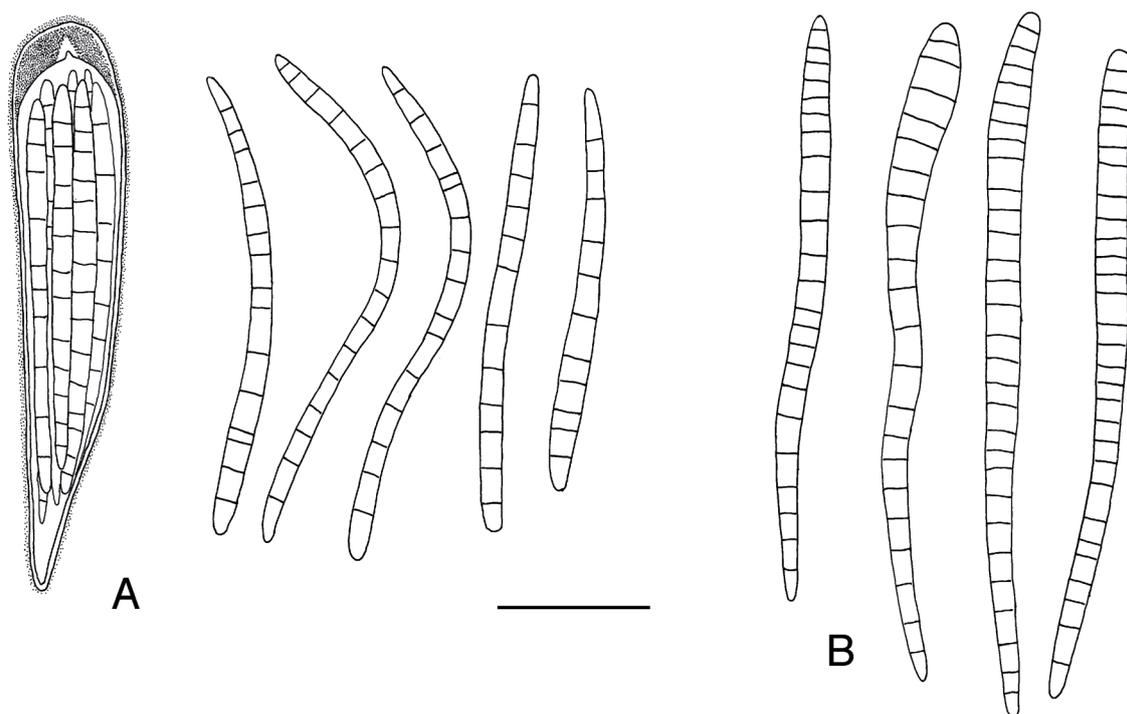


Fig. 2. Anatomy of *Bacidia*, showing typical, *Bacidia*-type asci and filiform, multi-septate ascospores. **A** *B. brigittae*; **B** *B. septosior*. Scale = 20 μ m.

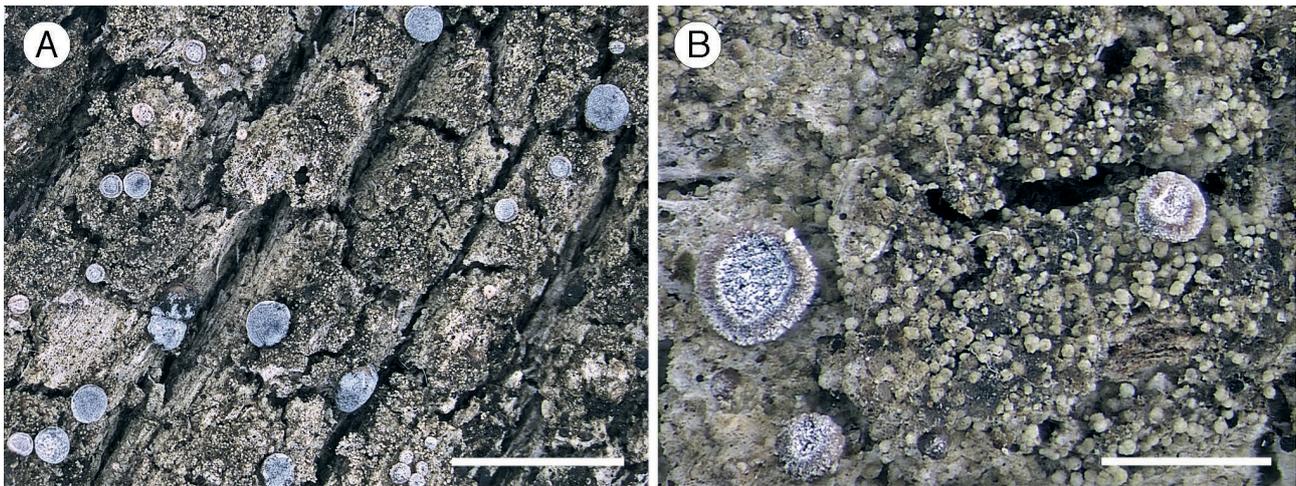


Fig. 3. *Bacidia brigitteae* (isotype). **A** Habit, showing persistently pruinose apothecia. Scale = 5 mm. **B** Detail, showing the characteristic, granular to goniocyst-like thallus. Scale = 1 mm.

the bases of eucalypts, *Callitris*, species of *Melaleuca*, or shrubs of the Asteraceae such as *Olearia* or *Bedfordia*. It appears to prefer marginally moister conditions, such as swampy *Melaleuca*-dominated woodland or older trees in locally damper microhabitats within dry eucalypt woodland. It is usually part of a rich association of epiphytic lichens, the more common of which include *Bacidia brigitteae* Kantvilas, *Megalania grossa* (Pers. ex Nyl.) Hafellner, *Menegazzia caesiopruinosa* P.James, *M. subpertusa* P.James & D.J.Galloway, *Pannaria elixii* P.M.Jørg. & D.J.Galloway, *P. obscura* Müll. Arg., *Parmotrema perlatum* (Huds.) M.Choisy, *Physcia poncinsii* Hue and *Pseudocyphellaria aurata* (Ach.) Vain.

Specimens examined

SOUTH AUSTRALIA, Kangaroo Island: Cape du Couedic Road, 1 km S of Rocky River Settlement, 35°57'S 136°44'E, 70 m alt., 1994, *H. Streimann* 54997 (AD, CANB); Willson River, 35°52'S 137°56'E, 1997, *R.J. Bates* 48365 (AD); Moffatt Road, 35°49'S 138°00'E, 70 m alt., 2011, *G. Kantvilas* 251/11 & *B. de Villiers* (HO); West Bay, 35°53'S 136°33'E, 10 m alt., 2011, *G. Kantvilas* 299/11 (AD, HO); Creek Bay Farm, headwaters of Lubra Creek, 35°49'S 138°06'E, 40 m alt., 2011, *G. Kantvilas* 379/11 (AD, BM, HO); Brown Beach, 35°48'S 137°50'E, 10 m alt., 2012, *G. Kantvilas* 435/12 & *B. de Villiers* (AD, CANB, HO); North Cape Road, 35°36'S 137°35'E, 5 m alt., 2013, *G. Kantvilas* 261/13 & *B. de Villiers* (HO); the Old Cannery, American River, c. 1 km SW of Ballast Head, 35°46'S 137°48'E, 3 m alt., 2013, *G. Kantvilas* 347/13 & *B. de Villiers* (AD, HO); Rocky River, 35°56'S 136°37'E, 10 m alt., 2015, *G. Kantvilas* 518/15 (HO); South-West River, 36°01'S 136°52'E, 10 m alt., 2015, *G. Kantvilas* 423/15 (HO). VICTORIA: Furnells Landing, 20 km S of Cann River township, 37°43'20"S 149°08'14"E, 1 m alt., 2008 *G. Kantvilas* 155/08 & *J.A. Elix* (HO). TASMANIA: southern coast, [1804], *R. Brown* s.n. (BM); Marrawah to Montague Track, 40°48'S 144°50'E, 30 m alt., 1986, *G. Kantvilas* 113/86 (HO); Swan Basin, 42°12'S 145°16'E, sea-level, 2000, *G. Kantvilas* 32/00 (HO); Buckland Military Training Area, S of Bluestone Tier, 42°30'S 147°48'E, 300 m alt., 2003, *G. Kantvilas* 325/03

(HO); eastern side of Stanley Hwy, 40°47'S 145°16'E, 5 m alt., 2011, *G. Kantvilas* 452/11 (HO); end of Bolduans Road, 40°47'S 145°02'E, 1 m alt., 2011, *G. Kantvilas* 474/11 (HO); Stony Point, 40°45'S 144°59'E, 2 m alt., 2016, *G. Kantvilas* 275/16 (HO). Bass Strait, Flinders Island: Patriarchs Inlet, 39°57'S 148°11'E, 1983, *J.S. Whinray* s.n. (HO, MEL).

Bacidia brigitteae Kantvilas, sp. nov.

Bacidia septosiori similis et item excipulo crystallis angularibus insperso sed thallo granuloso, apotheciis persistente griseo-pruinosis, hymenio tenuiore, 80–90 μm crasso, ascis parvioribus, 60–75 μm longis, 12–15 μm latis, et ascosporis brevioribus angustioribusque, 43–80 μm longis, 2.5–4 μm latis, modo 8–18-septatis praecipue differt.

Typus: South Australia, Kangaroo Island: Grassdale Lagoon, 36°00'S 136°53'E, 20 m alt., on *Melaleuca* in mallee woodland, 4 Oct. 2015, *G. Kantvilas* 326/15 & *B. de Villiers* (holo: HO 580598; iso: AD).

Mycobank number: MB821079.

Thallus granular or \pm goniocyst-like, bright to dull green, less commonly becoming evanescent and endophloeodal, forming irregular, often discontinuous, undelimited patches to 10 cm wide or more; individual granules crowded together or dispersed, 30–60 (–80) μm wide, sometimes somewhat isidioid in appearance, comprising tightly clustered photobiont cells in a sheath of rather short-celled hyphae 2.5–5 μm wide; prothallus absent; photobiont a unicellular green alga with globose cells 5–12 μm diam. *Apothecia* biatorine, 0.5–1.5 mm diam., scattered, superficial, basally constricted, disciform; disc mostly plane or occasionally becoming undulate or convex, pale brown but persistently and thickly pale grey pruinose from the earliest stages; proper excipulum persistent, somewhat inrolled when young and usually remaining \pm taller than the disc, only rarely excluded when the disc is highly convex, at first pale grey to pale brown, soon becoming brown to dark brown to black, persistently grey pruinose in the upper part and concolorous with the disc, on the underside epruinose, in section

cupulate, 50–110 µm thick laterally, 90–150 µm basally, colourless within but sometimes pale brownish, K–, N± pale orange at the upper edge, composed of radiating, anastomosing hyphae 2.5–3.5 µm thick in a gel matrix, lacking enlarged terminal cells, interspersed with clusters of angular, rectangular or rhomboidal crystals up to 10 µm across that do not dissolve in K but dissolve in N. *Hypothecium* 100–180 µm thick, colourless throughout or pale yellowish grey in the upper part, weakly intensifying yellowish in K and N. *Hymenium* 80–90 µm thick, colourless, occasionally sparsely interspersed with oil droplets, overlain by a greyish brown epithecium, K+ purplish brown, N+ crimson and fading; asci of the *Bacidia*-type, elongate-cylindrical, with an amyloid tholus not entirely pierced by a ± non-amyloid, conical masse axiale, 60–75 × 12–15 µm; paraphyses simple or sparsely branched, 1.5 (–2) µm thick, with apices not capitate. *Ascospores* filiform with blunt or acute apices, side-by-side or, less commonly, coiled in the ascus, (43–) 50–60.1–77 (–80) × (2.5–) 3–3.3–4 µm, 8–18-septate. *Pycnidia* not found. *Chemistry*: no substances detected by t.l.c. **Figs 2A, 3.**

Etymology. The new species is named in honour of Brigitte de Villiers, who has accompanied me throughout my excursions on Kangaroo Island, with great patience strongly supported my lichen investigations there, and co-collected the type as well as many other specimens.

Remarks. When first collected, this taxon was shoehorned, with considerable reservations, into *B. septosior* on the basis of having apothecia with an excipulum interspersed with crystals, and generally filiform, multiseptate ascospores. Morphological differences such as the persistently pruinose, disciform rather than somewhat urceolate apothecia and the granular thallus were initially considered unusual variations of *B. septosior*. The opportunity to observe this species in the field and make subsequent, rich collections soon confirmed that this taxon was indeed distinct, and that the distinctive morphological thalline and apothecial characters mentioned above were consistently evident. There are further anatomical differences between the two species. In *B. brigitteae*, the hymenium is always thinner, with concomitantly shorter asci. Furthermore, the ascospores are consistently shorter and narrower, with fewer septations. Apothecial pigmentation appears superficially rather similar and at least some of the described differences may be due to differences in pigment concentration, especially with respect to the excipulum. However, the epithelial pigment of *B. brigitteae* is different but difficult to characterise: there is no hint of greenish coloration in either water or KOH, yet it reacts crimson in HNO₃, but with no subsequent development of a dark blue precipitate.

According to Ekman (1996), a goniocyst-like thallus is unusual in *Bacidia*, and is more characteristic of the genus *Bacidina*. Yet the new species lacks the expanded, pseudoparenchymatous hyphae at the outer edge of the

excipulum that characterise *Bacidina*, and appears to belong comfortably in *Bacidia*.

Distribution and ecology. *Bacidia brigitteae* is known only from Kangaroo Island, where it grows on the soft, furrowed bark of *Melaleuca* in coastal old growth mallee woodland or *Melaleuca*-dominated woodland, in close proximity to rivers and lagoons where, presumably, humidity levels are higher, at least intermittently. Associated species include *Bacidia septosior*, *Caloplaca kaernefeltii* S.Y.Kondr., Elix & A.Thell, *Leptogium crispatellum* Nyl., *Pannaria obscura* Müll.Arg., *Physcia rolandii* Elix, *Psoroglaena halmaturina* P.M.McCarthy & Kantvilas, *Rinodina australiensis* Müll.Arg. and *Strangospora pinicola* (A.Massal.) Körb.

Specimens examined

SOUTH AUSTRALIA, Kangaroo Island: Ravine des Casoars, along riverbank, c. 0.5 km inland from coast, 35°48'S 136°35'E, 15 m alt., 2012, *G. Kantvilas* 482/12 & *B. de Villiers* (AD, HO); South-West River, 36°01'S 136°52'E, 10 m alt., 2015, *G. Kantvilas* 426/15 & *B. de Villiers* (AD, HO).

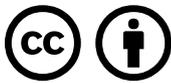
Acknowledgements

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Goodenia asteriscus (Goodeniaceae), a new arid zone species from north-western South Australia and eastern Western Australia

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Abstract: *Goodenia asteriscus* P.J.Lang, a perennial, facultatively stoloniferous, rosette-forming herb is described, illustrated and mapped, with distinguishing features and affinities also discussed. While this species belongs to a group characterised by unequal wings on the adaxial corolla lobes, it does not closely resemble any other species. An amendment to the *Flora of Australia* key is provided.

Keywords: biodiversity, new species, taxonomy, Australia, *Goodenia* subsect. *Goodenia*

Introduction

In May 2011, the second author collected a potentially new *Goodenia* species while employed by Outback Ecology Services to undertake an environmental assessment survey of the proposed Southern Borefield for the Metal-X Wingellina Nickel Project in far eastern Western Australia (WA), c. 100 km SW of Irrunytju (Wingellina) in the Ngaanyatjarra Aboriginal Lands. Davies (2011) noted its affinity to *Goodenia heteromera* F.Muell., a species not recorded from WA, but recognised it as different. He sent the collection (R.J.-P.Davies & L.Ransom LR868) to PERTH where it was examined by M. Hislop, who could not place it satisfactorily with any currently recognised species of *Goodenia* in WA. Hislop (pers. comm., 2011) confirmed the apparent affinity to *G. heteromera*, noting a similarly-shaped indusium, but pointed out that there were no signs of stolons on the specimen and that it had significantly larger seeds with much wider wings outside the range given for that species by Carolin (1992, p. 235). He suggested that it be referred to as *Goodenia* sp. aff. *quasilibera* (Davies & Alford 2012).

In November 2011 a further six collections were made by RJPD along a proposed access track for the borefield (Davies & Chapman 2011). These were referred to PJJ whose investigations of this and other material resulted in the description and account presented here.

Matching specimens assembled by M. Hislop and loaned from PERTH showed that the taxon had been collected twice elsewhere in WA. The first known collection was made in 1963 (*A.S. George 4809*) and the second in 1973 (*D.E.Symon 8437*). Neither had been identified to species, but an AD duplicate of the latter

had been identified as *Goodenia fascicularis* F.Muell. & Tate by R.C. Carolin in 1976.

A review of AD collections was made to see if it was also present in South Australia (SA), focussing on unidentified material and species of similar appearance from the adjoining North-western Region (NW). This uncovered four collections, all of which had been misidentified as *G. fascicularis*.

In 2016, a short visit to the Anangu Pitjantjatjara Yankunytjatjara Lands in the NW of SA by PJJ enabled additional field observations and collections for this paper, including the type.

Goodenia asteriscus P.J.Lang, sp. nov.

Type: P.J.Lang 2928 & C.J.Brodie, 11 Oct. 2016, 12.1 km NW Kunytjanu homeland, 48.3 km SSE from Pipalyatjara on road to Watarru, 26°35'11"S 129°16'55"E, North-western Region, South Australia (holo.: AD 278175; iso.: CANB, DNA, K, PERTH).

Goodenia sp. aff. *quasilibera* (L. Ransom 868) R.J.Davies & J.Alford, *Metals X Ltd Wingellina Nickel Proj. Level 1 Fl. & Veg. Assessment Wingellina Borefield Apr. 2012* (2012).

Goodenia fascicularis auct. non F.Muell. & Tate: Symon in W.R.Barker et al., *J. Adelaide Bot. Gard. Suppl.* 1: 133 (2005), partly.

Perennial, facultatively stoloniferous, rosette-forming herb 8–22 cm high, developing a woody taproot and thickened basal stem retaining old pedicel bases; vegetative parts strigose to sericeous, predominantly clothed in simple hairs that are antrorse, lightly to strongly appressed, laterally basifixed, straight to gently and irregularly curved, moderately thick and stiff, whitish (to pale gold) and translucent, sometimes

also with some obscure sparse minute short glandular hairs, and spreading, long, thin, irregular, white, septate, cottony hairs in and approaching axils and occasionally extending sparsely to lower parts of leaves. *Leaves* in dense basal rosettes, sometimes also terminal on flowering racemes transitioning to form secondary rosettes, procumbent to inclined adaxially, spatulate or (narrowly-) obovate to oblanceolate-elliptic, (15–) 25–65 × 5–18 mm (including petiole), all entire or earlier leaves entire and later ones dentate to pinnatifid and sometimes pinnatisect basally, with mid-dense antrorse simple hairs and obscure sparse small glandular hairs or the latter absent; lamina gradually tapering to an indistinct petiole, 10–35 mm long; margins with 0–8 lobes, each 1–9 × 1–3.5 mm; apex acute; stolons 40–75 (–100) mm long or absent. *Inflorescences* radiating from base of rosette, with 0–19 single-flowered ebracteolate scapes (20–) 30–90 (–110) mm long, stiff when mature, (usually) straight and persisting long after flowers or fruit have fallen, and 0–21 erect to decumbent 2–5 (–8) -flowered, ebracteolate racemes (30–) 60–140 mm long; bracts leaf-like, (narrowly) oblanceolate, 10–25 × 1.5–5 mm, entire, with acute apex, all (excepting sometimes the lowest) subtending pedicels; racemes

often contracted distally and grading to stolons bearing terminal rosettes; scapes, raceme axes, and pedicels with antrorse ± appressed simple hairs only, denser and more spreading at articulation with ovary. *Sepals* (narrowly) lanceolate to very narrowly elliptic 3.5–6 × 1–1.4 mm, their basal $\frac{1}{3}$ adnate to lower $\frac{1}{2}$ – $\frac{2}{3}$ of the ovary, outside with mid-dense antrorse, appressed, strigose, simple hairs and sparse short glandular hairs, inside glabrous. *Corolla* predominantly yellow, deeper towards the throat and paler on wings, grading to grey-violet with darker anastomosing venation on lower adaxial lobes and base of abaxial lobes to dark violet inside throat, 12.5–18 mm long, all of outside with dense indumentum of short glandular hairs, strigose hairs sparse, confined to lobe apices, or absent; tube 1.6–3 mm long to dorsal sinus of adaxial lobes, with pouch moderately developed and extending 1–1.5 mm below sepal lobe attachment but 0.5–0.8 mm short of ovary base; without enations, erect short simple hairs on much of inside of tube and throat and extending forwards along lateral margins of a raised, thickened yellow zone below the median lobe; auricles exceeding indusium, overlapping each other and obscuring indusium in flower; corolla lobes often decurved. *Abaxial corolla lobes* (3.5–) 4.5–8 (–9.3) × 1.5–2.3 mm, fused for 5–8 mm beyond junction with adaxial lobes, apex acute; wings along terminal 2.5–6.5 mm of lobes, 3.5–7.5 (–9) mm × 1.3–3.2 mm, projecting 0.8–2.5 mm beyond lobe apex, with entire margins. *Adaxial*



Fig. 1. *Goodenia asteriscus*, 92 km SW of Wingellina, WA, on 21 Nov. 2011 (R.J.Davies 464). **A** Old plant with a woody base, persistent radiating scapes and entire leaves; **B** closer view of flowers.



Fig. 2. *Goodenia asteriscus*, c. 12 km NW Kunyntjanu homeland, SA, on 11 Oct. 2016. **A** Decumbent plant with lobed leaves (P.J.Lang 2928 & C.J.Brodie, Holotype); **B** young plant with prostrate inflorescences in early stage of transition to stolons (P.J.Lang 2926 & C.J.Brodie).

corolla lobes 7–11.5 × 1–1.9 mm, fused to throat for a further 1–3.5 mm to their divergence at dorsal sinus; auricle yellowish-white, cuneate-cymbiform, 3.2–5.5 × 1.5–2.1 mm, with a fringe of hairs 0.2–5 mm long along its junction with lobe; wings unequal, above the auricle vestigial and 0.15–0.4 (–0.8) mm wide, on opposite side along terminal 2.3–4.2 mm of lobe, 3–7 × 1–2.5 mm, with entire margins. *Stamen* filaments linear, dorsiventrally flattened, 2.5–4 mm long, anthers (narrowly) oblong 1.6–2.4 × 0.4–1 mm, base auriculate. *Ovary* 3–4.8 × 1.9–2.8 mm, narrowly obovate, tapering basally into a short stalk for 0.3–1.5 mm above articulation with pedicel; septum incomplete, $\frac{2}{3}$ length of locules, glabrous; ovules 38–48. *Style* straight, 3.3–4.5 × 0.8–1.0 mm, expanding to 1.8 mm at junction with indusium, with spreading fine soft simple hairs 0.2–0.3 mm long, denser on underside and forming a beard at indusium junction. *Indusium* light brown, convex above, dorsi-ventrally compressed, obverse-trapeziform, slightly wider than long, 1.5–2.2 × 1.6–2.6 mm, glabrous on back, apical margin straight on dorsal side, retuse on ventral side, orifice narrow, bristles dense, white, flexed upwards on dorsal lip, reflexed on ventral lip, grading in length from 0.2 mm at margins to 0.7 mm at centre. Fruit (widely-) ellipsoid, 7–10 × 5–7 mm. Seeds (3.5–) 4–6.2 × (3–) 3.5–5.2 mm, not mucilaginous; seed body brown, flat to lightly convex, broadly lacrimiform-obovate, seed coat shallowly reticulate; wing (0.7–) 1–1.9 mm wide, pale-brown to stramineous, continuous with seed body. **Figs 1–6.**

Affinities and distinctive features. *Goodenia asteriscus* belongs in *Goodenia* sect. *Goodenia* subsect. *Ebracteolatae* K.Krause, based on its yellow corolla, prominent seed wing and the absence of bracteoles. Within this subsection it fits Group 8 in the *Flora of Australia* key of Carolin (1992) defined by “Flowers not bracteolate; corolla wings unequal on [adaxial]¹ lobes”. It is a distinctive species that does not closely resemble any other.

Goodenia asteriscus is most like *G. heteromera* and *G. pascua* Carolin in the very strong differentiation of the adaxial (or posterior) corolla lobes, and with these two species also shares a convex brownish indusium with reflexed white bristles, articulate pedicels, and reticulate seeds with prominent wings. *Goodenia pascua* is readily distinguished by its well-developed long racemes, the absence of pedicels arising directly from the rosette, and its smaller flowers (6–10 mm long) with the outside of the corolla covered in strigose hairs. The corolla of *G. pascua* has a distinctive brown throat, and the corolla of *G. asteriscus* most closely resembles that of *G. heteromera* where the adaxial lobes differ from the abaxial ones, not only by their markedly unequal wings (very narrow or vestigial on the side above the auricle), but also by having purple-violet coloration and dark veining extend further up from the base of the lobes

towards the apex² (Figs 6 & 7). However, compared to *G. heteromera*, *G. asteriscus* has larger flowers 12.5–18 mm long (vs. 6–11 mm), with a well-defined corolla pouch (vs. weakly or not developed); larger auricles much exceeding the indusium (vs. similar in length to indusium), but with much shorter fringing hairs; and larger seeds 3.5–5.2 mm diam. (vs. 1.5–2.5 mm) with a proportionately wider and more confluent wing (vs. edge of seed body bevelled near wing junction). Also, the indusium differs in detail, being broader and dorsiventrally compressed with a thin orifice (cf. more elongate and barrel-shaped with a gaping orifice in *G. heteromera*). A distinctive feature is the marked gradation in bristle length across the indusium orifice (cf. gradation weak or not apparent in *G. heteromera*) (Figs 6 & 7).

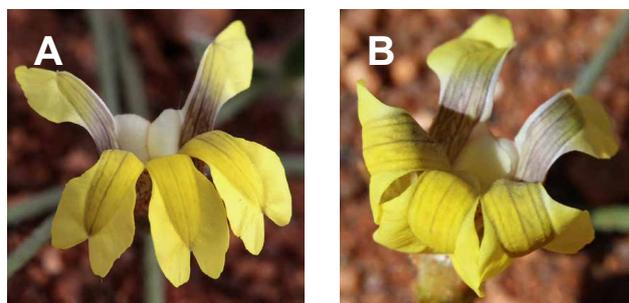


Fig. 3. *Goodenia asteriscus*, flowers. **A** P.J.Lang 2928 & C.J.Brodie (Holotype); **B** P.J.Lang 2926 & C.J.Brodie.



Fig. 4. *Goodenia asteriscus* (D.E.Symon 8437). **A** Mature fruit; **B** dissepiment.



Fig. 5. *Goodenia asteriscus*, seeds (R.J.Davies 461).

¹ in error as “abaxial” as noted by Sage (2000, p. 375)

² This difference is sometimes obscured on pressed specimens as the darker coloration becomes stronger and more extensive on drying.



Fig. 6. *Goodenia asteriscus* (P.J.Lang BS23-25475). **A** Pressed flower, showing auricles much exceeding the indusium, and markedly unequal adaxial lobe wings; **B** closer view of different flower, showing indusium with gradation in length of bristles at orifice.



Fig. 7. *Goodenia heteromera*. **A** Pressed flower, showing adaxial corolla lobes with unequal wings (P.J.Lang 2275); **B** closer view, showing indusium with orifice bristles of \pm even length and the relatively small auricles (D.J.Duval 2298).



Fig. 8. *Goodenia elongata*. **A** Pressed flower, showing adaxial corolla lobes with equal wings and elongate auricle exceeding the indusium, which has its left side partly folded under (M.Fagg 354); **B** closer view, showing transversely oblong indusium with orifice bristles of \pm even length and dorsal hairs; glandular hairs on outside of corolla visible on lower left adaxial lobe (R.Bates 6675).

Recent DNA sequencing (Shepherd *et al.*, in prep.) places *G. asteriscus* (represented by *R.J.-P.Davies & L.Ransom LR868*) as sister to *G. elongata* Labill., before linking to clades with *G. heteromera* and *G. pascua*. In *G. elongata* the adaxial corolla lobes are relatively undifferentiated with their wings either equal (in most specimens observed) (Fig. 8A) or only a little narrower above the auricles. This species also shares the broadly similar indusium, articulate pedicels, and reticulate, prominently winged seeds, but in addition matches *G. asteriscus* by its glandular hairs on the outside of the corolla (although varying from mid-dense to sparse) (Fig. 8B), large elongate auricles, and large flowers.

Goodenia elongata is a species of damp habitats confined to south-eastern Australia. In addition to the equal to sub-equal adaxial corolla wings, it is readily distinguished from *G. asteriscus* by its rhizomatous and erect habit with well-developed cauline leaves and weak rosette formation (vs. facultatively stoloniferous rosettes), variable indumentum of stems and leaves ranging from glabrous to mid-dense and sub-appressed to strongly spreading (vs. mostly mid-dense and lightly to strongly appressed), and a transversely oblong indusium more than twice as wide as long (vs. slightly wider than long) bearing simple hairs on its back (vs. glabrous) and shorter orifice bristles of uniform length (Fig. 8B) (vs. grading to longer in the centre).

Stolon production in *G. asteriscus* is much less strongly developed than in *G. heteromera*, a trait which enables that species to rapidly colonise wet clay soils in its flood plain habitats subject to temporary inundation. Fully differentiated stolons were seen in only a few collections of *G. asteriscus* (e.g. *D.E.Symon 8437*, *P.J.Lang 2959 & C.J.Brodie*), while some others had intermediate states in transition from racemes. Furthermore, individual plants varied widely in the proportion of racemes to single-flowered scapes arising from the main rosette. Counts of racemes vs. scapes ranged from 10:1 and 17:3 at one extreme through to 1:5 and 0:25 at the other. Variation in the ratios of these inflorescence types was independent of rosette size, and together with occasional development of stolons from racemes is indicative of different growth phases, possibly determined by conditions in the immediate environment.

The particularly large auricles (Fig. 6), also present in *G. elongata*, are a notable feature of *G. asteriscus*. In all fresh flowers of *G. asteriscus* observed, they overlapped each other and completely obscured the indusium (Figs 1B & 3), similar to the effect noted and illustrated by Holland (2015, p. 64, fig. 2) for *G. effusa* A.E.Holland. Holland (2012, p. 690) found enclosing of the indusium by the auricles in *G. minutiflora* F.Muell. to be variable and suggested that this might be due to flowering stage or an artefact of pressing. However, field observations of *G. asteriscus* showed it to be consistent during flowering. In *G. heteromera* the auricles are only large enough to partly cover the indusium (Fig. 7B). Yeo (1993, p. 150) suggested that sheltering of the

indusium by the auricles was important in controlling access to pollen and favoured pollination by bees.

Although *G. quasilibera* Carolin is similar to *G. asteriscus* in having glandular hairs on the outside of the corolla, it differs significantly in other characters and analyses of both cpDNA markers and the nrDNA Internal Transcribed Spacer indicate that it is not closely related (Shepherd *et al.*, in prep). Other major differences include non-reduced adaxial lobe wings, a prominent corolla pouch or spur (often extending beyond the base of the ovary), the indusium with a concave margin at its orifice and glandular and simple hairs on its dorsal surface, and distinctive black seeds with a narrow overlapping wing.

Goodenia fascicularis, with which earlier collections were sometimes confused, is readily distinguished by the outside of its corolla lacking glandular hairs but covered in strigose hairs, a broader and less convex indusium with bristles uniform in length, and wings \pm equal in width on the adaxial corolla lobes.

The *Goodenia* key in *Flora of Australia* (Carolin 1992, p. 164) should be amended for Group 8 by replacing couplet 6 with the following:

6. Plant stoloniferous

6a. Corolla > 12 mm long, outside mainly covered by short glandular hairs ***G. asteriscus***

6a: Corolla < 11 mm long, outside mainly covered by simple strigose hairs ***G. heteromera***

6: Plant not stoloniferous

6b. Rosette-forming herb ***G. asteriscus***

6b: Herb or subshrub with erect leafy stems **7**

Distribution. The known distribution of *G. asteriscus* spans 220 km from west of Cavenagh Range in WA to Mt Lindsay (Watarru) in the NW Region of SA, in areas that are not dominated by dense dunefields (Fig. 9). It is also reported for the Northern Territory, just across the border from SA, where P. Latz observed sterile plants matching those of *P.Latz 24770*.

Ecology. The species grows in hard clay and loam soils and is able to colonise compacted gravelly surfaces of road margins (*P.J.Lang 2926 & C.J.Brodie*) and an 'airway scrape' (*D.E.Symon 847*). It has been mostly found on limestone plains with outcropping calccrete or nodular limestone and associated plant communities dominated by *Triodia scariosa* hummock grassland, often with emergent *Eucalyptus socialis* subsp. *eucentrica* open mallee or *Acacia kempeana* open shrubland. The associated suite of plants recorded in the Wingellina Nickel project area (Davies 2011, Davies & Alford 2012), and those observed near Kunitjanu, closely fit floristic Group 22 'Spinifex Hummock Grassland on Limestone Plains' of Lang *et al.* (2003, p. 171), an extensive community in the Anangu Pitjantjatjara Yankunytjatjara Lands of South Australia.

A collection from NE slopes of a rocky hill known as 'Scarface' in the Tomkinson Ranges (J.Z. Weber 5397), is an exception to this habitat. It was confirmed by the discovery of a single plant (P.J. Lang 2959) on a rocky slope of the same range system composed of dark red-brown ultra-mafic rock.

Flowering. Mainly Sep.–Jan.

Conservation status. *Goodenia asteriscus* has been infrequently collected and the populations observed in the Wingellina borefield area (RJP) and NW of Kunytjanu (P.J.L.) amount to only a few hundred individuals in total. However, the widespread occurrence of its major habitat type, in terrain with limited road and track access, means that many more populations may exist. Until targeted surveys are undertaken, and in the absence of any discernable threatening processes, it is best assigned to the 'Data Deficient' category (IUCN 2017).

Etymology. The epithet, a Latin noun in apposition, is derived from the Greek *asteriskos* meaning 'little star'. It alludes generally to the radiating pattern of peduncles and secondary rosettes, but more particularly to the disposition of persistent flower scapes reminiscent of an asterisk symbol. A number of *Goodenia* species retain their scapes long after flowers or fruits have abscised, but this is a pronounced feature in *G. asteriscus*. Similar long, stiff, straight persistent radiating scapes are also seen in *G. pedicellata* L.W.Sage & K.W.Dixon (Sage & Dixon 2005, p. 515, fig. 1) and *G. gibbosa* Carolin (e.g. E.A. Shaw 450, 451) although these are not closely related.

***Goodenia asteriscus* other specimens examined**

WESTERN AUSTRALIA: R.J.Davies 460 (-462, -464, -465, -466), 93 (-91, -92) km direct SW of Wingellina, c. 9 (-10.5) km direct W of Tjuntjuntjarra Track, on proposed access track route, (20–) 21 Nov. 2011 (AD); R.J.-P.Davies & L.Ransom LR868, Great Victoria Desert, c. 100 km SW of Wingellina township, towards southern end of proposed Southern Borefield for Metal-X Wingellina Nickel Project, 6 May 2011 (PERTH); A.S.George 4809, N end of Cavanagh [Cavanagh] Range, 8 Jul. 1963 (PERTH); M.Henson & M.Hannart 32638, 28 km SSE of Warburton [coordinates plot as: 113 km W of Warburton & 28 km S of Jameson Community], 29 Nov. 2011 (PERTH); D.E.Symon 8437, Blackstone Range, Wingellina [Wingellina], 8 Jan. 1973 (AD, PERTH; NSW *n.v.*).

SOUTH AUSTRALIA: **North-Western:** N.N.Donner 6458, up to c. 1 km SW of Krewinkel Hill, 2 Sep. 1978 (AD; G *n.v.*); P.J.Lang BS23-25475, 12.2 km NW of Kunytjanu Homeland on road to Pipalyatjara, 3.0 km direct WNW of Krewinkel Hill, 5 Sep. 1995 (AD, PERTH); P.J.Lang 2926, 2927, 2930 & C.J.Brodie, (12.1–) 12.2 km NW Kunytjanu homeland, 48.2 (–48.3) km direct SSE from Pipalyatjara, 12 Oct. 2016 (AD); P.J.Lang 2959 & C.J.Brodie, 0.85 km SW Kalka

community, on mid-slopes of Dulganina Hill range, 12 Oct. 2016 (AD); P.Latz 24770, 5 km NNW of Aparatjara, on track to Lake Wilson, 53 km E of Kalka, 3 Sep. 2009 (NT *n.v.*, image seen, AD *n.v.*, PERTH *n.v.*); D.E.Murfet BS23-27534, 14.5 km from Mt Lindsay NE towards Kintore Ave turn-off, 10.8 km direct NNE Wartaru [Watarru], 5 Sep. 1995 (AD); J.Z.Weber 5397, Tomkinson Ranges, Dulganina Hills, NE slopes of Scarface, c. 9 km direct NW of Mt Davies summit, 2 Sep. 1978 (AD; COLO *n.v.*).

***Goodenia quasilibera* type specimens examined**

WESTERN AUSTRALIA: A.S.George 2171, Thomas River valley, N of Homestead, 10 Dec. 1960 (Holotype, PERTH).

Acknowledgments

Support from Sara Weir and Anangu trainee rangers at Pipalyatjara in facilitating a revisit by P.J.L. of the population NW of Kunytjanu homeland, and from Chris Brodie for field assistance on that trip, was much appreciated. We are grateful for the initial investigation of WA collections by Mike Hislop, the loan of specimens from PERTH herbarium, and refinements to this paper suggested by Kelly Shepherd and Dave Albrecht.

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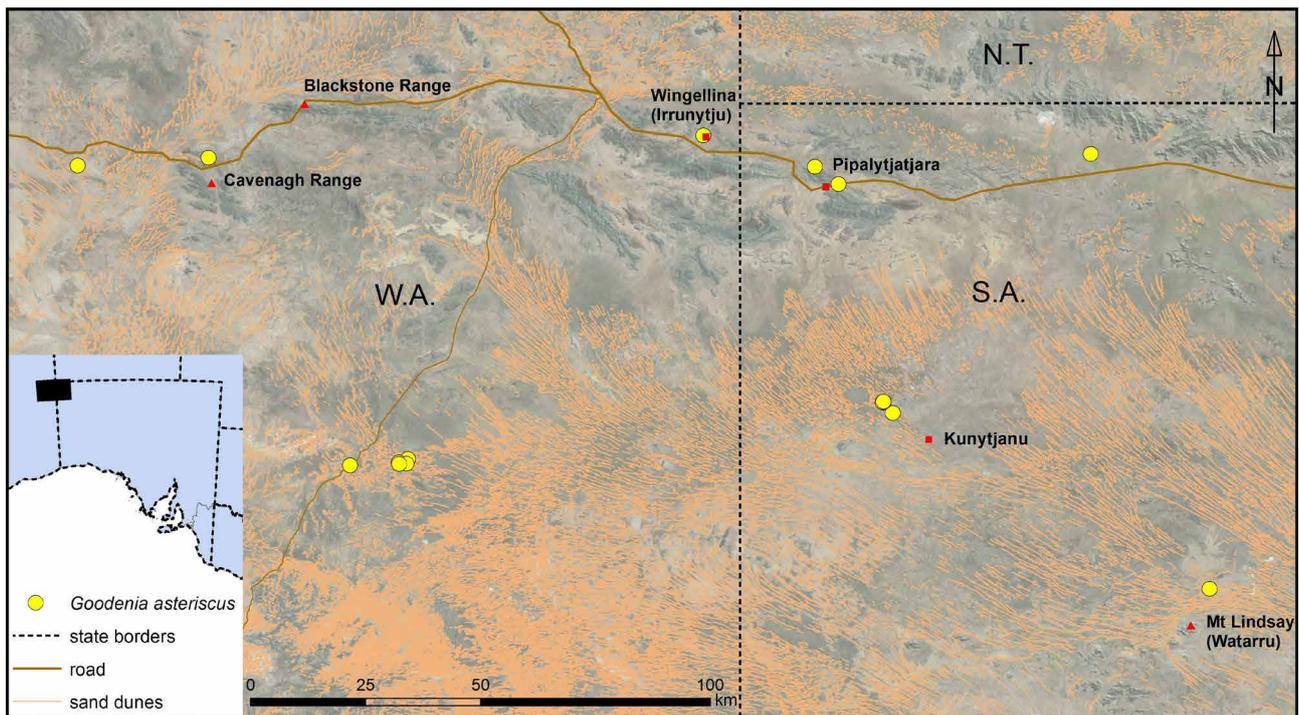


Fig. 9. *Goodenia asteriscus*, known distribution.

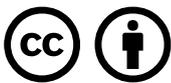
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Pertusaria crassilabra Müll. Arg. – a reinstated name for an Australasian lichen

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Abstract: *Pertusaria crassilabra* Müll. Arg., based on a Victorian type specimen and hitherto considered a synonym of *P. melanospora* Nyl., is reinstated and recorded for south-eastern Australia (including Tasmania) and New Zealand. The species is described and illustrated. *Pertusaria amaurospora* Hellbom and *P. melanospora* var. *sorediata* Elix & A.W.Archer are synonyms of *P. crassilabra*. The occurrence in Australasia of *P. melanospora* sens. str., based on a type from South America, is considered doubtful.

Keywords: Australia, biodiversity, lichenised fungi, New Zealand, Pertusariaceae

Introduction

Pertusaria DC. is one of the largest genera of lichenised fungi and, with 191 formally recorded taxa, certainly one of the largest in Australia (McCarthy 2017). The genus has been extensively studied in the region, in particular by the Australian lichenologist, Alan Archer, who, alone or in collaboration, compiled several, continent-wide accounts (Archer 1997, 2004; Archer & Elix 2016). Regional studies for Tasmania (Kantvilas 1990, Kantvilas & Elix 2008) and New Zealand (Galloway 1985, 2007) have also been published.

Although most species of *Pertusaria* have colourless ascospores, a small number are known to develop brown or grey-brown spores at maturity or at senescence. One such species is the aptly named *P. melanospora* Nyl. This saxicolous species is based on a type from Chile (Nylander 1855) but has been more widely recorded, including for Australia (Archer 1997) and New Zealand (Archer & Elix 1993) and Southern Africa (Stizenberger 1890). Along the way, several Australasian *Pertusaria* names have been consigned to synonymy with *P. melanospora*; viz. *P. crassilabra* Müll.Arg., *P. amaurospora* Hellbom and *P. limescens* Zahlbr. More recently, Elix & Archer (2013) described a sorediate variety of *P. melanospora*, based on material from Kangaroo Island, South Australia, but also recorded from elsewhere in south-eastern Australia and New Zealand.

The present study is based on a review of Australasian herbarium material filed as *P. melanospora*, field work in Tasmania, Kangaroo Island and New Zealand's North Island, study of specimens of *P. melanospora* sens. str. from South America, and an examination of relevant type material. As a result, a long-disused name, *P. crassilabra* is reinstated for the Australasian taxon, and the occurrence of *P. melanospora* in Australasia is considered doubtful.

Material and methods

Anatomical and morphological observations were undertaken using light microscopy, with thin hand-cut sections mounted in water, 10% KOH, lactophenol cotton blue and ammoniacal erythrosin. Ascospore measurements are presented in the format: 5th percentile–average–95th percentile, with outlying values given in brackets; these are based on 45 observations for each taxon. Routine chemical analyses by thin-layer chromatography follow standard methods in lichenology (Orange *et al.* 2001).

Taxonomy

Pertusaria crassilabra Müll.Arg.

Hedwigia 32: 126 (1893). – **Type:** [Australia] Victoria: Loutit Bay [near Lorne], 1891, *Luehmann s.n.* (holo: G!).

Pertusaria amaurospora Hellbom, *Bih. Kongl. Svenska Vetensk.-Akad. Handl.* 21(3) 13: 73 (1896). – **Type:** New Zealand, South Island, Maunganui, near Taurunga, Dec. 1874, *S. Berggren* [lecto.: S! (L5124), *fide* Galloway 1985; isolecto.: S! (L986, L5125, L5126)].

Pertusaria melanospora var. *sorediata* Elix & A.W.Archer, *Australas. Lichenol.* 73: 8 (2013). – **Type:** Australia, South Australia, Kangaroo Island, Cape St Albans, 35°48'S, 138°07'E, 20 m alt., on laterite in pasture, 24 Sep. 2010, *G. Kantvilas* 176/10 (holo.: HO!; iso.: AD!).

Pertusaria melanospora auct. non Nyl.: A.W.Archer, *Biblioth. Lichenologica* 69: 104 (1997), *Fl. Austral.* 56A: 146 (2004); A.W.Archer & Elix, *New Zealand J. Bot.* 31: 111 (1993), *Austral. Pertusaria* 85 (2016); D.J.Galloway, *Fl. New Zealand Lich.* (ed. 2) 1150 (2007).

Thallus crustose, very tightly adnate, rimose-areolate, dull yellowish or brownish yellow, up to 10 cm wide or more, sorediate; individual areoles 0.1–0.5 mm wide, to 200 (–500) μm thick, plane or slightly convex, contiguous or dispersed over an effuse, patchy, pale greyish prothallus, with an upper cortex 20–30 μm thick, composed of short-celled hyphae 4–5 μm wide; soredia whitish or greenish white, coarse, sometimes becoming elongate, corticate and “pseudoisidiate” at the most mature stage, arising in irregular soralia 0.3–0.5 mm wide, formed by a disintegration of the thallus upper cortex, typically sparse and inconspicuous, but sometimes spreading across the entire thallus; photobiont a unicellular green alga with individual cells globose, 6–14 μm diam. *Apothecia* verruciform, smooth or rather wrinkled, apically flattened, when well developed 0.4–1.3 mm wide, constricted at the base and appearing lecanorine; ostioles mostly 1–4 per verruca, at length gaping, to c. 0.4 mm wide and appearing disc-like. *Epithecium* brownish grey, weakly K+ violet, C+ violet. *Ascospores* 4–8 per ascus, at first hyaline, later bluish grey to brownish, K+ violet, C+ violet, ellipsoid to ovate, 48–58.4–74 (–76) \times 24–31.8–40 (–42) μm ; wall mostly 10–15 μm thick. *Pycnidia* immersed, flask-like, 60–100 μm wide, visible as black specks in the surface of the thallus; conidia filiform, mostly \pm straight, 16–22 \times 0.8–1 μm . **Figs 1–2.**

Chemistry. Arthothelin; thallus K–, KC+ orange, C+ orange, P–, UV+ dull orange. Elix & Archer (2013) also record 4,5-dichloronorlichexanthone, 2,5-dichloronorlichexanthone, 2,4-dichloronorlichexanthone (\pm), thiophanic acid (\pm) and atranorin (\pm) in trace concentrations.

Remarks. *Pertusaria crassilabra* is very distinctive and has no known confusing species within its distributional range. Perhaps the most similar species, on account

of its verruciform apothecia and sometimes yellowish thallus, is *P. lophocarpa* Körb., but this common taxon differs by having an esorediate thallus containing 2'-O-methylperlatolic acid as the major secondary substance, has larger apothecia (to 1–3 mm wide) and colourless ascospores (unpubl. observations and Archer 2004). Fertile material of *P. crassilabra* is rather uncommon (for example, none has been collected in Tasmania) but the yellowish, areolate, C+ orange thallus with scattered soralia is unmistakable. The degree of development of soredia is highly variable. In some specimens, including the type specimens, they are sparse and associated mainly with abraded parts of the thallus. Such a specimen is illustrated by Archer & Elix (2016, Fig. 75) as *P. melanospora* var. *melanospora*. In others, the soredia spread across the entire upper surface and may become elongate, corticate and essentially pseudoisidiate (for example, see Fig. 2). There does not appear to be any obvious correlation between development of soredia and habitat factors and all specimens seen display at least some evidence of soredia. The K+, C+ violet pigment has not attracted comment from previous Australasian workers, although it is noted by Schmitt *et al.* (2006) in their study of some related North American taxa. It is consistently present and displays the same reactions as *sedifolia*-grey of Meyer & Printzen (2000), a pigment that is scattered amongst lichens, occurring, for example, in species of *Micarea* Fr. and *Rimularia* Nyl., and in *Pertusaria erubescens* (Taylor) Nyl.

Although clearly related to *P. melanospora sens. str.* and sharing \pm identical ascospores and thallus chemistry, *P. crassilabra* consistently has a distinctly thinner, chinky-areolate, sorediate thallus, morphological characters that justify recognising these taxa at species rank. In the course of this study, I have examined a wide range of Australasian specimens labelled as *P. melanospora* in various herbaria (as listed below) and found all to be



Fig. 1. *Pertusaria crassilabra* habit (Kantvilas 176/10), showing the rimose thallus, scattered soralia and basally constricted, verruciform apothecia. Scale = 2 mm.

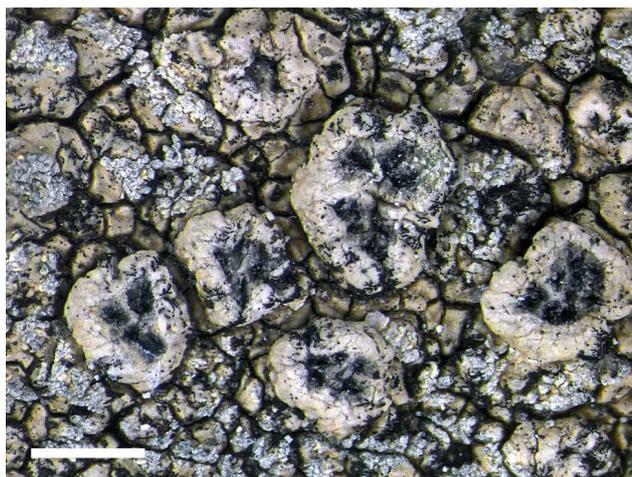


Fig. 2. *Pertusaria crassilabra* detail (Kantvilas 176/10). Note the "Lecanora-like" apothecia with multiple, black ostioles, and the coarse, pseudoisidiate soredia (top left). Scale = 1 mm.

sorediate, and therefore matching *P. crassilabra*. The presence of *P. melanospora* in Australasia is thus highly doubtful, given that all specimens cited by Galloway (1985) and Archer & Elix (1993) are sorediate.

The type specimen of *P. amaurospora* is clearly sorediate and conspecific with *P. crassilabra*. Galloway (1985) regarded *Pertusaria limescens* Zahlbr., based on a type collection from New Zealand's South Island, as a synonym of *P. amaurospora*, albeit with some doubt as he did not examine the type collection. Subsequently, both of these taxa were listed as synonyms of *P. melanospora* by Archer & Elix (1993). I am reluctant to accept *P. limescens* as a synonym until authentic material can be located and studied. The original description of Zahlbruckner (1941) makes no mention of certain critical characters, such as, for example, the distinctly yellowish thallus or the pigmented ascospores; instead the thallus is described as K+ reddish, C–, and the spores as uncoloured.

Distribution and ecology. *Pertusaria crassilabra* is known from Kangaroo Island and mainland South Australia, from Victoria, Tasmania, New South Wales, the Australian Capital Territory, and the North and South Islands of New Zealand. It has a very wide distribution on exposed rocks, but chiefly in drier areas and especially at the coast. Elix & Archer (2013) list a suite of lichens with which *P. crassilabra* (under its synonym, *P. melanospora* var. *sorediata*) may be associated with and which indicate its broad ecological amplitude.

Selected specimens examined

TASMANIA. Furneaux Islands, East Kangaroo Island, 40°10'S 147°54'E, 3 m alt., 20.iv.1969, *J.S. Whinray s.n.* (MEL); Cockle Bay Lagoon, 42°42'S 147°56'E, 1 m alt., 24.vii.2011, *G. Kantvilas 218/11* (HO); Spiky Bridge, 42°11'S 148°04'E, 60 m alt., 11.viii.2011, *G. Kantvilas 225/11* (CANB, HO); Gunners Quoin, 42°46'S 147°19'E, 440 m alt., 1.iv.2013, *G. Kantvilas 23/13* (HO); Lucas Point,

Fishermans Haul, 43°02'S 147°20'E, 1 m alt., 8.xii.2013, *G. Kantvilas 407/13* (HO); Cape Surville, 42°57'S 148°00'E, 25.ix.2014, *G. Kantvilas 476/14* (HO); Dorman Point, 42°54'S 147°44'E, 5 m alt., 13.xii.2014, *G. Kantvilas 497/14* (HO); mouth of Interview River, 41°35'S 144°53'E, 3 m alt., 31.i.2015, *G. Kantvilas 140/15* (HO); The Nut, 40°46'S 145°18'E, 2 m alt., 25.x.2016, *G. Kantvilas 399/16* (HO). SOUTH AUSTRALIA. Kangaroo Island: Windmill Bay, 35°51'S 138°07'E, 20 m alt., 17.ix.2012, *G. Kantvilas 469/12* (AD, HO); c. 3.5 km NE of Stokes Bay, 35°37'S 137°13'E, 50 m alt., 19.ix.2012, *G. Kantvilas 536/12* (AD, HO); Western River Cove, W end of beach, 35°40'S 136°58'E, 2 m alt., 27.ix.2015, *G. Kantvilas 413/15* & *B. de Villiers* (HO). VICTORIA. Point Wilson, 15 km NE of Geelong, 38°04'S 144°30'E, iii.1980, *A. Geddes s.n.* (MEL); Lake Condah, 38°04'05"S 141°49'53"E, 28.iii.2011, *V. Stajsic 5724* (MEL, NSW); Phillip Island, Kitty Miller Bay, 38°30'34"S 145°10'20"E, 2.iv.2013, *V. Stajsic 7379* & *J.G. Eichler* (HO, MEL).

NEW ZEALAND, NORTH ISLAND. Waitakere Ranges, Mercer Bay Track, summit of Farley Point, 36°59'S 174°28'E, 10.xi.2016, *G. Kantvilas s.n.* (AK, HO); Union Bay, N end of Karekare Beach, 36°59'12"S 174°28'24"E, 1.5 m alt., 10.xi.2016, *G. Kantvilas s.n.* (AK, HO).

Further specimens from South Australia, New South Wales, the Australian Capital Territory and South Island, New Zealand, held in CANB, are cited by Elix & Archer (2013) and are not repeated here.

***Pertusaria melanospora* Nyl.**

Ann. Sci. Nat., Bot., sér. 4, 3: 159 (1855). – **Type:** Chile, Quilmenco, *C. Gay s.n.* (lecto.: H-NYL 23603!, *vide* Archer & Elix 1993; isolecto: H-NYL 23604!).

A description of this species is provided by Messuti (2005). It is characterised by a relatively thick, continuous, esorediate, yellowish thallus containing arthothelin as the major substance, verruciform apothecia, (4–) 6–8-spored asci and bluish grey to brownish ascospores. Messuti (2005) gives the ascospore dimensions as 55–81 × 30–39 μm; in the present study, these were measured as (36–) 44–57–74 × (24–) 25–31–36 μm ($n = 43$). Both the ascospores and the greyish epithecium react a faint K+ violet, C+ violet.

Messuti & Archer (2003) and Schmitt *et al.* (2006) list several synonyms of *P. melanospora* (*viz.* *P. calcarea* (Nyl.) Nyl., *Melanaria atacamae* C.W. Dodge and *P. ochracea* Kremp.), based on South American types, but these were not examined during the present study; the published descriptions of the taxa make no mention of soredia. The status of the African report of this South American taxon (Stizenberger 1890) remains unresolved.

Specimens examined

CHILE, JUAN FERNÁNDEZ ISLANDS. Isla Robinson Crusoe (Más a Tierra), Gipfel, SW of Tres Puntas, "Vogelgipfel", alt. 380 m. s. m., 5.i.1917, *C. & I. Skottsberg* (S 55391); Santa Clara, northeast coast opposite El Morro del Spartán, 15.xii.1965, *H.A. Imshaug 38182* (S).

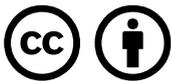
CHILE. Prov. Coquimbo, Küstenkordille, Serra de Frai Jorge, 17.viii.1917, C. & I. Skottsberg (S 55390); Valparaíso, Alto del Puerto, 14.viii.1940, R. Santesson 2997 (S); Prov. Aconcagua, Punto Los Molles, 50 m alt., 13.xi.1976, W.A. Weber & B. Johnston (*Lich. Exsicc. Colo.* 545) (MEL, S).

Acknowledgements

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The type of Sturt pea found

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Abstract: The type collection of Sturt pea was thought to have been lost soon after the publication of its original name, *Donia formosa* G. Don. For a long time, it was assumed (wrongly) to be at the Natural History Museum (BM), but it has now been located in the herbarium in Geneva (G). Annotations on the sheet show that the collection details have also been mistaken: instead of the 'Curlew River', collected by Phillip Parker King or Frederick Bedwell, it was collected by Allan Cunningham on the Malus Islands in the Dampier Archipelago.

Keywords: Sturt pea, *Donia formosa*, *Clianthus formosus*, *Swainsona formosa*, *Willdampia formosa*, Fabaceae, Lambert Herbarium, typification

Introduction

Sturt pea is a spectacular flower that has evoked admiration since its discovery by William Dampier in 1699. Explorers and collectors who came across it in the 19th century tended to exclaim over it (Symon & Jusaitis 2007; George 1999b). It was described in pre-Linnaean literature, and first named in the Linnaean system in 1832. Since then it has been treated in many works such as floras, horticultural works and field guides, and it has attracted the interest of many artists. On 23 November 1961 it was proclaimed as the floral emblem of South Australia (*Government Gazette of South Australia* no. 51: 1731).

One matter in Sturt pea's nomenclatural history has received little attention and can only now be resolved—the type collection, namely the locality, the collector, and the present whereabouts of the type specimen itself. George Don (1832) published two names for what we regard as Sturt pea. His protologues are:

D. SPECIOSA ; herbaceous, very villous ; leaflets opposite, lanceolate, acute ; flowers umbellate ; calyx 5-cleft ; legume silky. 2. G. Native of New Holland, at Regent's Lake. Flowers large, crimson.

D. FORMOSA ; plant herbaceous, very villous ; leaflets opposite, obovate ; flowers racemose ; calyx 5-cleft ; legume silky. 2. G. Native of the North-west coast of New Holland, at the Curlew river. Capt. King.

The symbol 2 refers to the herbaceous habit and G to the requirement to grow it in a glasshouse. The differences in leaflet shape and inflorescence were considered insignificant by Brown (1849), who recognised just one species for which he accepted the name *Clianthus dampieri* A. Cunn. This specific epithet

was accepted by Bentham (1864) and all other writers until Ford and Vickery (1950).

The person cited as collector of the type of *Donia formosa*, 'Capt. King.', was Phillip Parker King (1791–1856), captain of HMC *Mermaid* (and later HM Survey Ship *Bathurst*) on several surveying voyages around the Australian coast from 1817 to 1822. He sometimes assisted the plant collector Allan Cunningham, as well as collecting on his own account. King gave the name 'Curlew River' to a tidal creek just east of the mouth of a river later called the Ashburton, Western Australia (c. 21°41'S, 114°58'E), but it never became an official name. There is a Curlew Bank just offshore, named by J.W. Combe around 1899/1900, apparently alluding to King's name (Murray & Hercocock 2008). Later, the collector of the type was thought to be the master's mate, Frederick Bedwell, who is recorded as bringing aboard a specimen of 'Dolichos' from an excursion ashore at the Curlew River on 19–21 February 1818 (Curry *et al.* 2002). It has been thought that this specimen was Sturt pea, e.g. Symon & Jusaitis (2007, p. 18), but note that the quotation given there refers to Cunningham's landing on the Malus Islands on 1 March (see below), not the Curlew River.

Cunningham's journal (A.E. Orchard, pers. comm.) tells a different story. His entry for 20 February 1818 reads:

Our first officer had landed on the Main and had visited the Saltmarsh at the Back of the Beach, & reports the quantities of crystallized Salt he saw on these flats. He brought me a specimen of a Dolichos with acute stalks, which he had gather'd on the Sands (D. foliolis rhombeo-hastatis, reticulato-ramis, pedunculis petiolo duplo longioribus, racemis parvis, leguminibus glabris, solitariis, stipulis ovatis, acutis, a small annual plant).

The officer was Bedwell, but features of the plant rule out this being Sturt pea, especially its glabrous pods.

Further, Cunningham's entry for 1 March, when he landed on the Malus Islands (21°31'S, 116°41'E), reads:

I was not a little surprised to find *Kennedia speciosa*, a plant discover'd in July 1817 in sterile bleak open flats near the Regent Lake on the Lachlan River in Lat. 33°13'S and Long. 146°40'E. It is not common, I could only see 3 plants, of whom one was in flower. ... This island is the Isle Malus of the French.

Robert Brown (1849, p. 72) repeated this account almost verbatim but, apart from Bentham (1864), no later worker has noted the correct locality.

'*Kennedia speciosa*' was Cunningham's manuscript name for Sturt pea. His collection from Regent's Lake (now Lake Cargelligo) New South Wales in July 1817, while on an expedition with John Oxley, became the type of *Donia speciosa* G. Don.

The type of *Donia formosa* was originally in the hands of Aylmer Bourke Lambert (1761–1842), a man of private means who accumulated a large herbarium (Miller 1970). Lambert welcomed botanists to study in his herbarium and library, and these included George Don, whose brother David worked for Lambert as his assistant from 1820 to 1836. After Lambert's death, his herbarium was divided into lots and sold in 1843.

In discussing the species, Robert Brown (1849) appears to have thought that there was more than one specimen of Cunningham's since he wrote that the specimen on which Cunningham based his name *Clianthus Dampieri* "cannot now be found in his Herbarium, as Mr. Heward, to whom he bequeathed his collections, informs me : nor can I trace Mr. Lambert's plant" (i.e. from King's voyage in the *Mermaid*). Given that Cunningham found a single plant in flower on Malus Island, it is possible that he gathered just the one specimen that was in Lambert's herbarium. Heward gave Bentham a set of Cunningham's legumes "in so far as his material allowed" (Orchard 2014) but there is no specimen of this collection of Sturt pea at Kew, implying that there was no duplicate in Heward's set.

In the *Flora Australiensis* 2: 214 (Bentham 1864), this collection was cited as "Dampier's Archipelago, A. Cunningham". In his Preface in volume 1 of the *Flora*, Bentham discussed the collections that he had used in its preparation. Regarding Allan Cunningham's plants he wrote "I have, I believe, been able to examine the whole of them." This included a set in the Hookerian herbarium at Kew as well as a set in R. Heward's herbarium that contained Cunningham's private herbarium (these specimens are now also at Kew, donated by Heward in 1862). While there are specimens of the type of *Donia speciosa* at BM and K, there is, as stated above, none of *D. formosa*. Bentham wrote:

With the few Australian species described from the herbarium of the late A.B. Lambert, I have had much difficulty. [...] I have, therefore, in most instances been obliged to rely chiefly on circumstantial evidence for the identification of such of these plants as are only known by the brief diagnoses of G. Don and others.

While he had further material of Sturt pea to study, this indicates the difficulty he had in seeing Don's material. It seems likely that his citation of Dampier Archipelago was based upon a reading of Brown's account of 1849.

In many later accounts treating the species, the presence of the type collection has received little attention. When they made the combination *Clianthus speciosus*, Ascherson and Graebner (1909) did not mention the type collection, nor did they mention the name *Donia formosa*. Ford and Vickery (1950) accepted the collection details of the protologue of *Donia formosa* but did not cite a herbarium for the type, while Thompson (1990, 1993) repeated these details and cited the holotype as being at the Natural History Museum (BM). This was repeated by later authors, e.g. George (1999a), Orchard (2017), but searching has failed to find it there. Until recently, following Brown's comment and being unable to locate the type, I believed that it had been lost and that a neotype should be designated. My attention was then drawn to a paper that discussed the fate of Lambert's herbarium (Miller 1970) and listed herbaria that held material from it. From my own searching I knew that the type was not at Kew (K), the Natural History Museum (BM), Cambridge (CGE) or Oxford (OXF), so I emailed the other herbaria listed. I received one positive reply, from the Phanerogamic Herbarium, Conservatoire et jardin botaniques, Geneva (G), with a scanned image that proved to be of the elusive type (Figs 1–2).

The sheet is G 00418563. The annotations on it are:

"New: Holland Curlew River NW Cape. Capt King", with 'Curlew River' struck out and "Malus Island", and others of Dampiers Archip^o - 1818 A.C." added.

At the foot of the sheet is written: "*Clianthus magnificus* G. Don", with 'magnificus' struck out and an annotation in pencil "formosus" written above. Another note in pencil reads "vide Dampier voy 3 vol 2", this refers to Fig. 2 of Tab. 4 in Dampier's *A Voyage to New Holland etc. in the Year 1699*, volume 3 (Dampier 1703).

I do not know the hand of the original, upper annotation with 'Curlew River'. The amendments to it are in Cunningham's hand. It appears that, when he published the species in 1832, George Don was not aware of these amendments.

When compared with a sample of his writing given by Miller (1970, p. 507), the annotations at the foot of the sheet appear to be all in the hand of George Don.



Fig. 1. The holotype of *Donia formosa* G. Don, sheet G 00418563 in the Phanerogamic Herbarium, Conservatoire et jardin botaniques, Geneva, Switzerland (reproduced by permission).

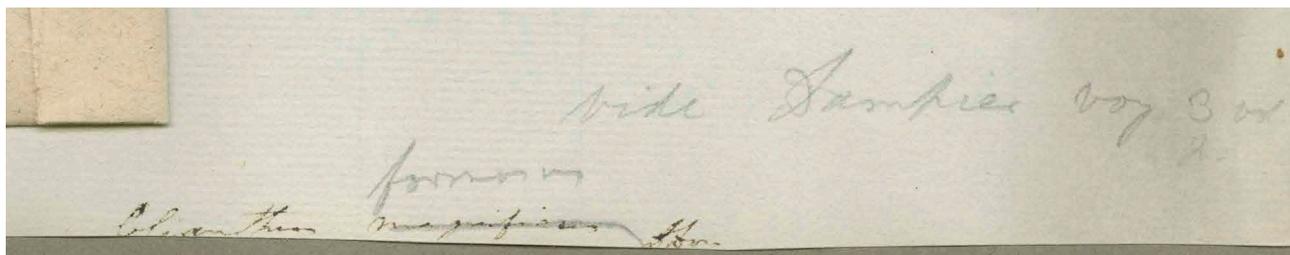


Fig. 2. Enlargement of the annotations at the foot of the holotype sheet.

The monogram appears to be ‘G.Don’. The pencil annotation (changing the epithet and adding the reference to Dampier) are in the same hand—for example, compare ‘f’, ‘m’ and ‘us’ in the two epithets, and ‘D’ of Dampier with ‘D’ of Don. In changing the epithet one cannot but wonder if Don took into account Dampier’s description of the flowers as “very beautiful”.

The specimen fits Don’s description in having obovate leaves (although this is a common shape for the species) but particularly in having a racemose inflorescence (typically it is umbellate).

I conclude that the specimen can be regarded as the holotype.

The nomenclature for the species is:

***Donia formosa* G.Don**

Gen. Hist. 2: 468 (1832). — *Clianthus formosus* (G.Don) Ford & Vickery, *Contr. New South Wales Natl. Herb.* 1: 303 (1950). — *Swainsona formosa* (G.Don) Joy Thomps., *Telopea* 4: 4 (1990). — *Willdampia formosa* (G.Don) A.S.George, *W. Austral. Naturalist* 22: 191 (1999). — **Type citation:** “North-west coast of New Holland, at the Curlew river, Capt. King”. — **Holotype:** W.A., Malus Islands, Dampier Archipelago [c. 20°31’S, 116°41’E], [1 March] 1818, *A. Cunningham* (G 00418563).

Note: The Malus Islands are named not for the apple, but for French physicist Étienne-Louis Malus (1775–1812), noted for his studies of light and optics. Coincidentally they lie less than 20 kilometres from East Lewis Island, where Dampier collected his specimens in 1699 (not at Shark Bay as given by Symon & Jusaitis 2007).

Clianthus dampieri A.Cunn. ex Lindl., *Trans. Hort. Soc. London* series 2, 1: 522 (1835), *nom. illeg.*, *nom. superfl.*, published as a new name for *Donia formosa* G.Don., based on same Cunningham collection and Dampier’s specimen. — *Clianthus dampierii* F.Muell., *Syst. Census Austral. Pl. Suppl.* 1: 4 (1884), *orth. var.*

This leaves the question of the ‘Dolichos’ that Frederick Bedwell brought aboard the *Mermaid* from his excursion at the Curlew River on 20 February 1818. At Kew there is a specimen collected by Cunningham on the north-west coast in February 1818, determined by

J. Grimes as *Cullen stipulaceum* (Decne) J.W.Grimes, but this does not fit Cunningham’s notes as it is a robust perennial having flowers with a glandular-silky ovary. A strong possibility is *Swainsona pterostylis* (DC.) Bakh.f. which occurs at the mouth of the Ashburton River, though there is no specimen of the species among Cunningham’s collections. Another is *Canavalia rosea* (Sw.) DC. which occurs commonly along the north-west coast but is a robust perennial. Yet another is *Crotalaria cunninghamii* R.Br. which is common at the locality but is a shrub and has pubescent pods. From his journal it is clear that Cunningham frequently culled his dried specimens, discarding those that had not dried satisfactorily or were inadequate for other reasons. Bedwell’s plant may have met this fate.

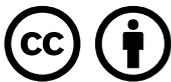
Acknowledgements

I am grateful to the editor and the reviewer of an earlier draft of this paper for suggesting further searching for the type, and to the herbaria that responded to my inquiry for this. Tony Orchard, Canberra, confirmed that the amendment to the locality on the type sheet is in the hand of Allan Cunningham and assisted with discussions. I also appreciate discussions with Gwilym Lewis, Royal Botanic Gardens, Kew. Thomas Pink and Liz Taylor, Royal Horticultural Society, London, assisted with bibliographic and chirographic inquiries.

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Micarea kartana sp. nov. (lichenised Ascomycetes) from Kangaroo Island, South Australia

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Abstract: The new species, *Micarea kartana* Kantvilas & Coppins, is described from Kangaroo Island, South Australia. A member of the *M. prasina* Fr. complex, it is characterised by a goniocyst-like thallus that contains *sedifolia*-grey pigment and gyrophoric acid, grey to blackish apothecia, and 0–1-septate ascospores, 10–14 × 4–5.5 µm. It is compared briefly to selected other species of the group.

Keywords: lichens, Pilocarpaceae, taxonomy, new species, South Australia

Introduction

The genus *Micarea* Fr. is a large and diverse assemblage of crustose lichen taxa which is widespread in boreal, austral, temperate and tropical regions, and occurs on a wide range of substrata, including bark, wood, rock and soil. Phylogenetic studies (Andersen & Ekman 2005) indicate that the genus is highly variable and contains infra-generic groups worthy of generic rank [e.g. *Brianaria* (Ekman & Svensson 2014) and *Szczawinskia* (Funk 1983)], as well as taxa with their closest affinities in other genera, for example *Psilolechia* A.Massal. (Coppins & Purvis 1987). In addition, several infra-generic groups can be recognised within *Micarea* on the basis of their anatomy, morphology and chemistry, and may well be separated into distinct genera in the future (Andersen & Ekman 2005).

In Australia, the genus remains poorly known. Occasional new species have been published (Stirton 1875; Jatta 1911; Coppins & Kantvilas 1990; McCarthy & Elix 2016a, b), and some chiefly Northern Hemisphere taxa have been confirmed as being present in the region (e.g. Rambold 1989; Coppins 2009). However, the 24 species listed by McCarthy (2017) are hardly representative of what is clearly a very species-rich genus in Australia. Unpublished studies by the author in Tasmania (in collaboration with B.J. Coppins) have indicated in the order of a dozen additional, mostly undescribed taxa there, and potentially many more are to be found in the extensive unidentified collections held in Australian herbaria.

The *Micarea prasina* group, of which the new species is a member, includes the generic type and was first recognised as such by Coppins (1983) for species with a goniocyst-like thallus, strongly convex, immarginate apothecia and mostly 0–1-septate, ellipsoid-ovoid ascospores. The group has since been the focus of

chemical (Elix *et al.* 1984) and morphological and phylogenetic studies (e.g. Czarnota & Guzow-Krzemińska 2010) and, as a result, many species have been recognised (e.g. Coppins & Tønsberg 2001; van den Boom & Coppins 2001; Czarnota 2007; Coppins 2009; Czarnota & Guzow-Krzemińska 2010; Brand *et al.* 2014; Guzow-Krzemińska *et al.* 2016; van den Boom *et al.* 2017). The group is well represented in Australia where it is especially abundant on rotting wood and bark in forested habitats, but its taxonomy is poorly resolved and with most collections ascribed either to *M. prasina* Fr. itself, or to the related *M. micrococca* (Körb.) Gams ex Coppins. However, additional taxa are present and several unpublished entities, recognised by Coppins and Kantvilas (unpubl. ms.) were listed by Jarman & Kantvilas (2001) and Kantvilas & Jarman (2012) in their study of wet eucalypt forest, a prime *Micarea* habitat.

Here a further member of the *M. prasina* group is described from Kangaroo Island, South Australia, and compared to other members of the complex.

Material and methods

Anatomical and morphological observations were undertaken using light microscopy, with thin hand-cut sections mounted in water, 10% KOH, lactophenol cotton blue, Lugol's iodine after pretreatment with dilute KOH, and ammoniacal erythrosin. Ascospore measurements are presented in the format: 5th percentile–average–95th percentile, with outlying values given in brackets. Routine chemical analyses by thin-layer chromatography follow standard methods (Elix 2014). Comparative data on related species were derived from the literature as cited. Nomenclature of pigments follows Meyer & Printzen (2000).

The species

Micareea kartana Kantvilas & Coppins sp. nov.

Micareae prasinae s.lat. affinis sed thallo acidum gyrophoricum et pigmentum "sedifolia-grisea" continenti, apotheciis sordidis vel denigratis, pigmentum singulare olivaceum continentibus et ascosporis comparate late ellipsoideis, 10–14 µm longis, 4–5.5 µm latis distinguibilis.

Typus: Australia, South Australia: Kangaroo Island, Grassdale Lagoon, 36°00'S 136°53'E, 20 m alt., on a moist log of rotting eucalypt in dry sclerophyll forest, 4 Oct. 2015, G. Kantvilas 338/15 (holo: HO 580610; iso: AD, E).

Mycobank number: MB 824888.

Thallus minutely granular, generally bright green when wet or dry, here and there with dull greyish patches, composed of coralloid, rather isidioid goniocysts and forming a brittle, thinly dispersed crust 0.2–0.3 mm thick; goniocysts 30–45 µm wide, composed of fascicles of photobiont cells in a mostly colourless gel matrix with patches of greyish, *sedifolia*-grey pigment, K+ violet, C+ violet; photobiont a micareoid green alga with ± globose cells 5–11 µm wide. *Apothecia* scattered, dull grey to blackish, 0.2–0.6 mm wide, c. 0.15–0.25 mm tall, plane to convex, sometimes very strongly so, nestled among the goniocysts, immarginate from the outset but occasionally a little less intensely pigmented at the outer rim. *Excipulum* reflexed and ± excluded, at most visible only in section in the youngest apothecia as a layer c. 20 µm thick of loosely entangled, branched and anastomosing hyphae. *Hypothecium* 40–80 (–170) µm thick, interspersed with oil droplets, patchily olive-green, intensifying greenish to yellowish green in both K and N, C+ yellowish brown and fading. *Hymenium* 40–55 µm thick, mostly colourless but overlain by a patchy layer of olive-green pigment (as in the hypothecium) which forms vertical bands

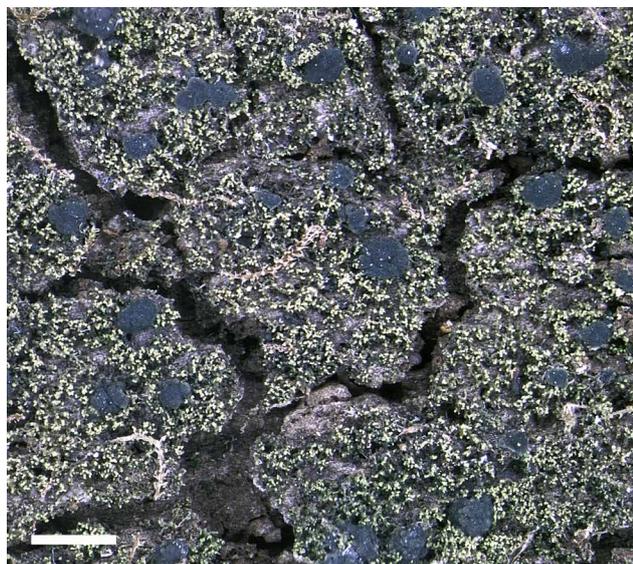


Fig. 1. *Micareea kartana* habit (holotype). Scale = 1 mm.

between the asci. *Paraphyses* numerous, branched and anastomosing, 0.8–1 µm wide, with the apices not enlarged. *Asci* 8-spored, 40–52 × 10–15 µm, with a well-developed, intensely amyloid tholus, pierced by an indistinct channel that mostly lacks a darker staining ring structure (approximating the Pilocarpaceae-type). *Ascospores* ellipsoid to ovoid, 0–1-septate, hyaline but with occasional older spores steeped in olive-green pigment, (9–) 10–11.6–14 (–15) × 4–4.9–5.5 (–6) µm (n = 100). *Pycnidia* not found. *Chemistry:* gyrophoric acid; thallus in squash C+ faintly reddish. **Figs 1–2.**

Etymology. The specific epithet is derived from the name *Karta* (meaning island of the dead), given to Kangaroo Island by Australia's indigenous inhabitants.

Remarks. The diagnostic characters of *Micareea kartana* are summarised in Table 1, where this species is compared to a selection of other taxa from the *M. prasina* group; of these, *M. prasina*, *M. micrococca* and *M. viridileprosa* have all been recorded for Australia (McCarthy 2017). Distinguishing members of this group can be tricky (e.g. see Barton & Lendemer 2014), and characters that have been usefully applied include thallus chemistry, apothecial pigments, anatomy and morphology, ecological and geographical distribution, as well as DNA-sequence data. The new species has several highly diagnostic characteristics. For example, the presence of *sedifolia*-grey pigment in the thallus is commonly encountered in the *M. prasina* group, but in such instances, one might expect that the dark colouration of the apothecia would also be due to this pigment. Instead, *sedifolia*-grey is absent in the apothecia and replaced by an unusual olivaceous pigment that intensifies greenish to yellowish green in both K and N–, and reacts C+ yellowish brown. Furthermore, the ascospores of *M. kartana* are noticeably wider and more broadly ellipsoid than in other members of the group.

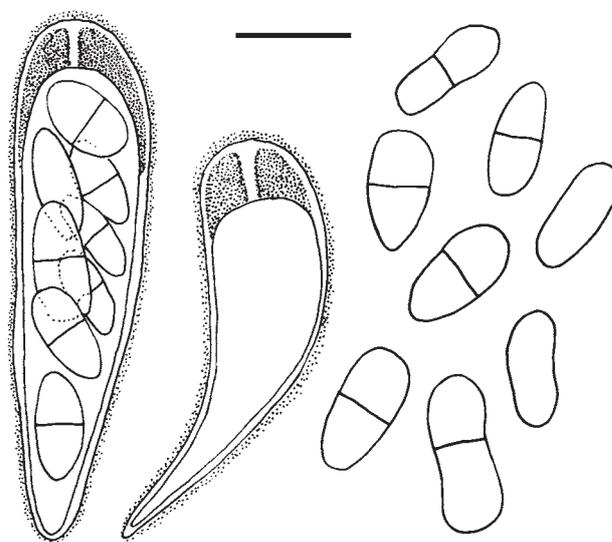


Fig. 2. *Micareea kartana* asci and ascospores, with amyloid parts stippled (holotype). Scale = 10 µm.

Three additional corticolous species of *Micarea* have been recorded from Kangaroo Island (unpublished data). None are common or widespread and all are easily distinguished from *M. kartana*. These taxa include *M. prasina*, whose distinguishing features are summarised in Table 1, and two taxa, *M. denigrata* (Fr.) Hedl. and *M. globusella* (Nyl.) Coppins, that both contain gyrophoric acid and *sedifolia*-grey pigment, but with the latter, significantly, confined to the apothecia. *Micarea denigrata* differs further by having 0–1-septate ascospores, 10–12 × 3–4 µm, whereas *M. globusella* differs by having ascospores 1,3 (–7)-septate and 15–28 × 2.5–3 µm (Czarnota 2007; Coppins 2009).

Ecology and distribution. The new species is known only from the type locality in dry sclerophyll forest, where it grew on a rotting, charred eucalypt log on the ground, sheltered by undershrubs. The habitat is fairly typical for *Micarea* species although, in general, such forests tend to be rather too open and dry for these lichens. Thus, whereas the genus is species-rich in moister, cooler, forested parts of Australia, on Kangaroo Island, only three additional corticolous or lignicolous taxa have been recorded to date (unpubl. data; see above). Lichens associated with the new species included *Leptogium pecten* F.Wilson, *Carbonicola foveata* (Timdal) Bendiksby & Timdal and *Hertelidea pseudobotryosa* R.C.Harris, Ladd & Printzen.

Additional specimen examined

SOUTH AUSTRALIA, Kangaroo Island: type locality, 2015, *G. Kantvilas 337/15* (AD, HO).

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Table 1. Salient features of selected members of the *Micarea prasina* complex. All taxa have a goniocyst-like thallus.

| | thallus | chemistry | apothecia | ascospores | conidia |
|--|--|----------------------|--|--|--|
| <i>M. byssacea</i> (Th.Fr.) Czarnota <i>et al.</i> ¹ | green to olive-green, with <i>sedifolia</i> -grey pigment | methoxymicareic acid | pallid to grey to black, often mottled, with <i>sedifolia</i> -grey pigment | (6–) 8–12 (–13) × 2.7–3.5 (–4.2) µm, 0 (–1)-septate | mesoconidia: (3.8–) 4.5–5.5 × 1.2–1.5 µm; microconidia: 5–7.5 (–8) × 0.8–1 µm |
| <i>M. kartana</i> Kantvilas & Coppins | bright green, with <i>sedifolia</i> -grey pigment | gyrophoric acid | dull grey to blackish, with unknown olive pigment | 9–13.5 (–15) × 4–5.5 (–6) µm, 0–1-septate | unknown |
| <i>M. levicula</i> (Nyl.) Coppins ² | pale greenish, becoming ± isidioid | gyrophoric acid | pallid | 8–12 × 2.5–3.5 µm, 0–1-septate | unknown |
| <i>M. micrococca</i> (Körb.) Gams <i>ex Coppins</i> ¹ | bright green to olive-green | methoxymicareic acid | pallid, without pigments | 10–12 (–16) × 3–4.5 µm, 0 (–1)-septate | mesoconidia: (3.8–) 4.5–5.5 × 1.2–1.5 µm; microconidia: 5–7.5 (–8) × 0.8–1 µm |
| <i>M. prasina</i> Fr. ³ | pale to dark grey-green, sometimes with <i>sedifolia</i> -grey pigment | micareic acid | pale to dark grey or blackish, sometimes with <i>sedifolia</i> -grey pigment | (7–) 8–12 (–14) × (2.3–) 3–4 (–5.5) µm, 0–1 (–3)-septate | mesoconidia: (3.5–) 4–6 × 1–1.2 (–1.5) µm; microconidia: (5–) 5.5–8 × 0.5–1 µm |
| <i>M. subviridescens</i> (Nyl.) Hedl. ³ | pale grey-green to bluish green, sometimes with <i>sedifolia</i> -grey pigment | prasinic acid | pallid to grey to blackish, with <i>sedifolia</i> -grey pigment | 10–18 × 4–6 µm, (0–) 1–3-septate | unknown |
| <i>M. viridileprosa</i> Coppins & v.d. Boom ² | bright green, becoming ± soresiate | gyrophoric acid | pallid, without pigments | 8–12 (–14) × 2.5–4 µm, 0–1 (–2)-septate | mesoconidia: 4.5–6 × 1.3–2 µm |
| <i>M. xanthonica</i> Coppins & Tønsberg ⁴ | pale yellow-green | thiophanic acid | pallid, without pigments | 9.3–14 (–14.3) × (3.5–) 3.8–4.2 (–4.7) µm, (0–) 1 (–3)-septate | unknown |

Data sources. ¹ Czarnota & Guzow-Krzemińska (2010); ² van den Boom & Coppins (2001); ³ Coppins (2009); ⁴ Coppins & Tønsberg (2001).

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Notes on the taxonomy of Australian *Lindernia* subg. *Didymadenia* (Linderniaceae)

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Abstract: Names are formalised as a precursor to more detailed taxonomic and evolutionary accounts of *Lindernia* subg. *Didymadenia* in Australia for five newly founded sections (*Prolatae* W.R.Barker, *Didymadenia* (W.R.Barker) W.R.Barker, *Scapigerae* W.R.Barker, *Heterandrae* W.R.Barker and *Hemiarrhena* (Benth.) W.R.Barker) and 22 new species (*L. prolata* from the near-coastal regions of central eastern Australia, *L. cyanoplectra* and *L. porphyrodinea* from the Kimberley region, Western Australia, with *L. dunlopii* extending into Northern Territory, and *L. atrata*, *L. murfetiana*, *L. dierythra*, *L. scopularis*, *L. petrensis*, *L. tiwiensis*, *L. leucochroa*, *L. thyridostoma*, *L. scutellata*, *L. pustulosa*, *L. brennanii*, *L. lucrusmiana*, *L. venustula*, *L. enypniastina*, *L. acrandra*, *L. pronanthera*, *L. robyniae* and *L. calliandra* from northern Northern Territory). Some of the new species are established as a result of the typification of several existing names through examination of types or type photographs. The misapplication of *L. lobelioides* (F.Muell.) F.Muell. and the partial misapplications of *L. scapigera* R.Br. and *L. plantaginea* (F.Muell.) F.Muell. are corrected, *L. mitrasacmoides* (O.Schwarz) W.R.Barker and *L. grossidentata* O.Schwarz are resurrected as names of two common Northern Territory species and the separation of *L. tectanthera* W.R.Barker from *L. lobelioides* is clarified.

Keywords: Australia, new species, infrageneric classification, subg. *Didymadenia*, *Lindernia*, Linderniaceae

Introduction

Linderniaceae in Australia, segregated relatively recently from the now dismantled broadly circumscribed traditional Scrophulariaceae (e.g. Rahmzadeh *et al.* 2005), has been, until the last six years, represented by two genera, the subshrub *Artanema* D.Don, represented by a single north-east Australian species, and the genus *Lindernia* All. In the 1800s, Brown (1810) initially placed Australian species in *Artanema*, *Lindernia* and *Torenia* L., but later authors (Bentham 1846, 1868; Mueller 1859; Bentham & Hooker 1876) included the Australian species, many of them today known to be endemic, in globally widespread genera such as *Bonnaya* Link & Otto, *Vandellia* P.Browne ex L. and, less often, *Ilysanthes* Raf. Ultimately Mueller (1867, 1882, 1889) followed Brown's lead and placed all Australian species, except *Artanema fimbriatum* (Hook. ex Graham) D.Don, in *Lindernia*.

In the 20th century, the widespread genera *Vandellia*, *Bonnaya* and *Ilysanthes* were subsumed in a widely circumscribed *Lindernia* as subgenera or sections in the works of Pennell (1935, 1943a, 1943b) on north-east American, Himalayan and New Guinean species, Philcox (1968) on Malesian species, and Yamazaki (1978a, 1978b, 1980, 1981, 1985, 1990) on Asian species.

Hemiarrhena Benth. (1868), a monotypic Australian genus of doubtful tribal affinities, was universally

maintained as a distinct genus. Originally described by Bentham as a phyletically isolated member of the tribe Rhinanthae Lam. & DC., a view adopted in other works on the Scrophulariaceae (e.g. Wettstein 1891–1893), it was always maintained in the *Lindernia* alliance by Mueller (1889), who viewed it and other species of *Lindernia* in the field and described it from his own collections. In the late 1900s it was returned to *Lindernia* in Australian works, starting with Barker (1983) and Dunlop (1987), with Barker (1990) including it in his new subg. *Didymadenia*, which he established for the main Australian radiation of *Lindernia*.

A recent molecular study by Fischer *et al.* (2013) reconstituted *Lindernia*, giving it a narrow circumscription covering the type and allied species, and resurrecting the globally widespread genera *Bonnaya* and *Vandellia*. Apart from some wide-ranging tropical species placed in *Bonnaya*, they removed all Australian species from *Lindernia* to *Vandellia*, although their approach was based on limited evidence (Biffin *et al.*, in press).

In an analysis of new molecular sequence data (Biffin *et al.*, in press), the bulk of Australian species have been returned from *Vandellia* to *Lindernia*. The following genera of Linderniaceae are now recognised in Australia: *Artanema*, *Bonnaya*, *Lindernia*, *Torenia* and an unpublished genus established in Biffin *et al.* (in press). Three subgenera of *Lindernia* are confirmed, the type *L. procumbens* (Krock.) Philcox in subg. *Lindernia*, east

Australian *L. hyssopioides* (L.) Haines in a subgenus based on the generic name *Ilysanthes* (Biffin *et al.*, in press), and the main radiation of Linderniaceae restored to subg. *Didymadenia* W.R.Barker.

The establishment of a firm generic framework has been critical to publishing the following taxonomic changes and additions which further expand the known diversity of Australian Linderniaceae and particularly its subg. *Didymadenia* (Barker 1990, 1992a, 1992b, 1998, 2000; Wannan 2013, 2016). More detailed taxonomic advances (Barker, in prep.) and an evolutionary study (Barker & Biffin, in prep.) of the genus in Australia are well-advanced towards publication.

Diagnostic attributes

Hair types

Glandular hairs 0.2–1.0 mm long with multicellular uniseriate stalks are evident in many species across the family. Their presence or absence and relative length on vegetative parts and in the inflorescence can be of diagnostic value at the species or infraspecific

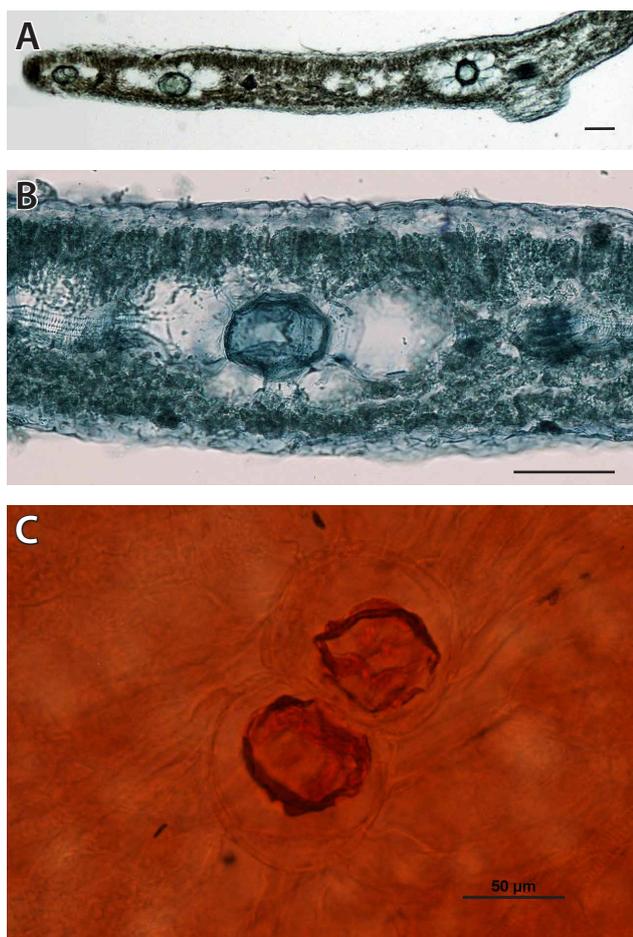


Fig. 1. The subepidermal gland in *Lindernia* subg. *Didymadenia*. **A, B** Transverse section of leaf of *Lindernia mitrasacmoides* (W.R. Barker 7045, AD), stained in Toluidine Blue O. **C** View through top of leaf of *Lindernia dunlopii* (R.M. Barker 284, AD), cleared with KOH and stained with Sudan IV. — Scale: A, B = 100 μ m; C = 50 μ m.

level. Other hairs are of diagnostic value outside the subgenus. These tiny hairs, terminated by four-celled glands c. 15–30 μ m in diameter, occur across the family; such hairs have been seen, for example, in samples of *Bonnaya* and the subgenera *Lindernia* and *Didymadenia* of *Lindernia*. Apparently homologous hairs occur widely across the families of the traditional Scrophulariaceae (Barker, pers. obs.). Antrorse narrow deltoid single-celled eglandular hairs occur on leaf, bract and sepal margins in many genera of Linderniaceae; they are absent from subg. *Didymadenia* although a few species in sect. *Hemiarrhena* (Benth.) W.R.Barker bear probably homoplasious soft antrorse eglandular hairs along the sepal margins.

Subepidermal glands

Lindernia subg. *Didymadenia* is defined by 2-celled glands, elliptic in outline, which are found midway between upper and lower surfaces of the leaves (Fig. 1), on stems and branches, bracts and sepals and sometimes the corolla and capsule. While always embedded in the cellular matrix below the cuticle, they are often evident externally, through the cuticle. On occasions (e.g. in *L. dunlopii* and *L. pustulosa*) the surface of green parts of the plant (e.g. leaves, bracts and sepals) is raised above each gland, or in other species these parts and the capsule surface are ‘spotted’ arising from the visibility of the glands through the epidermis. The descriptive term ‘blister glands’ is proposed for these instances.

Seeds

Seed morphology is a promising area of study for establishing synapomorphies for defining genera and infrageneric groups in the Linderniaceae (Biffin *et al.*, in press).

While seeds in the newly erected sect. *Didymadenia* have four longitudinal ribs (Barker 1990, 1992a), they can be more variable in other sections of subg. *Didymadenia*, with some species having up to 8-ribbed seeds. The concavities between the ribs are generally relatively deep furrows, but in some species of sect. *Hemiarrhena* the seeds are almost circular in transverse section. The ribs are bridged by finer transverse ridges, varying in number from about four to 20, which are in some species confined to the intervening furrows, while in others they connect across the longitudinal ribs.

Scent

Some of the Australian species of subg. *Didymadenia* are noticeably scented. The source of the scent is likely to be the 2-celled subepidermal glands, although whether they contain aromatic oil still has to be proven.

Herbarium material examined

Specimens from PERTH, DNA and AD form the principle basis of this paper, supplemented by observation of material on visits to BRI, MEL and CANB and examination of specific specimens by staff or associates in PERTH, MEL and NSW. The

specimen citations reference only duplicates that have been examined for this study.

The material of *L. grossidentata* O.Schwarz and *Ilysanthes mitrasacmoides* O.Schwarz used in the protologues (Schwarz 1927) was sent to Berlin by Darwin-based collector F.A.K. Bleeser. Many of the Berlin collections were destroyed in World War II, including the B syntypes of these species, while Bleeser's own herbarium was destroyed after a cyclone (McKee 1963; Willis 1966; George 2009). Their absence from the B collection has been confirmed by Dr R. Vogt (pers. comm., 9 Apr. 2018). Herbarium web sites have been searched for type material. Duplicates of Bleeser collections survive, principally in MEL, NSW and K, with some secondarily in DNA. The Australasian Virtual Herbarium (2017) provides details of 230 Bleeser collections, mainly in MEL and NSW, while an on-line search of the specimen image database on JSTOR Global Plants (2017) revealed 27 types collected by Bleeser, including some duplicates, mostly in MEL and NSW, as well as K, B, BM and WIS, but no syntype material, identifiable by annotations by Schwarz, has been located. Fortunately, isosyntypes of *Ilysanthes mitrasacmoides* are housed in NSW and DNA.

Taxonomy

Lindernia subg. *Didymadenia* W.R.Barker

J. Adelaide Bot. Gard. 13 (1990) 79. — **Type:** *L. chrysopectra* W.R.Barker

Hemiarrhena Benth., *Fl. Austral.* 4 (1868, as 1869) 518; Benth., *Hooker's Icon.* Pl. 11 (Ser. 3: 1) (1870) 46, pl. 1059. — **Type:** *L. plantaginea* (F.Muell.) F.Muell.

Bradshawia F.Muell., *Proc. Linn. Soc. New South Wales*, Ser. 2, 6 (1892) 473, *nom. prov.*, based on *L. macrosiphonia* (F.Muell.) W.R.Barker.

Annuals, rarely perennial herbs; subepidermal glands present in the stems, leaves, sepals and often capsule wall. *Vestiture:* leaf, bract and calyx margins not scabrous from antrorse robust aculeate eglandular hairs, rarely with scattered soft eglandular hairs. *Stamens:* two pairs inserted on the abaxial and adaxial side of the corolla tube, sometimes one of the pairs lost or reduced

to staminodes; lower filaments bearing a lateral spur, rarely the spur reduced to a knob or absent; anthers with two confluent opposed, sometimes obliquely so, cells, sometimes 1-celled through reduction or loss of a cell. *Stigma* 2-lobed. *Capsules* narrow obloid-ellipsoid to globular; seeds many, longitudinally 4–8-ribbed, with a few to many transverse secondary ridges across the intervening furrows.

Distribution. Mostly confined to northern and northeastern tropical and subtropical Australia; two species, *L. subulata* and *L. scapigera*, extend to southern New Guinea.

Note. Five sections within this subgenus are defined below.

A. Lindernia sect. *Prolatae* W.R.Barker, sect. nov.

Typus: *L. prolata* W.R.Barker

Annuals; stems and branches erect or narrowly ascending, terminated by open erect racemes. *Leaves* sessile and subulate or subpetiolate, narrow to broadly ovate. *Pedicels* erect to widely spread. *Corolla* regular, without internal longitudinal flaps; tube narrow, elongated, conspicuous, as long or longer than the limb; upper lip porrect, emarginate. *Stamens* 4, the abaxial filaments with a cylindrical spur; anthers 2-celled. *Capsules* ovoid to subglobular; seeds with 4–8 longitudinal ribs and c. 6–20 secondary transverse ridges.

Distribution. A section spread from the Dampier Peninsula near Broome, Western Australia, across tropical and subtropical northern Australia and eastern Australia as far as the north coastal region of New South Wales. This matches the geographical range of *Lindernia* in Australia.

Note. The section includes *L. subulata* R.Br., *L. beasleyi* Wannan, *L. stantonii* Wannan and the species newly described here.

Etymology. The epithet of the type species (q.v.) was chosen in part as the resultant sectional name reflects the broad geographical distribution of the section.

Key to sections of *Lindernia* subg. *Didymadenia*

1. Perfect anthers 4
 2. Anthers 2-celled
 3. Corolla tube and hood not infolded, the stamens and style evident from below
 4. Leaves entire, subulate and sessile or ovate and sessile or subsessile **A. sect. Prolatae**
 - 4: Leaves entire through sinuate to dentate, subpetiolate, ovate or broadly so **C. sect. Scapigerae**
 - 3: Corolla tube infolded, the adaxial filaments and style positioned above the folds . . . **B. sect. Didymadenia**
 - 2: Anthers of adaxial pair 2-celled, of abaxial pair 1-celled **D. sect. Heterandrae**
- 1: Perfect anthers 2, 1- or 2-celled, with or without a pair of abaxial staminodes **E. sect. Hemiarrhena**

Key to species of *Lindernia* sect. *Prolatae*

1. Inflorescence (rachis, bracts, pedicels and sepals) glabrous
2. Leaves ovate to \pm circular **1. *L. prolata***
- 2: Leaves narrow linear to subulate
3. Sepals red- to black-lined; middle lobe of the lower corolla lip white with two blue-purple blotches . . . **2. *L. atrata***
- 3: Sepals not lined; corolla not as above
4. Pedicels more than 10 mm long
5. Corolla lobes spotted; ovary glandular pubescent ***L. subulata***
- 5: Corolla lobes not spotted; ovary glabrous ***L. beasleyi***
- 4: Pedicels less than 10 mm long ***L. stantonii***
- 1: Inflorescence glandular hairy
6. Corolla white to blue without red spotting; lower corolla lip with a green blotch
7. Glandular hairs in inflorescence 0.01–0.025 mm long **3. *L. cyanoplectra***
- 7: Glandular hairs in inflorescence 0.1–0.15 mm long **4. *L. murfetiana***
- 6: Corolla yellow with red spots **5. *L. dierythra***
-

1. *L. prolata* W.R.Barker, sp. nov.

Holotypus: *R.W. Jobson 1291*, 1 Oct. 2011, Kingaroy, Queensland (NSW 885850). **Isotypi:** AD 279775, BRI.

L. sp. Tingoora (A.R. Bean 10311) Queensland Herbarium: N.Fechner in Bostock & A.E.Holland, *Census Queensland Fl. 2007* (2007) 188.

Multi-branched ?annual herb, the main branches c. 3.5–19 cm long, decumbent to ascending, rooting at basal nodes. *Leaves* ovate to \pm circular, 3–10 mm long, sessile, narrow cuneate, sometimes subpetiolate. *Inflorescences* open erect terminal racemes; pedicels erect, sometimes spreading in fruit, much longer than the bracts. *Corolla* (4.0–) 6–8.5 mm long along upper side, blue to blue-purple, rarely white; lower lip with a white mid lobe, with dark blue-purple base and two blotches. *Stamens* 4; abaxial spur exserted, cylindrical, pale blue or bluish-white; anthers 2-celled. *Capsule* obloid-ovoid to globular, 2.5–3.5 mm long, glabrous; seeds (*Johnstone 2355 & Orme*) obloid-ellipsoid, rarely broadly so, 0.35–0.45 (–0.5) mm long, with 6 sharp longitudinal ribs.

Distribution. In eastern Australia in regions neighbouring coastal south-eastern Queensland and north-eastern New South Wales. In seasonally inundated areas.

Etymology. The adjectival epithet derives from the Latin adjective *prolatus*, extended or elongated, alluding to the very long pedicels at flowering time; also influenced by resultant sectional name (q.v.).

Selected additional specimens

QUEENSLAND: 7.2 km along Dangore Mtn road, WSW of Tingoora, 21 May 1996, *A.R. Bean 10311* (AD); 33 km NNE of Chinchilla, 1 Oct. 1993, *M.E. Ballingall 2733* (AD); Hellhole Creek, near Auburn Road in Barakula Forestry [Reserve], 6 Mar. 1984, *V. Hando s.n.* (AD 98413060).

NEW SOUTH WALES: C. 2 km (direct) E of Coopernook along Spring Hill Road, 30 Apr. 2008, *R. Johnstone 2355 &*

A.E. Orme, (NSW, as photo, AD, seeds only); 20 km W of Wooli, 23 Nov. 1987, *R. Bates 12879* (AD).

2. *L. atrata* W.R.Barker, sp. nov.

Holotypus: *I.D. Cowie 12020*, 22 Apr. 2008, Limmen National Park, c. 24 km S of Ranger Station, Northern Territory (AD 246363). **Isotypi:** DNA (*n.v.*), B (*n.v.*).

Erect glabrous single-stemmed annual, 12–50 cm tall. *Leaves* deltoid-linear to filiform, the longest on a stem 5–12 mm long, sessile, entire. *Inflorescences* open simple terminal racemes of 1–7 or more flowers; pedicels longest at lowest node, ascending, 5–22 mm long, much longer than the subulate bracts. *Corolla* 5–8 mm long along the upper side, mid blue throughout, sometimes with fine red-purple striations, with two mid yellow blotches, one behind the other, on the lower side of the mouth and throat and with two deep purple blotches at base of lowest lobe. *Stamens* 4; abaxial spur exserted, cylindrical, white; anthers 2-celled. *Capsule* ellipsoid to globular, 2–2.3 mm long, glabrous; seeds obloid, 0.25–0.28 mm long, c. (?5–) 6 longitudinal sharp ribs, with 9–10 fine secondary ridges across intervening furrows.

Distribution. In the Limmen region of Northern Territory, on the west coast of the Gulf of Carpentaria, south of Arnhem Land.

Etymology. from the Latin adjective *atratus*, dressed in black, derived from *ater*, black, dark, and the suffix *-atus*, meaning provided with, alluding to the conspicuous red- to black-lined margins of the sepals.

Selected additional specimens

NORTHERN TERRITORY: Limmen National Park, c. 12 km SW of Nathan River Ranger Station, Site 70, 18 Apr. 2008, *P.S. Short 5513* (DNA); Cox River Station, 30 June 1977, *T.S. Henshall 1568* (DNA).

3. *L. cyanoplectra* W.R.Barker, sp. nov.

Holotypus: *B.J. Carter 679*, 6 Sep. 1993, Taylors Lagoon, c. 76 km ENE of Broome, Western Australia (PERTH 3234320). **Isotypus:** AD 270009.

Annual, 7–10 cm high, with erect to decumbent branches, with the inflorescence covered by tiny glandular hairs to c. 0.02 mm long. *Leaves* sessile, subulate, 3–15 mm long, dilated at the base. *Inflorescence* an open terminal raceme, with pedicels much longer than the subulate bracts. *Corolla* 4.5–6.5 mm long along upper side, light to mid blue, the lower lip with a green blotch. *Stamens* 4; abaxial spur long, exerted, blue; anthers perfect, blue, 2-celled. *Capsule* broadly ellipsoid, 1.8–2.8 mm long, glabrous; seeds (*Carter 679*) ellipsoid, c. 0.3–0.35 mm long, with 4–5 (–?6) longitudinal ribs.

Distribution. South and east of the Dampier Peninsula, northern Western Australia, in seasonally inundated areas.

Etymology. The adjectival epithet derives from the Greek *kyanos*, dark blue, and *plektron*, a tool for plucking or spur, alluding to the colour of the conspicuous staminal spurs of this species.

Selected additional specimens

WESTERN AUSTRALIA: C. 75 km E of Broome, just S of highway to Fitzroy Crossing, 26 June 2007, *D. Coultas & B. Taylor Opp 10* (PERTH); Edge of Nemila Creek near Blina Swamp, 21 Mar. 2010, *D. Murfet 6786 & A. Lowrie* (AD); 55 km E of Broome, just S of highway to Fitzroy Crossing, 27 June 2007, *Woodman & K. Greenacre Y1S11-01* (PERTH).

4. *L. murfetiana* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 9129 & K. Brennan*, 19 May 2013, on vehicular track c. 250 m SE of Litchfield Park Road, c. 1.2 km direct S of Finnis River Crossing, Northern Territory, Darwin & Gulf District (AD 268115). **Isotypi:** BRI, CNS, CANB, DNA, PERTH.

L. sp. Hann River (M. Lazarides 9167) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Erect, rarely decumbent, annual herb, (10–) 20–25 cm tall, glabrous but for the moderately dense to dense glandular hairs in the inflorescence. *Leaves* sessile, filiform to narrow ovate-caudate, near base of plant 3–8 mm long but much shorter distally. *Inflorescence* a terminal few-flowered raceme. *Corolla* 9–10.5 mm long along the upper side, white, yellow or blue, with green blotches on the lower lip. *Stamens* 4, with abaxial spurs exerted from the corolla mouth, cylindrical, long; anthers white, 0.8–1.0 mm long, 2-celled. *Capsule* broad ellipsoid to globular, 2.3–2.5 mm long, glabrous; seeds ellipsoid-obloid to obloid, 0.2–0.3 mm long, with 6–8 longitudinal ribs.

Distribution. Mainly in the Darwin to Litchfield area of northern Northern Territory, with outliers further west in Arnhem Land; in seasonally inundated areas.

Etymology. Named after Denzel Murfet, an avid collector associated with the State Herbarium of South Australia, whose many collections and associated floral photographs from Northern Australia have been valuable in the unravelling of the taxonomy of *Lindernia*.

Selected additional specimens

NORTHERN TERRITORY: Howard Springs, S side of ephemeral lagoon area (Sect. 3950), over fence bordering Sections 3953 and 3954, ca. 1 km E of Dutchies Lagoon, c. 100 m N of Corella Avenue, 29 May 1997, *W.R. Barker 7735 & R.M. Barker* (AD); 300 m from Cox Peninsula Road and Bynoe Harbour road, 6 July 2008, *D.E. Murfet 6054* (AD); Edge of McMinn's Lagoon, 26 June 1968, *D. Wheelwright 45* (AD, DNA); 19 km NNW of Twin Falls, 3 June 1980, *M. Lazarides 9167* (CANB, DNA).

5. *L. dierythra* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 7873 & K. Brennan*, 16 Apr. 1999, near Lost City [precise locality withheld for conservation reasons], Litchfield National Park, Northern Territory (AD 268129). **Isotypi:** B, BRI, CANB, CNS, DNA, K, MEL, MO, NSW, PERTH.

L. sp. Litchfield (I.D. Cowie 5725) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Erect, finely glandular-pubescent, annual herb, 3.5–17 cm high, often a simple single stem. *Leaves* sessile, narrow linear, longer at higher nodes, the longest 8–15 mm long. *Inflorescence* an open terminal raceme or appearing paniculate when upper branches are present; pedicels longer than the bracts, usually reflexed in fruit. *Corolla* 6.5–8 mm long along upper side, bright yellow with red spots on the lower lip. *Stamens* 4, the abaxial spurs short, cylindrical, yellow; anthers 0.7–0.8 mm long, 2-celled. *Capsules* broad ovoid, c. 3.5 mm long, glandular-pubescent; seeds obloid or broadly so, c. 0.4 mm long, with 4 blunt longitudinal ribs.

Distribution. Near The Lost City, Litchfield National Park, Northern Territory in grassy herbfield on sand.

Note. As observed by I.D. Cowie (5725), this species mimics taxa such as *Uvedalia linearis* R.Br. var. *lutea* (Benth.) W.R.Barker & Beardsley in the rare attribute of having yellow flowers with prominent red spotting on the lower side of the corolla.

Etymology. The epithet *dierythra* is an adjective meaning spotted or variegated with red (Brown 1956), alluding to the red-freckled corolla mouth; it is derived from the elision of the Greek *dia-*, a prefix for indicating separation, and *erythros*, red.

Additional specimen examined

NORTHERN TERRITORY: Near Lost City, 16 Apr. 1995, *I.D. Cowie 5725* (AD, DNA).

B. *Lindernia* sect. *Didymadenia* (W.R.Barker)**W.R.Barker, stat. nov.**

Lindernia subg. *Didymadenia* W.R.Barker, *J. Adelaide Bot. Gard.* 13 (1990) 79, basionym. — **Type:** *L. chrysoplectra* W.R.Barker

Annuals or short-lived perennials; stems and branches erect or narrowly ascending, terminated by open erect racemes, or prostrate, procumbent or pendent (from rock faces) with terminal inflorescences not strongly demarcated through the foliose bracts. *Leaves* subpetiolate, narrow to broadly ovate to obovate. *Pedicels* erect or ascending, in fruit sometimes deflexed, rarely elongating and extending into rock crevices. *Corolla* regular or resupinate, invaginated on either side into a pair of internal flaps; tube usually conspicuous, rarely much shorter than the limb; upper lip porrect or upturned, emarginate. *Stamens* 4, or 2 with 2 adaxial (abaxial in resupinate flowers) staminodes; abaxial filaments with a cylindrical or reduced spur, rarely

lacking; perfect anthers 2-celled. *Capsules* ovoid to subglobose; seeds 4-furrowed, with c. 6–20 transverse ridges.

Distribution. Most species occur in the Kimberley region of northern Western Australia, but a few occur in northern Northern Territory and north Queensland. In wet situations, woodland, stony ground and on rock faces.

Notes. The section includes the following newly described species, as well as *L. cleistandra* W.R.Barker, *L. eremophiloides* W.R.Barker, *L. macrosiphonia* (F.Muell.) W.R.Barker, *L. hypandra* W.R.Barker, *L. chrysoplectra* W.R.Barker, *L. aplectra* W.R.Barker, *L. tectanthera* W.R.Barker and *L. barkeri* Wannan.

The flowers, fruits and seeds of *L. macrosiphonia* are remarkably large.

Key to species of *Lindernia* sect. *Didymadenia*

1. Basal leaves subulate or narrow linear
 2. Corolla 9–10 mm long; anthers 1.2 mm long; lower filaments golden-spurred **L. chrysoplectra**
 - 2: Corolla 5.5–7.3 mm long; anthers 0.4 mm long; lower filaments without spurs **L. aplectra**
- 1: Basal leaves foliose, spatulate
 3. Flowers subtended by foliose bracts throughout the inflorescence; plant foliose, procumbent on ground or pendent from vertical rock faces
 4. Corolla tube 70–100 mm long **L. macrosiphonia**
 - 4: Corolla tube up to 15 mm long along the upper side
 5. Leaves alternate; sepals fused for 1/8 to 1/3 their length **L. eremophiloides**
 - 5: Leaves opposite; sepals free almost to base
 6. Pendent perennial, growing on rock faces
 7. Pedicels hardly lengthened in fruit, exposed; capsule 5.5–9.5 mm long **6. L. scopularis**
 - 7: Pedicels turned back and elongated into dense foliage or deep into crevices; capsule 3.5–5.5 mm long **L. cleistandra**
 - 6: Procumbent annual **7. L. petrensis**
 - 3: Flowers subtended by narrow linear to subulate bracts, apart sometimes for the basal nodes of the inflorescence; plant erect annual, with cluster of leaves at base, and stem with scattered leaves reduced in size or a scape
 8. Flower regularly oriented
 9. Stamines without a spur
 10. Stamines outcurved, conspicuous, yellow, terminated often with an obscure vestigial anther often with a very short to short filiform white filament; robust, erect, scapiform herb; leaves usually confined to a basal rosette, sometimes of reduced size at a few nodes up the stem or main branches **L. tectanthera**
 - 10: Stamines porrect, white; delicate erect to scandent herb; leaves broadest in middle nodes of stem up to the node below the inflorescence **L. barkeri**
 - 9: Stamines porrect to outcurved, with a terminal spur and a short to long filament arising behind its tip **8. L. lobelioides**
 - 8: Flower resupinate
 11. Corolla tube narrowly dilated **L. hypandra**
 - 11: Corolla tube broadly dilated **9. L. porphyrodinea**

6. *L. scopularis* W.R.Barker, sp. nov.

Holotypus: W.R. Barker 7080 & R.M. Barker, 5 June 1994, Bessie Springs, Northern Territory (AD 99818368). **Isotypi:** BRI, CANB, CNS, DNA, GH, K, MEL, NSW, PERTH.

L. sp. Cliff lover (P.K. Latz 10123) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Perennial glabrous herb, usually with pendent branches to c. 40 cm or more long, or, when smaller, forming small cushions. *Leaves* spatulate, (1–) 2–4 (–6) cm long, usually coarsely serrulate, sometimes entire. *Inflorescences* terminal, leafy, with to 10 or more flowers, with pedicels shorter than the leafy bracts, c. 1–10 mm long, in fruit recurved but not elongating. *Corolla* 8–10 mm long along the upper side, usually white, with fine blue striations extending from tube to lobes, sometimes “pale lilac” or “pale mauve”. *Stamens* 2, in adaxial position, the abaxial pair reduced to staminodes; adaxial anthers 1–1.4 mm long, 2-celled; abaxial staminodes obloid, yellow or white, tipped by a very short lateral filament and vestigial anther. *Capsule* ovoid, 5.5–9.5 mm long, glabrous; seeds narrow obloid, often curved, 1.4–1.8 mm long, 4-angled, with 10–12 transverse ribs between.

Distribution. Inland from the west coast of the Gulf of Carpentaria, Northern Territory, east-northwest and southwest of Borroloola in the Nathan River station area to the Abner Range (Bessie Springs).

Etymology. The adjectival epithet is derived from the Latin *scopulus*, cliff, and the suffix *-aris*, belonging to, alluding to the cliff face habitat of this species.

Selected additional specimens

NORTHERN TERRITORY: 28 km S Nathan River homestead, 11 Sep. 1995, P.K. Latz 14547 (AD); McArthur River area, 27 Jan. 1976, L.A. Craven 3413 (NT); 11 km S of Balbarini Homestead, 10 Nov. 1988, P.K. Latz 11041 (AD, DNA).

7. *L. petrensis* W.R.Barker, sp. nov.

Holotypus: W.R. Barker 7838 & K. Brennan, 5 Apr. 1999, on south face of Nourlangie Rock, c. 200 m N and above Anbangbang rock art site, Northern Territory (AD 279073). **Isotypi:** BRI, CANB, CNS, DNA, PERTH.

L. sp. Kakadu (J.L. Egan 4819) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Procumbent, rarely scandent, much-branched, glandular-pubescent annual, with stem and main branches 5–30 cm long. *Leaves* spatulate, 0.2–4 cm long, serrulate, rarely entire. *Inflorescence* rarely solitary, usually a few flowers in a leafy open raceme; bracts leaf-like or shorter, 0.3–2.5 cm long, the pedicels to 2.5 cm long, deflexed in fruit. *Corolla* 6.5–9 mm long along upper side, with white tube and mid blue-purple limb. *Stamens* 2, adaxial perfect, the anthers 0.5–0.6 mm long, 2-celled, deep blue; abaxial staminodes linear,

golden yellow, tipped by a vestigial anther. *Capsule* globular, 2.5–4.2 mm long, glabrous; seeds obloid, 0.8–1.3 mm long, 4-angled.

Distribution. Across northern Arnhem Land, Northern Territory, and to the south and south-west on Bradshaw Station. Between sandstone rocks in dense sorghum over herbfield or in bare sandstone gravel.

Etymology. An adjectival epithet from the Greek *petra*, rock, shelf or ledge or rock; *petrensis*, among rocks, alluding to the habitat on flattish ground in skeletal soil on or between rocks.

Selected additional specimens

NORTHERN TERRITORY: Arnhem Land, c. 81 km SSW of Maningrida, 23 Mar. 2000, I.D. Cowie 8738 (DNA); East of entry to Merl camping area, 21 Apr. 1999, W.R. Barker 7887 & I. Cowie (AD); Upper Liverpool River, Chester Ck Kulnguki area, 20 Apr. 2009, K.G. Brennan 7983 (DNA); Bradshaw Station, near Fire Plot 3, 18 Feb. 1999, C. Mitchell 2183 (DNA).

8. *L. lobelioides* (F.Muell.) F.Muell.

Syst. Census Austral. Pl. (1882) 97. — *Vandellia lobelioides* F.Muell., *Trans. Philos. Inst. Victoria* 3 (1859) 61, basionym (“Sect. Bonnaya”) [non *V. lobelioides* Oliv., *Trans. Linn. Soc. London* 29 (1875) 120, *nom. illeg.* (= *Craterostigma newtonii* (Engl.) Eb. Fisch., Schäferh. & Kai Müll.)]. — *Ilysanthes lobelioides* (F.Muell.) Benth., *Fl. Austral.* 4 (1868) 498. — **Type citation:** “A companion of *Vandellia clausa* to which it stands in close affinity. ... [From treatment of *V. clausa* referred to in the protologue] On sand-plains, subject to occasional inundations, on the Victoria River and its tributaries.” — **Lectotypus (hic designatus):** *F. Mueller s.n., s.dat.*, Victoria River, from the Depot Creek to the main camp [the latter at c. 15°34'S, 130°22'E] / *Dr M[ueller] s.n.*, May [18]56, Victoria River, below Steep Head, [c. 15°33'S, 130°55'E] (MEL 1552811; Fig. 2). **Isolectotypus:** *Dr M[ueller] s.n., s.dat.*, Victoria River (K 859763; Herb. Hooker) (“Bonnaya (*Ilysanthes*) *lobelioides* ferd. Mueller” in Mueller’s hand). **Syntypus possibilis sed exclusus:** *F.Muell. s.n., s.dat.*, Victoria River (MEL 1552812; “*Vandellia lobelioides* ? / *Lindernia*” in Mueller’s hand).

Typification. The lectotype was collected between 6th and 9th May 1856. During this period, the Gregory exploring party returned to the Bynoe Range on the Gregory River where Steep Head is located (Birman 1979).

The MEL lectotype is the better of the two syntypes; it has a clearly discordant label (the mid in the right-hand group of three) with handwritten notes and a sketch by Mueller showing unilocular anthers matching those of *L. clausa* (F.Muell.) F.Muell., which Mueller collected on the same expedition (MEL 1552814, MEL 1552815).

The collection MEL 1552812 has also been considered a potential syntype. However, it is not this species; the capsules are elongated as evidenced by the distinctly narrow septum.

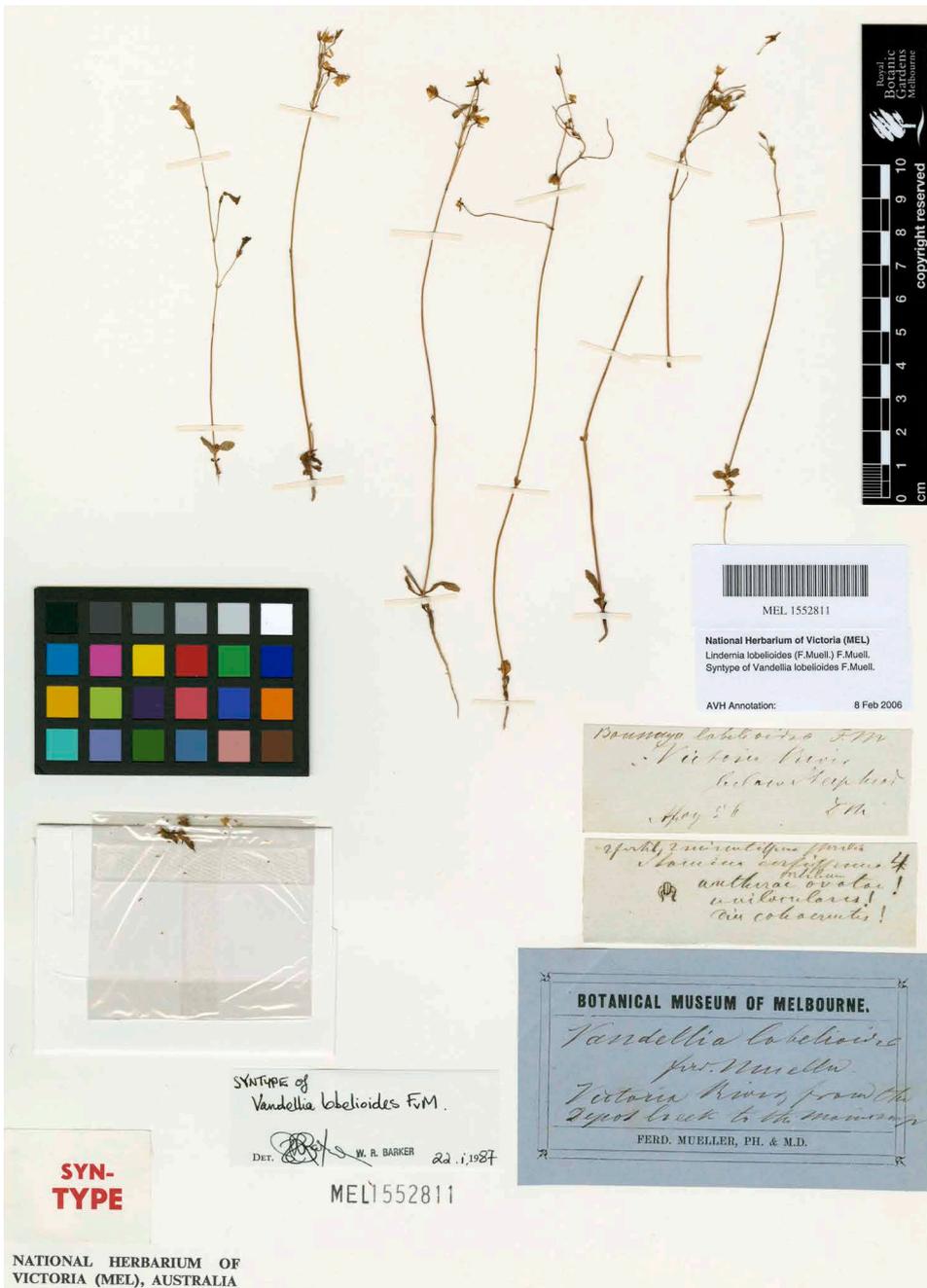
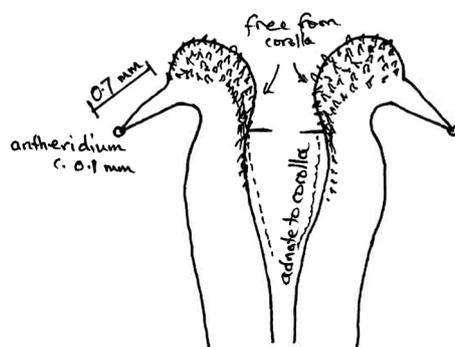


Fig. 2. Lectotype of *Vandellia lobelioides* F. Muell. at the National Herbarium of Victoria (MEL 1552811; reproduced with permission from the Royal Botanic Gardens Victoria).



Lindernia lobelioides
Staminodia of detached
flower. Rehydrated &
drawn by N.G. Walsh 7.viii.2017

Fig. 3. Staminodes in lectotype of *Vandellia lobelioides* F. Muell. (MEL 1552811). Del. Neville Walsh (published with his permission).

Notes. The descriptions of *L. tectanthera* by Barker (1990, 1992a) encompass both *L. lobelioides* and *L. tectanthera* except in the description of the staminal spurs.

L. lobelioides and *L. tectanthera* are both widespread in the Kimberley and are very similar in almost all respects, in floral shape and coloration, and in habit, although the latter is rosulate with multiple scapes, the former usually erect with larger leaves above the ground, and a single terminal inflorescence. The staminodes, however, are very different morphologically, as presented in the above key. Results of DNA analysis (Barker & Biffin, in prep.) show the two taxa to be phylogenetically well separated.

9. *L. porphyrodinea* W.R.Barker & M.D.Barrett, sp. nov.

Holotypus: *M.D. Barrett 4647* & *K.W. Dixon*, 20 Mar. 2015, near Bachsten Creek [precise locality withheld for conservation reasons], Western Australia (PERTH 8926859). **Isotypi:** AD, BRI, CANB, DNA, K.

Erect glabrous annual herb to c. 20–35 cm high. *Leaves* in rosette at plant base, sessile or very shortly subpetiolate, obovate, 10–20 mm long, along stem subulate, 2–5 mm long. *Inflorescences* floriferous open racemes terminating the branches or in upper leaf axils, the pedicels much longer than the bracts, widely spreading in fruit. *Flower* resupinate, the corolla bilabiate, 6.5 mm long along the upper (adaxial) side, purple with the throat marked with a white longitudinal band along the lower side and a pair of white striations on each side. *Stamens* 2 functional, positioned abaxially, anthers c. 0.8–1 mm long; staminodes 2, positioned adaxially, stout, yellow. *Capsules* globular, 2.5 mm long, glabrous; seeds (2 seen) narrow obloid, 0.4–0.5 mm long, finely 4–5 angled.

Distribution. In the Prince Regent River watershed, western Kimberley, Western Australia. On sand flats in mixed herbfield or damp clay in closed grassland.

Note. A patch of hundreds of plants, most in full flower, co-occurred with *L. hypandra* which was only just coming into flower (*M.D. Barrett 671*, AD).

Etymology. The adjectival epithet is derived from the Greek *porphyro-*, purple, *dinos*, cup, and *-eus*, noted for (Stearn 1966, p. 267), alluding to the distinctively open-mouthed purple-limbed corolla.

Selected additional specimen

WESTERN AUSTRALIA: Blyxa Creek, Prince Regent River Reserve, 19 Aug. 1974, *A.S. George 12432* (CANB, PERTH).

C. *Lindernia* sect. *Scapigeræ* W.R.Barker, sect. nov.

Typus: *L. scapigera* R.Br.

Annuals; stems and branches erect or narrowly ascending to procumbent, terminated by open racemes. *Leaves* subpetiolate, narrow to broadly ovate to obovate. *Pedicels* erect or ascending, in fruit sometimes deflexed, hardly elongating. *Corolla* regular, lacking internal longitudinal flaps; tube conspicuous, as long or longer than the limb; upper lip porrect or slightly upturned, emarginate. *Stamens* 4, with the abaxial filaments bearing a lateral cylindrical spur; anthers 2-celled. *Capsules* ovoid to subglobular; seeds longitudinally 4–8-ribbed, with 5–9 (–?10) transverse ridges.

Distribution. From the Kimberley, Western Australia, to north and east Queensland.

Note. The section includes *L. alsinoides* R.Br., *L. pubescens* (Benth.) F.Muell. and *L. scapigera* R.Br. Three further species that have been confused with *L. scapigera* are separated.

Key to species of *Lindernia* sect. *Scapigeræ*

1. Corolla to c. 6 mm long along upper side ***L. alsinoides* s. lat.**
- 1: Corolla greater than 6 mm long along upper side
2. Stems and leaves glandular hairy ***L. pubescens***
- 2: Stems and leaves glabrous
3. Corolla blue to blue-purple
4. Scandent, often multi-stemmed annual; leaves entire through undulate to coarsely serrulate within a population; corolla blue, purple or blue-purple with white tube, rarely white, with deeper blue-purple blotches on either side of the lowest lobe **10. *L. scapigera***
- 4: Erect, free-standing annual; leaves entire to coarsely serrate within a population; corolla mid blue with lower lip splashed with white **11. *L. grossidentata***
- 3: Corolla yellow
5. Corolla light to deepish yellow throughout, often with a few red streaks in the mouth; hood, 1.3–2.5 mm long; adaxial staminal spur 1.6–2.4 mm long **12. *L. tiwiensis***
- 5: Corolla white inside, yellow in throat extending onto lower lip, with outside of tube above yellow to brown; hood 0.8–1.5 mm long; adaxial staminal spur 0.6–1.5 mm long **13. *L. leucochroa***

10. *L. scapigera* R.Br.

Prodr. (1810) 441. — *Vandellia scapigera* (R.Br.) Benth. in DC., *Prodr.* 10 (1868) 415. — *Tittmannia scapigera* (R.Br.) Spreng., *Syst. Veg.*, ed. 16, 2 (1825) 800. — *Ilyogeton scapigera* Benth. in DC., *Prodr.* 10 (1868) 415, *pro syn.* (this combination in *Ilyogeton* Endl. did not appear in Walp., *Rep. Bot. Syst.* 3: 297, as attributed by Bentham). — **Type citation:** “(T.) v.v.” [from the tropical region of Australia, seen living *in situ*]. — **Lectotypus** (Philcox 1968: “holotype”): *R. Brown Iter Australiense 2696*, lect. 20 Dec. 1802, desc. 21 Dec. 1802, Carpentaria Islands h, cfr *Vandelioides* a facing Island. / North Coast, *Lindernia gracilis*. / *R. Brown s.n.*, Northern Territory, North Island (island h), Sir Edward Pellew Group (BM 1040723; Fig. 4). **Isolectotypi:** *R. Brown s.n.*, 20 Dec. 1802, Northern Territory, North Island (island h), Sir Edward Pellew Group (BM 1040724); *R. Brown Iter Australiense 2696*, *s. loc.* (“*Lindernia scapigera*, *Vandellia scapigera*”; K 859768, photo); [*R. Brown*] *s.n.*, *s.dat.*, Carpentaria (ex Herb. R. Brown 8/80). / “*Vandellia scapigera*, Bth [sic!]” (K 859770).

Typification. The name *L. scapigera* has been applied to several taxa of similar appearance across northern Northern Territory. High quality photographs of the types available on-line through JSTOR Global Plants enable confirmation that the type belongs with a species that extends from south of Darwin to the Sir Edward Pellew Group of islands in the Gulf of Carpentaria. This is the only species in the east of the range of the complex (Barker, in prep.). Brown collected and immediately described the collection in detailed notes. The collection is represented by three sheets (syntypes), necessitating a lectotypification. The specimen BM 1040723 is the best collection as it has multiple labels by Robert Brown and has several plants in flower and fruit. This is the syntype annotated with the species identity by Philcox (1968) for his revision of Malesian *Lindernia*, in which he cited the BM specimen as a holotype: “Carpentaria Island Dec., R. Brown ‘2696’ (Holotype BM, isotype K)”. The ICN (Art. 9.9: McNeill *et al.* 2012) indicates Philcox’s published designation of holotype is to be interpreted as a lectotypification.

The syntypes in BM and K are clearly from the same collection from the annotations and the similarity of the specimens; they are also in good condition.

L. scapigera 2: Biffin *et al.*, *Austral. Syst. Bot.* 31 (2018), in press.

Distribution. In Northern Territory, from south of Darwin across northern Arnhem Land to Vanderlin Island in the Sir Edward Pellew Group islands in the Gulf of Carpentaria.

Selected additional specimens

NORTHERN TERRITORY: Angularli Creek, Coburg Peninsula, 23 Aug. 2009, *D.E. Murfet 6570* (AD, DNA); Hades Flat Met[eorological] Station, 1 km W of Oenpelli road, 17 km from Arnhem Highway, 6 May 1983, *R.M. Barker 458* (AD); Gulungul Creek crossing on Arnhem Highway, c. 600 m W of turnoff to Jabiru Airport, 16 May 1994, *W.R. Barker 6881*, *R.M. Barker & M.C. O’Leary* (AD);

Arafura Swamp, east side, c. 17 km SE of Ramingining, 10 Dec. 1998, *I.D. Cowie 8129 & R.K. Harwood* (AD); 5 km NNW of Lake Eames, Vanderlin Island, 24 July 1988, *P.K. Latz 10747* (AD); Near Gulbuwangay River on track to Mirrnaja, 11 Oct. 2009, *D.E. Murfet 6616* (AD; voucher for Biffin *et al.*, in press).

11. *L. grossidentata* O.Schwarz

Repert. Spec. Nov. Regni Veg. 24 (1927) 96. — **Type citation:** “9 mi E of Darwin, wet patch of ground: Bleser 186”. — **Neotypus (hic designatus):** *W.R. Barker 7050 & R.M. Barker*, 1 June 1994, Howard Springs Park Estate, pending subdivision; c. 400 m down Parakeet Road from Bronzewing Road; 50 m N of road, Northern Territory (AD 99818363). **Isonotypi:** CANB, DNA, NSW.

Typification. No type material has been located despite a search of on-line resources (see p. 61). The species to which the name is applied here, and to which the neotype belongs, matches the protologue closely, particularly in the aniseed scent and often coarsely toothed leaves (“*margine remote et acute grossidentata*”; Schwarz 1927).

L. sp. Mount Bunday (C.R. Dunlop 8840) [N.T. Herbarium]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Distribution. In Northern Territory, in the vicinity of Darwin, extending to the Fish River area.

Note. Schwarz (1927) provides a detailed description of the species.

Selected additional specimens

NORTHERN TERRITORY: Mount Bunday Quarry, 12 Apr. 1991, *Dunlop 8840 & Cowie* (DNA); Charles Darwin National Park, 6 Mar. 1998, *P.S. Short 4667 & C.R. Dunlop* (AD, DNA); Douglas Hot Springs road, 17.6 km from old Stuart Highway, 29 Apr. 1983, *R.M. Barker 360* (AD).

12. *L. tiwiensis* W.R.Barker, sp. nov.

Holotypus: *I.D. Cowie 8462*, 16 Feb. 2000, Melville Island, c. 7 km SE of Garden Point, Northern Territory (AD 279773). **Isotypi:** DNA, BRI, CANB, K, MEL, NY, PERTH.

L. sp. Melville Island (C.R. Dunlop 4609) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007), partly.

Erect to scandent, glabrous, annual herb, simple or with up to 5 stem-like branches, these 8–40 cm long. *Leaves* in spaced pairs, spatulate, 5–25 mm long, entire to coarsely serrate. *Inflorescences* open terminal racemes of up to 10 flowers; pedicels much longer than the subulate to linear bracts, 7–25 mm long, deflexed in fruit. *Corolla* 6–6.7 mm long along the upper side, yellow, sometimes with red streaks; upper lip a porrect hood, 1.3–2.5 mm long. *Stamens* 4, perfect, with abaxial spur narrow cylindrical, straight or distally curved outwards and/or upwards, 1.6–2.4 mm long; anthers 2-celled, white. *Capsule* narrow obloid-ovoid to



Fig. 4. Lectotype of *Lindernia scapigera* R.Br. at the Natural History Museum, London (BM 001040723; image by Natural History Museum, CC-BY 4.0).

ovoid, 3.2–4 mm long; glabrous; seeds c. 0.5–0.6 mm long, with c. 5–6 longitudinal ribs.

Distribution. Confined to the Tiwi Islands, Northern Territory.

Etymology. The adjectival epithet alludes to the restriction of this species to the Tiwi Islands.

Selected additional specimens

NORTHERN TERRITORY: Melville Island, 8 Sep. 1977, C.R. Dunlop 4609 (AD, DNA); northern part, headwaters of Dudwell Ck, 28 Oct. 2014, I. Cowie 13702 & N. Cuff (DNA);

Bathurst Island, 30 Apr. 1998, C. Michell 1288 & R.K. Harwood (DNA); Melville Island, 10 km NW Pickertaramoor, 7 Jun. 1987, J. Russell-Smith 2496 & D. Lucas (DNA).

13. *L. leucochroa* W.R.Barker, sp. nov.

Holotypus: W.R. Barker 9116, R.M. Barker & K. Brennan, 12 May 2013, c. 250 m towards Jabiru from Nourlangie Rock turnoff on the Kakadu Highway to Pine Creek, Northern Territory (AD 268116; voucher for Biffin *et al.*, in press). **Isotypi:** CANB, DNA, PERTH.

L. sp. Melville Island (C.R. Dunlop 4609) [W.R.Barker]; R.A.Kerrigan & Alb., Checkl. N. Territory Vasc. Pl. (2007), partly.

L. scapigera 1: Biffin *et al.*, *Austral. Syst. Bot.* 31 (2018), in press.

Scandent to suberect, glabrous, annual herb, with stem and main branches 12–40 cm or more long. *Leaves* spatulate, distally 0.5–1.8 cm long, entire to coarsely serrulate. *Inflorescence* an open terminal raceme, the pedicels reflexed in fruit, much longer than the tiny bracts. *Corolla* 8–11 mm along the upper side, in front view with the lower lip white and the throat yellow, with the outer surfaces pale yellow, the hood sometimes flushed brown and then sometimes with its extremities flushed with blue. *Stamens* 4, perfect, with abaxial spur narrow cylindrical, yellow; anthers 0.8–1 mm long, white. *Capsules* ellipsoid to broad ovoid, 3–4.5 mm long, glabrous; seeds obloid to ellipsoid, 0.3–0.4 mm long, longitudinally 5–8-ribbed.

Distribution. From Daly River to central Arnhem Land plateau, Northern Territory, in herbfield or woodland.

Etymology. An adjective, formed by the elision of the Greek adjectives *leucos*, white, and *ochros*, yellow, alluding to white face of the flowers with conspicuous yellow encompassing the throat and mouth and often at the back of the limb.

Selected additional specimens

NORTHERN TERRITORY: Nigalaye Brook, 30 km WNW of Cannon Hill Ranger Station, 30 May 1980, *M. Lazarides 9099* (AD, DNA ex OSS); On Jabiru-Oenpelli road, on jump up at NE end of crossing of Magela Creek floodplain, 23 May 1994, *W.R. Barker 6991 & R.M. Barker* (AD); Margins of Flying Fox Creek, c. 50 m W of bridge, 12 May 2013, *W.R. Barker 9123 & R.M. Barker* (AD); Noonamah, Jenkins Road near creek, 12 July 2008, *D.E. Murfet 6060* (AD).

D. *Lindernia* sect. *Heterandrae* W.R.Barker, sect. nov.

Typus: *L. thyridostoma* W.R.Barker

Annuals; stems and branches erect or narrowly ascending terminated by open scapiform racemes. *Leaves* subpetiolate, broadly ovate to obovate. *Pedicels* erect or ascending, in fruit sometimes deflexed. *Corolla* regular, lacking internal longitudinal flaps; tube much shorter than limb; upper and lower lips widely spread forming an open throat. *Stamens* 4, with the abaxial

filaments with the lateral spur reduced to a swelling; adaxial anthers 2-celled, abaxial with a single perfect cell. *Capsules* narrow ovoid to subglobular; seeds 4-ribbed, with 6–9 transverse ridges.

Distribution. Confined to northern Northern Territory, this section comprises the following two species.

14. *L. thyridostoma* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 7812, K. Brennan & R.M. Barker*, Edge of hill c. 3 km NW of Nabarlek air strip, Northern Territory (AD 269127). **Isotypi:** BRL, CANB, CNS, DNA, K, PERTH.

L. sp. Open throated (J. Russell-Smith 5581) [W.R.Barker]; R.A.Kerrigan & Alb., Checkl. N. Territory Vasc. Pl. (2007).

Erect, rarely scandent, usually rosulate, delicate annual herb, 1.5–30 cm high, with a single stem or up to 15 stem-like branches, with long flexuous glandular hairs on the leaves and in the inflorescence. *Leaves* spatulate, 0.5–10 cm long. *Inflorescences* usually open racemes, rarely few-branched panicles, with pedicels much longer than the subulate bracts. *Corolla* 3.5–4 mm long along upper side, darkish blue with the mouth marked by a yellow spot on the lower side, often with brown-purple speckling on either side, and a translucent spot on either side of the dilated rear of the tube. *Capsule* ovoid, 3–4.5 mm long, glabrous or with tiny glandular hairs; seeds 0.3–0.4 mm long, with 4 longitudinal angles.

Distribution. Widespread across northern Northern Territory, in caves or sheltered places on rock faces.

Etymology. The adjectival epithet derives from the Greek, *thyris*, *-idos*, small door or window, and *stoma*, throat, alluding to the pale translucent blotches on the upper side of the corolla throat.

Selected additional specimens

NORTHERN TERRITORY: Tributary of Fitzmaurice River, 23 Feb. 1994, *G.J. Leach 4203* (AD, DNA); Litchfield National Park south, Tableland Creek Gorge, 14 Feb. 1996, *I.D. Cowie 6167 & R. Booth* (AD, DNA); Radon Springs [Upper Baroalba Creek, Mt Brockman], 13 May 1987, *B.S. Wannan & C.J. Quinn UNSW 20271* (AD); UDP Falls, Waterfall Creek Nature Reserve, 9 May 1983, *R.M. Barker 496* (AD); Gulungul, Kakadu National Park, 23 Mar. 1995, *J. Russell-Smith 10214* (DNA); Limmen National Park, St Vidgeons block SW corner, c. 65 km from St Vidgeons ruins, 24 Apr. 2009, *D.L. Lewis 1106* (AD).

Key to species of *Lindernia* sect. *Heterandrae*

1. Corolla blue-purple and often red-spotted, with a gullet mouth, the very back dilated, distally with parallel sides and with two translucent patches at the rear **14. *L. thyridostoma***
 1: Corolla mid blue through pink to white, with a widely dilated dish-like mouth with widely spread sides **15. *L. scutellata***

15. *L. scutellata* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 9108, R.M. Barker, K. Brennan & S. Ranger*, 9 May 2013, c. 500 m direct NNW from crest of road over Koongarra Saddle at head of Baroalba Creek valley, on W side of creekline (AD 268119).

Isotypi: CNS, DNA, PERTH.

L. sp. Small whitish corolla (I.D. Cowie 5661) [W.R.Barker]: R.A.Kerrigan & Alb., Checkl. N. Territory Vasc. Pl. (2007).

Erect to scandent delicate annual herb, 6–70 cm high, with a single stem to several stem-like branches arising from ground level, sometimes with tiny glandular hairs in the inflorescence. *Leaves* often subrosulate, largest near ground level, spatulate, 7–55 mm long, entire to irregularly coarsely undulate. *Inflorescence* an open terminal raceme or panicle, with pedicels much longer than the subulate bracts. *Corolla* like an open saucer, 2–4 mm long along upper side, mid blue to white, with a yellow tube and a yellow spot on the lower side of the mouth. *Capsule* ovoid or narrowly so, 2.7–4.3 mm long, covered by sparse tiny glandular hairs, rarely glabrous; seeds obloid, c. 0.4–0.5 mm long, with 4 blunt longitudinal ribs.

Distribution. Confined to the northwest and western Arnhem Land escarpment and plateau in the Northern Territory.

Etymology. The adjectival epithet derives from the diminutive of *scutum*, shield, and *scuta* flat tray, platter, *scutella*, a small flat dish or plate, alluding to the saucer shaped corolla.

Selected additional specimens

NORTHERN TERRITORY: Myra Falls vicinity, Tin Camp Creek, 29 May 1973, *T.G. Hartley 13807* (CANB); c. 700 m WSW of the East Alligator River, c. 3.4 km S of Cahill's Crossing, c. 23.5 km NNW of Jabiru Airstrip, 20 Apr. 1999, *W.R. Barker 7885 & I. Cowie* (AD); 22 km SE of Jabiru airstrip, Magela Creek upper catchment, 12 Apr. 1995, *I. Cowie 5661 & K. Brennan 3122* (AD, DNA); 1 km direct S of Koongarra Saddle, 20 May 1994, *W.R. Barker 6928, K. Brennan & R.M. Barker* (AD).

E. *Lindernia* sect. *Hemiarrhena* (Benth.) W.R.Barker, comb. et stat. nov.

Hemiarrhena Benth., *Fl. Austral.* 4 (1868) 518, basionym. — **Type:** *L. plantaginea* (F.Muell.) F.Muell.

Annual, rarely perennial, herbs; stems and branches erect or narrowly ascending to procumbent. *Leaves* subpetiolate, narrow to broadly ovate to obovate. *Inflorescences* open racemes, often scapiform, or dense scapiform heads. Pedicels short, erect or ascending, in fruit sometimes deflexed, hardly elongating. *Corolla* regular, lacking internal longitudinal flaps; tube conspicuous, as long or longer than the limb; upper lip perfect or sharply reflexed upwards, emarginate or lobed. *Stamens* 2, the abaxial pair absent or present as a pair of staminodes; anthers 1-celled. *Capsules* narrow obloid to

subglobular; seeds 4-angled, shallowly furrowed, with c. 5–9 fine, sometimes obscure, transverse ridges.

Distribution. Apart from *L. clausa*, *L. plantaginea* and *L. dunlopii*, which extend to northern Western Australia, and *L. mitrasacmoides*, which extends more widely in northern Northern Territory, the group is confined to western and northern margins of the Arnhem Land plateau, Northern Territory, where it is very diverse.

Note. The species have narrow ecologies in the overall range of the section, which includes savannah woodland, herbfields, skeletal soil on damp sandstone pavements, in caves in sandstone cliffs, on top of outcrops, and, in at least one instance, in a gorge with remnant rainforest.

16. *L. mitrasacmoides* (O.Schwarz) W.R.Barker, comb. nov.

Ilysanthes mitrasacmoides O.Schwarz, *Repert. Spec. Nov. Regni Veg.* 24 (1927) 96, basionym. — *Lindernia mitrasacmoides* O.Schwarz, *nom. inval.*: Dunlop *et al.*, *Checkl. Vasc. Pl. N. Terr.* (1987) 74. — **Type citation:** “Port Darwin, 10 miles E (Bleeser no. 206, flor.), 4 miles N (Bleeser no. 315, fruct.); bruised plant smells strongly of aniseed.” — **Lectotypus (hic designatus):** *F.A.K. Bleeser 315*, Apr. 1927, Darwin (NSW 50225; Fig. 5). **Isolectotypus:** DNA A0030367.

Nomenclatural note. Previous instances of publication of this combination in *Lindernia* are invalidly published. After 1 Jan. 1953, a new combination requires the basionym to be clearly indicated and directly referenced (McNeill *et al.* 2012: Art 41.5).

Typification. The syntype material seen by Schwarz is lost (see p. 61). The NSW and DNA specimens are isosyntypes, the NSW specimen being referred to as such (“duplicate of a syntype of *Ilysanthes mitrasacmoides* O.Schwarz”) by McKee (1963). In keeping with the citation of the syntypes in the protologue, the NSW specimen is largely, but not entirely, in fruit, and bears a faint number “315” written on a newspaper rectangle, similar to the collector number labels on other Schwarz types, e.g. those of *Acacia pellita* O.Schwarz, *Capparis citrifera* O.Schwarz and *Calophyllum ramiflorum* O.Schwarz, seen on-line (JSTOR Global Plants 2017). Like the NSW *Lindernia* specimen, dated “4/1927”, these three examples were collected in 1927 and sent to Berlin in time for Schwarz’s publication later in the same year. The NSW specimen is the better quality of the two isosyntypes and therefore the choice for lectotype. Furthermore, from copied annotations, the DNA specimen has been segregated from the NSW material, which was presumably amongst the many collections sent directly by Bleeser to Blakely in Sydney (McKee 1963).

Ilysanthes lobelioides auct. non F.Muell: Specht, *Rec. Amer.-Austral. Sci. Exped. Arnhem Land* 3 (1958) 298, partly. — *L. lobelioides* auct. non (F.Muell.) F.Muell.: Dunlop *et al.*, *Checkl. Vasc. Pl. N. Terr.* (1995) 102.

Distribution. In the northern mainland margin of the Northern Territory between the Darwin region and north-west Arnhem Land.

Key to species of *Lindernia* sect. *Hemiarrhena*

- 1.** Anthers 2-celled
- 2.** Aniseed-scented annual; leaves, bracts and sepals smooth-surfaced, the leaves undulate to coarsely serrulate; inflorescence a moderately dense head; capsules ovoid or narrowly so **16. *L. mitrasacmoides***
- 2:** Flyspray-scented annual; leaves, bracts and sepals pustulate, the leaves usually pinnatifid to pinnatifid, rarely coarsely serrate; capsules broad ovoid **17. *L. pustulosa***
- 1:** Anthers 1-celled
- 3.** Filaments behind the anther connective terminated by an obloid swelling ***L. clausa***
- 3:** Filaments evenly narrow to the anther connective
- 4.** Flowers in dense heads; pedicels hardly longer than subulate bracts
- 5.** Corolla hood porrect; abaxial staminodes absent; anthers awned by the long distal attenuation
- 6.** Perennial herb with woody rootstock; leaf blades narrow elliptic to narrow obovate, entire to shallowly coarsely serrate **18. *L. plantaginea***
- 6:** Annual, with undeveloped rootstock; leaf blades narrowly to broadly ovate to obovate, entire to minutely sinuate, rarely denticulate **19. *L. dunlopii***
- 5:** Corolla hood with a distal upturned bilobed lip; abaxial staminodes present; adaxial anthers acute distally **20. *L. brennanii***
- 4:** Flowers in open racemes; pedicels longer than subulate bracts
- 7.** Corolla hood well-developed, coloured; anthers included in tube, under hood or against the front of the hood
- 8.** Corolla hood with recurved lip
- 9.** Upper corolla lip glabrous
- 10.** Perennial, with long scandent branches **21. *L. lucrusmiana***
- 10:** Annual, with erect branches **22. *L. venustula***
- 9:** Upper corolla lip eglandular hairy **23. *L. enypniastina***
- 8:** Corolla hood porrect; anthers under tip of hood, distally awned **24. *L. acrandra***
- 7:** Corolla hood reduced, hardly coloured; anthers exposed, yellow, projected well in front of corolla hood
- 11.** Anthers horizontal, in line with the filament, with dehiscence slits facing lower side of mouth
- 12.** Anthers 1.6–1.8 mm long **25. *L. pronanthera***
- 12:** Anthers 0.6–1 mm long **26. *L. robyniae***
- 11:** Anthers vertical, at right angles to the filament, with dehiscence slits facing forward; anthers 1.1–1.35 mm long **27. *L. calliandra***
-

Note. Schwarz (1927) provides a detailed description of the species.

Selected additional specimens

NORTHERN TERRITORY: Charles Darwin National Park, 4 Sep. 1998, *P.S. Short 4750 & C.R. Dunlop* (AD); Howard Springs Park Estate, pending subdivision, c. 400 m down Parakeet Road from Bronzewing Road, 50 m N of road, 1 June 1994, *W.R. Barker 7051 & R.M. Barker* (AD); 12.5 km S of Cannon Hill Ranger Station, 28 May 1980, *L.A. Craven 6018* (AD); c. 9 km by road towards Jabiru from Nourlangie Rock turnoff on the Kakadu Highway from Pine Creek, 12 May 2013, *W.R. Barker 9117, R.M. Barker & K. Brennan* (AD); 19 km NNW of Twin Falls, 3 June 1980, *L.A. Craven 6298* (DNA).

17. *L. pustulosa* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 7833, R.M. Barker & K. Brennan*, 4 Apr. 1999. Beside vehicular track, c. 1.0 km direct S of Koongarra Saddle, Northern Territory (AD 268130). **Isotypi:** CNS, CANB, DNA, PERTH, MEL.

L. sp. Dissected leaf (*N.B. Byrnes 1520*) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Robust, erect, often branched, annual 12–35 cm high, with the scent of flyspray, stem often branched from the base, with short glandular hairs in the inflorescence, the surface of the leaf segments, bracts and sepals prominently pustulate. *Leaves* pinnatifid to lobulate, 3–16 mm long. *Inflorescences* open terminal floriferous racemes, the pedicels 5–15 mm long, much exceeding the narrow deltoid to linear bracts. *Corolla* 10–12 mm long along the upper side, pale pink to blue,



Fig. 5. Lectotype of *Ilysanthes mitrasacmoides* O.Schwartz. **A** Herbarium sheet from the National Herbarium of New South Wales (NSW 50225), seedpacket folded upwards and not shown; the label at the bottom left of the lectotype has a faint, largely erased number not discordant with "315". **B** Label in packet with annotation by H.S. McKee. **C** Contents of packet. (Reproduced with permission of the Royal Botanic Gardens Sydney).

with long tube and closed mouth. *Stamens*: the adaxial pair perfect, with anthers c. 0.7 mm long, 2-celled; the abaxial staminodes terminated by a reduced empty anther, with a blue or yellow linear oblong spur. *Capsules* broad ovoid, 3–3.8 mm long; seeds 0.25–0.4 mm long, mid brown, sharply 4-angled.

Distribution. Known from northern and western margins of the Arnhem Land plateau, Northern Territory, on exposed sandstone rock sheets prone to inundation.

Etymology. The epithet is adjectival, deriving from the Latin *pustula*, blister, bubble, and the suffix *-osus*,

denoting abundance, alluding to the heavily blistered leaf segments, bracts and sepals.

Selected additional specimens

NORTHERN TERRITORY: Spencer Range, 43 km E of Oenpelli Mission, 17 Feb. 1973, *L.G. Adams 3014* (CANB); Edge of hill c. 3 km NW of Nabarlek air strip, 3 Apr. 1999, *W.R. Barker 7815*, *K. Brennan & R.M. Barker* (AD); Mt Brockman, 26 Mar. 1995, *J. Egan 4474* (DNA); 17 km SE of Twin Falls, 20 Mar. 1988, *R. Fensham 886* (DNA); Waterfall Creek, 1 m [ile] above falls, 2 Apr. 1969, *N. Byrnes 1520* (CANB, DNA).

18. *L. plantaginea* (F.Muell.) F.Muell.

Fragm. 6 (1867) 102 (at least as to the type “ad flumen Victoriae F.M.”); R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007), partly. — *Vandellia plantaginea* F.Muell., *Trans. Philos. Inst. Victoria* 3 (1859) 62 (“Sect. Bonnaya”), basionym. — *Hemiarrhena plantaginea* (F.Muell.) Benth., *Fl. Austral.* 4 (1868) 518, partly (as to Mueller and Marten collections). — **Type citation:** “In moist meadows near Macadam Range”. — **Lectotypus (hic designatus):** *Dr M[uell.] s.n., s.dat.*, Bonnaya ? *plantaginea* n.sp. / A rare plant, [moist] but ... between McAdam Range & Providence Hill (K 859761, Herb. Hooker; Fig. 6a). **Isolotypus possibilis:** *Ferd. Mueller*, Between Providence Hill & McAdam Range. / *Ferd. Mueller*, Sept [18]55, Ad ostium fluminis Victoriae / FM, 1855, Arnhem’s Land. *Hemiarrhena plantaginea* Benth. (MEL 1552813; Fig. 6b).

Typification. In the protologue, Mueller indicates: “This species is extremely rare, and the only flowering specimen which was found is deposited in Sir Wm. Hooker’s herbarium, at Kew.” A possible syntype MEL 1552813, identifiable by one of two more specific locality labels, has a single individual plant. It is in poor condition by comparison with the two K plants on the lectotype sheet; it lacks flowers and has apparently been detached from its root base. A second label referring to the mouth of the Victoria River appears to be discordant; the type location between Providence Hill and the Macadam Range, appearing on the first label, is some distance to the north. Rather than the Victoria River reference being a general regional statement, it is possible that it signifies that the MEL material is from a second distant collection.

Another collection (*F. Mueller s.n.*, 10 Jul. 1856, Elsey’s Creek, MEL 2255630), possibly of *L. aplectra* W.R.Barker, is annotated *Hemiarrhena plantaginea* by Mueller. However, as it is not annotated with the name “Bonnaya *plantaginea*” or mentioned in the protologue by citation of its locality, it is not considered a syntype.

L. sp. Long-leaved (*J.L. Egan 5112*) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Note. *L. plantaginea* differs from the following species, with which it has been confused to this time, by its perennial rootstock, alluded to in the protologue and early publications, and its consistently narrow leaves.

Selected additional specimens

WESTERN AUSTRALIA: Blyxa Creek, Prince Regent River Reserve, 19 Aug. 1974, *A.S. George 12419* (PERTH); Drysdale River crossing, 25 km SE of Carson River Station, 1 July 1997, *K.F. Kenneally 11880* (PERTH).

NORTHERN TERRITORY: Keep River National Park, SW of Jarrnarm, 19 May 1995, *J. Egan 5112* (AD, DNA).

19. *L. dunlopii* W.R.Barker, sp. nov.

Holotypus: *R.M. Barker 468* & *C. Dunlop*, 7 May 1983, Little Nourlangie Rock, 12.2 km from Jim Jim road, turnoff 21 km from Arnhem Highway, Northern Territory (AD 98504060). **Isotypi:** AD 98504061, CANB, CNS, DNA, K, MEL, NSW, PERTH.

L. plantaginea auctt. non (F.Muell.) F.Muell.: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007), partly; Biffin *et al.*, *Austral. Syst. Bot.* 31 (2018), in press, partly.

Erect, scented, rosulate, annual, 10–62 cm high, with non-woody rootstock, glandular hairy in upper parts. *Leaves* spatulate, to 4.3 cm long, entire to very shallowly sinuate. *Inflorescence* a dense floriferous terminal head, sometimes with secondary inflorescences from upper stem nodes, with bracts narrow elliptic-ovate to -obovate, 1–2.5 mm long, longer than the pedicels. *Corolla* 7.8–10.5 mm long along the upper side, pale blue; hood porrect, auriculate, attenuating into entire obtuse apex. *Stamens* an adaxial pair, the abaxial pair absent, slightly exerted; anthers distorted-obovoid, 0.5–1 mm long, mid to deep blue, 1-celled, awned. *Capsule* broad ovoid to almost globular, 2.5–3 mm long, covered by blister glands and dense glandular hairs; seeds obloid-ellipsoid, c. 0.3–0.35 mm long, 4-angled.

Distribution. Widespread from the Kimberley, Western Australia, to Arnhem Land, Northern Territory, in herbfield and woodland understorey.

Etymology. Named in recognition of Clyde Dunlop’s major contribution to floristic knowledge of northern Australia and to the infrastructure and community understanding of plant systematics in the Northern Territory.

Selected additional specimens

WESTERN AUSTRALIA: 2.3 km by road SE of Mt Elizabeth Homestead, on southward vehicular track, 17 May 2000, *W.R. Barker 8027* & *R.M. Barker* (AD); Outside mess hut, Amax Capsite, Mitchell Plateau, 26 June 1976, *K.F. Kenneally 5356* (PERTH); Above the E bank of Wonga Creek c. 25 km W of Kalumburu Mission, 31 May 1996, *A.A. Mitchell 4366* (AD).

NORTHERN TERRITORY: Litchfield National Park, c. 750 m direct E of car park at north end of Lost City, on vehicular track above first jump-up, 19 May 2013, *W.R. Barker 9127* & *K. Brennan* (AD; voucher for Biffin *et al.*, in press); 1 km direct S of Koongarra Saddle, 20 May 1994, *W.R. Barker 6930*, *K. Brennan* & *R.M. Barker* (AD); Katherine Gorge National Park, 21 June 1975, *C. Dunlop 3775* (AD).

20. *L. brennanii* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 6936*, *K. Brennan* & *M. O’Leary*, 21 May 1994, On Arnhem Land plateau, c. 32 km ESE of Jabiru, Northern Territory (AD 99843024). **Isotypi:** CANB, CNS, DNA, MEL, NSW.

L. sp. Cleft hood (*C.S. Robinson 686*) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Erect rosulate, scapose annual, 17–40 cm high, usually simple, sometimes with up to 14 erect stem-like branches, sometimes branched at upper nodes, perceived by some as scented, minutely glandular hairy in upper



Fig. 6. *Vandellia plantaginea* F.Muell. **A** Lectotype at the Kew Herbarium (K 859761; copyright of the Board of Trustees of the Royal Botanic Gardens, Kew). **B** Possible syntype at the National Herbarium of Victoria (MEL 1552813; reproduced with permission from the Royal Botanic Gardens Victoria).

parts. *Leaves* spatulate, 0.8–4.5 cm long, entire to irregularly shallowly coarsely sinuate. *Inflorescences* dense floriferous heads, with bracts deltoid, 2–2.5 mm long, longer than the pedicels. *Corolla* 8–12 mm long along the upper side (to the point of recurvature of the hood), blue, the hood distally recurved into a deeply emarginate, 2-lobed lip. *Stamens* in 2 pairs; adaxial pair fertile, with anthers ellipsoid-obloid, 0.7–1 mm long, blackish-purple, 1-celled, with obtuse to subacute, non-aristate ends; abaxial pair reduced to a pair of oblong to linear spurs. *Capsule* obovoid to ellipsoid or broadly so, 2.2–3 mm long, covered by tiny glandular hairs c. 0.02 mm long; seeds obloid, 0.4–0.5 mm long, with 4 sharp to blunt longitudinal ridges.

Distribution. Northern Territory, confined to the Arnhem Land plateau or north and west on surrounding watershed plains, in open, seasonally inundated situations.

Etymology. Named after Kym Brennan, long-time field botanist in northern Northern Territory, whose knowledge of the flora is held by few others, for his guidance in seeking out the diversity of *Lindernia*, and for his invaluable floral photographs.

Selected additional specimens

NORTHERN TERRITORY: On E side of Murgenna Creek crossing, on Oenpelli road, 26 May 1994, *W.R. Barker 7019*, *R.M. Barker 826* & *M. O'Leary* (AD); Rum Bottle Creek, 28 May 1972, *D.E. Symon 7936* (AD); Edge of hill c. 3 km NW of Nabarlek air strip, 3 Apr. 1999, *W.R. Barker 7816*, *R.M. Barker* & *K. Brennan* (AD); At creek crossing c. 1 km direct S of Koongarra Saddle, 20 May 1994, *W.R. Barker 6929*, *K. Brennan* & *R.M. Barker* (AD); Site 70, 10 km N of Twin Falls, 28 May 1980, *L.A. Craven 6056* (AD); above Gunlom Falls, 11 Apr. 1993, *K. Brennan 2219* (DNA ex OSS).

21. *L. lucrusmiana* W.R.Barker, sp. nov.

Holotypus: *D. Lucas 118*, 16 June 1988, Steep boulder gorge, Kakadu, Northern Territory (DNA 43216). **Isotypus:** BRI (n.v.).

L. sp. Robust branched (*D. Lucas 118*) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Procumbent to erect, glabrous, perennial herb, with main branches 20–50 cm or more long, rooting at lowest nodes. *Leaves* spatulate, 1.5–7 cm long, entire to coarsely serrulate. *Inflorescence* a simple erect terminal raceme of a few flowers; pedicels at lower nodes in fruit 8–10 mm long, variously spreading in fruit. *Corolla* 8.5–9.5 mm long along the upper side, purple or bluish purple, with a bi-lobed recurved upper lip, greatly exceeded by an elongated decurved lower lip 7–8 mm long. *Stamens:* adaxial pair perfect, the abaxial missing; anthers ellipsoid, c. 1 mm long, 1-celled, borne under upper corolla lip. *Capsules* narrow ellipsoid, c. 4.5 mm long; seeds ellipsoid-obloid, 0.45–0.5 mm long, 4 angled.

Distribution. On the north-western escarpment of the Arnhem Land plateau, Northern Territory. Known from two collections only from the same general location.

Etymology. The name concatenates the initial letters of the surnames of Jeremy Russell-Smith and Di Lucas, long-time Arnhem Land ecologists, in recognition of their continued substantial contribution to knowledge of the biodiversity of the region. They are the plant's only collectors and are ecological authorities on its rainforest habitat (e.g. Russell-Smith *et al.* 1993).

Additional specimen examined

12 km E of Mudginberri Homestead, 7 Jan. 1991, *Russell-Smith 8387* & *Lucas* (DNA, MEL *n.v.*).

22. *L. venustula* W.R.Barker, sp. nov.

Holotypus: *K. Brennan 3131*, 14 Apr. 1995, Jabiru Dreaming, East Alligator River, Northern Territory (AD 99530166). **Isotypi:** DNA, CANB, CNS, NSW, PERTH, K.

L. sp. Recurved hood (*I.D. Cowie 1171*) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Erect or decumbent annual, 3–40 cm tall, with stem usually branched, rarely simple, glabrous but for minute antrorse eglandular hairs lining the sepals. *Leaves* spatulate, 0.3–6 cm long, the longest entire to coarsely serrulate. *Inflorescences* usually simple, sometimes branched open racemes, with pedicels in fruit spreading to greatly deflexed. *Corolla* 2–10 mm long along the upper side, mid blue, rarely white or pink; upper lip recurved into two obtuse lobes divided by deep cleft. *Stamens* 2 in adaxial position, with no abaxial pair; anthers 0.4–0.95 mm long, usually mid blue, sometimes brown. *Capsule* cylindrical, 3.5–6.5 mm long, glabrous; seeds 0.3–0.35 mm long, with 4 weak longitudinal angles.

Distribution. Confined to the western escarpment and plateau of Arnhem Land, Northern Territory, in skeletal soil associated with rock faces, at their base, in caves, or on their summit.

Etymology. The adjectival epithet derives from the Latin *venusta*, Venus-like, elegant, graceful, and the diminutive *-ulus*, indicating a tendency, alluding to the curvaceous flowers noticeable in the type and other longer limbed variants of this species.

Selected additional specimens

NORTHERN TERRITORY: Ubirr Aboriginal Art Site, c. 30 m E of Main Gallery, c. 250 m N of car park, 19 May 1997, *W.R. Barker 7717*, *R.M. Barker* & *J.A. Barker* (AD); c. 5.5 km E of Mt Howship, c. 27 km SSW of Nabarlek, 3 Apr. 1999, *W.R. Barker 7817* & *R.M. Barker* (AD); Headwaters of East Alligator River, 13 May 1997, *G. Leach 4605* (AD); N facing wall in central part of Mt Brockman, 23 Feb. 1973, *L.A. Craven 2360* (DNA); Upper Baroalba Creek, 17 Apr. 1995, *K. Brennan 3143* (AD); near Kurundie Creek, 20 Apr. 1990, *I. Cowie 1167*, *1171* & *G. Leach* (AD, DNA).

23. *L. enypniastina* W.R.Barker, sp. nov.

Holotypus: *K. Brennan 3182*, 26 Apr. 1995, Narridj Creek area, Northern Territory (AD 99528336).

Isotypi: BRI, CANB, CNS, DNA, K, MEL, NSW, PERTH.

L. sp. Narridj Creek (R.K. Harwood 981) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Much-branched, delicate, glabrous or eglandular hairy annual, usually forming leafy clumps, rarely an unbranched stem, 8–30 cm high. *Leaves* spatulate, 8–40 mm long, coarsely serrulate, rarely ± entire. *Inflorescence* a terminal raceme of up to 15 flowers; pedicels 2–5.5 mm long, deflexed in fruit. *Corolla* deep blue purple, c. 9 mm long along the upper side; hood with 2 upturned rounded lobes; lower lip decurved, 5–6 mm long. *Stamens* the adaxial pair only; anthers obovoid, 1 mm long, 1-celled, positioned in front of tip of corolla hood, acute at the lower end. *Capsules* narrow ellipsoid, 6–6.5 mm long; seeds obloid-ellipsoid, 0.3–0.4 mm long, with 4 rounded longitudinal angles.

Distribution. Known from two sites on the north Arnhem Land escarpment, Northern Territory, in the north of Jabiru, and about 150 km to the west in the Cadell River watershed.

Etymology. An adjectival epithet from the Greek, *enypniastes*, m., a dreamer, and the suffix *-inus*, indicating possession, in recognition of the first Australians and their continuous spiritual ties to the land and its flora encompassing at least 65,000 years, evidence for which has been recently firmly established with an archaeological site found on the same plateau outlier as the type locality (Clarkson *et al.* 2017).

Selected additional specimens

NORTHERN TERRITORY: Foot of small gap high on outlier W of main escarpment, c. 250 m S of Narradj Creek plain, 8 May 2013, *W.R. Barker 9096*, *K. Brennan*, *Ambrose Djandjul & R.M. Barker* (AD); c. 2 km NW of Korlobidahda, Plot 2358, 13 Apr. 2000, *R.K. Harwood 981* (AD, DNA).

24. *L. acrandra* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 7810*, *K. Brennan & R.M. Barker*, 3 Apr. 1999, Edge of hill c. 3 km NW of Nabarlek air strip, Northern Territory (AD 279774).

Isotypi: BM, CANB, CNS, DNA, MEL, NSW.

L. sp. Nabarlek (K. Brennan 3156) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Delicate, erect, eglandular hairy, annual herb, 6–40 cm high. *Leaves* spatulate, 0.7–8.5 cm long, shallowly coarsely serrate. *Inflorescence* a terminal floriferous raceme; pedicels in fruit usually reflexed to spreading down, sometimes upward spreading, 5–7 mm long. *Corolla* 9–12.7 mm long along the upper side, deep blue purple, with the hood porrect, the lower lip broad, flat, spreading, 6.5–8 mm long. *Stamens* 2, adaxial, projected in front of the corolla hood; anthers joined, 1-celled, obloid, 1.4–1.7 mm long, white or pale

yellow. *Capsule* narrow obloid-ovoid, 5–7 mm long, sparsely eglandular pubescent, obloid to ellipsoid, often broadly so, 0.25–0.3 mm long, almost round in cross section, 4 angled, the cross-walling obscure.

Distribution. Known from north-west Arnhem Land in Northern Territory.

Etymology. An adjectival epithet, from the Greek *acro-*, at the apex, and *andros*, androecium, alluding to the anthers projected well in front of the corolla hood.

Selected additional specimens

NORTHERN TERRITORY: Nabarlek, 8 Apr. 1989, *R. Hinze 514* (DNA); c. 3 km SE of Mt Howship, c. 28 km SSW of Nabarlek, 3 Apr. 1999, *W.R. Barker 7822* (AD).

25. *L. pronanthera* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 7814*, *K. Brennan & R.M. Barker*, 3 Apr. 1999, Edge of hill c. 3 km NW of Nabarlek air strip, Northern Territory (AD 268131).

Isotypi: BRI, CANB, CNS, DNA, K, MEL, NSW, PERTH.

L. sp. Brennan's showy anthers (K. Brennan 3155) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Floriferous, fragile to robust, erect, rarely scandent, eglandular hairy, annual herb 8–35 cm high. *Leaves* spatulate, the upper or penultimate pair largest, 1.5–3.5 cm long, coarsely serrulate to serrate in the distal $\frac{1}{2}$ – $\frac{2}{3}$. *Inflorescences* terminal, open, floriferous racemes or panicles; pedicels 6–15 mm long, in fruit probably hardly elongated, narrowly spreading upward to almost vertically deflexed. *Corolla* 1.8–2 mm long along the upper side as far as the tip of the mid yellow tube; hood more or less absent; lower lip 4.5–5 mm long, mid yellow proximally, distally blue-purple. *Stamens* glabrous: abaxial pair absent; adaxial pair with anthers single-celled, ellipsoid, 1.6–1.8 mm long, mid yellow, directed forwards. *Capsules* narrow ellipsoid, 4–5 mm long, glabrous; seeds (*Barker 7814 et al.*) oblong to ellipsoid, 0.3–0.35 mm long, with 4 longitudinal angles, shallow furrows between traversed by c. 9 fine ridges.

Distribution. Confined to north-west Arnhem Land in Northern Territory.

Etymology. The epithet is an adjective derived from the elision of the Latin adjective *promus*, inclined forward, facing downward, and noun, *anthera*, in epithets also used adjectivally, alluding to the disposition of the prominent anthers.

Selected additional specimen

NORTHERN TERRITORY: Kakadu National Park, northern outliers S of Fire Plot 143, 12 July 2008, *K. Brennan 7751* (DNA).

26. *L. robyniae* W.R.Barker, sp. nov.

Holotypus: *W.R. Barker 7859* & *K. Brennan*, 14 Apr. 1999, Cliffs below Mary River Ranger Station, Northern Territory (AD 268126). **Isotypi:** CANB, CNS, DNA, NSW, PERTH.

L. sp. Robyn's showy anthers (*R.M. Barker 497*) W.R.Barker, ined.

L. sp. Robyn's showy anthers (*L.A. Craven 6234*) R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Erect to narrowly spreading, simple or branched, glabrous annual, 4.5–35 cm high. *Leaves* spatulate, 0.5–4.5 cm long; entire through sinuolate to irregularly coarsely dentate. *Inflorescences* open racemes, with pedicels deflexed to broadly downwardly spreading in fruit, much longer than the narrow-linear minute bracts. *Corolla* 2–3 mm long along the upper side, blue throughout, with yellow patch at base of lower lip behind anthers; lower lip spreading 2–4.8 mm long. *Stamens* 2, in the adaxial position, with abaxial pair absent; anthers projected well in front of hood, almost horizontal, ellipsoid-ovoid, 0.9–1.0 mm long, yellow, 1-celled. *Capsule* narrow ovoid-obloid, 3.8–7 mm long; seeds obloid to ellipsoid, 0.35–0.45 mm long, with 4 longitudinal angles.

Distribution. On south-western Arnhem Land escarpment, Northern Territory, and Mount Douglas not far to the west, in skeletal soil in rocky areas.

Note. While generally correctly applying the phrase name to this species using my manuscript keys, the Northern Territory Herbarium chose as the voucher in their collection a specimen of the following species (*L. calliandra*).

Etymology. The epithet is a Latin noun in the possessive case, in recognition of Robyn Barker, who has been a participant in my investigations into Australian *Lindernia*, having reported on its remarkable diversity before my own experiences.

Selected additional specimens

NORTHERN TERRITORY: Mt Douglas, W side, 6 July 1999, *I.D. Cowie* & *R.K. Harwood 8358* (AD); Ikoymarrwa Lookout, Kakadu National Park, 21 Mar. 2011, *D.E. Murfet 7191* & *A. Lowrie* (AD); c. 400 m upstream from Ferny Gully picnic area (at end of entrance track), 15 Apr. 1999, *W.R. Barker 7865* (AD); UDP Falls, 108 km NE of Pine Creek, 9 May 1983, *R.M. Barker 497* (AD).

27. *L. calliandra* W.R.Barker, sp. nov.

Holotypus: *K. Brennan 3139*, 14 Apr. 1995, Little Nourlangie Rock, Northern Territory (AD 99528344).

Isotypi: CNS, DNA, PERTH.

L. sp. Showy anthers (*L.A. Craven 2393*) [W.R.Barker]: R.A.Kerrigan & Alb., *Checkl. N. Territory Vasc. Pl.* (2007).

Erect to decumbent or scandent, glabrous herb, 3.5–36 cm high. *Leaves* spatulate, 0.4–6.5 cm long, entire to serrate. *Inflorescences* open, terminal, rarely

subpaniculate racemes, with pedicels in fruit spreading widely to strongly deflexed, much longer than the narrow linear-subulate bracts. *Corolla* 1.5–2.5 mm long along the upper side, yellow proximally on the tube and upper lip, which is blue-purple distally. *Stamens:* the abaxial pair absent; the adaxial pair with anthers in front of and almost at right angles to the corolla tube, facing forward, ellipsoid, 1.1–1.3 (–1.35) mm long, 1-celled, mid yellow. *Capsule* narrow ovoid-obloid glabrous 3–8 mm long; seeds obloid or irregularly so, 0.3–0.4 mm long, with 4 longitudinal angles.

Distribution. Confined to the west margins of the Arnhem Land plateau, Northern Territory, associated with rock faces and boulders, in sand, often in shade.

Etymology. The adjectival epithet derives from the Greek prefix *calli-*, beautiful, and *andros*, male, masculine, alluding to the showy anthers.

Selected additional specimens

NORTHERN TERRITORY: Site 64, 14.5 km NE of Jabiru East, 26 May 1980, *L.A. Craven 5951* (DNA); in small gorge c. 0.5 km SW of summit of Little Nourlangie Rock, on low sloping rock sheet, c. 50 m NW of edge of rock where vehicular track turns to Anbangbang Billabong, 20 May 1997, *W.R. Barker 7719, 7719A, R.M. Barker* & *J.A. Barker* (AD); Magela Creek upper catchment, 11 Apr. 1995, *I. Cowie 5599* & *K. Brennan* (AD, DNA); Twin Falls, c. 72 km SSW of Jabiru, Site 86, 1 June 1980, *L.A. Craven 6234* (AD, DNA).

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Antrelloides atroceraea, a new genus and species in the Pezizaceae (Pezizales) from Australia

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Abstract: A new genus, *Antrelloides*, and a new species, *Antrelloides atroceraea* P.S.Catches. & D.E.A.Catches. (Ascomycota, Pezizales, Pezizaceae) from Australia are described and illustrated. Phylogeny within the Pezizaceae is discussed and an overview of exothelial, cleistothelial and apothecial members of the Pezizaceae given. Morphological and phylogenetic comparisons are made within the Pezizales.

Keywords: Fungi, Pezizaceae, Pezizales, *Antrelloides*, Kangaroo Island, Australia

Introduction

A curious Ascomycete, first found in 2007, appears as small cushion-like black lumps (Figs 1A & 1B) amongst laterite nodules alongside and on sandy tracks of Flinders Chase National Park, Kangaroo Island (Fig. 1E). It has also been collected in grey sand on a track between Denmark and Walpole, Western Australia. The stipe is buried in the soil and, on excavation, the whole fruit body is seen to be turbinate, the obconic base capped by a thin, black, convex disc. In section, the stipe consists of irregular, knobby columns radiating upwards and outwards from the base. The ascoma resembles a miniature cavern or grotto of continuous columns of stalactites and stalagmites, but gathered at the base and capped by the hymenium (Figs 1C & 1D). When first observed, the black lumps looked like small pieces of discarded patent black shoe leather, hence the fungus was given the informal name ‘Shiny Black Shoe Leather’. The hymenial surface of later collections was dull, so the tag name became ‘Black Shoe Leather’—an appellation we still use, as it is helpful when describing to other potential collectors what to look for. However, the texture is firm and waxy but brittle, certainly not leathery nor, obviously, has it anything to do with shoes.

Flinders Chase National Park covers an area of approximately 325 km² of largely undisturbed remnant vegetation. Its habitats include eucalypt woodland, sandy heath, rugged coastal scrub and dunes. Since we have been surveying in Flinders Chase we have found rare and under-collected fungi such as *Amanita arenaria* (O.K.Mill. & E.Horak) Justo (Catcheside & Catcheside 2005) and the species described in this paper, both of which have also been found in Western Australia.

Materials and methods

Habitat and associated plant communities were noted in the field. Collection locations were recorded by GPS, geodetic datum WGS84/GDA94 (Garmin GPS12) and *in situ* and section photographs were taken with a Nikon E4500 or, for Fig. 1D, a Lumix DMC-GX7 and for Fig. 1E, the habitat shot, an Olympus TG2. Macroscopic characters were described directly from fresh material. Colours are designated using the Royal Botanic Gardens Edinburgh Colour Chart (1969), given as colour descriptor and number, e.g. violaceous black 38, and in general terms. For the more variable colouration in the stipe tissue, colours are given according to Kornerup & Wanscher (1978) (page number, column letter, row number, e.g. 2B4). Fresh material was dried in a food dehydrator at 35°C for 24 h (Hydraflo 1000FD).

Sections of fresh material and dried specimens were hand-cut and mounted in various media. For the amyloid reaction, fresh material was stained with Melzer’s reagent and dried material was rehydrated in 5% NH₄OH before staining. Water mounts were used to determine colour of context.

Measurements were made using an Olympus BH-2 microscope at 400× or 1000× with a calibrated ocular micrometer. Spore dimensions are given as: length range × width range (n = 40) and Q ratio (spore length/spore width). Dimensions of asci are given as length range × width range (n = 20). A Nikon 4500 camera was used to photograph microscopic characters. For scanning electron microscopy (SEM) a small piece of hymenial tissue was immersed in 2.5% KOH for 3 mins and rinsed in demineralised water to release

spores. A drop of the resulting material was mounted on aluminium stubs with double-sided tape, dried and then sputter-coated with platinum at Adelaide Microscopy. Specimens were viewed under 10kV in a JEOL Neoscope JCM 5000 SEM at the State Herbarium of South Australia.

Descriptions of *Antrelloides atroceracea* are based on the type collection, P.S. Catcheside PSC 2710 (AD-C 55811), unless otherwise stated, with outlying measurements for other collections given in brackets. Photographs of fruit bodies and microscopic characters are from the type collection, unless stated otherwise in the figure captions. All South Australian collections have been accessioned into the State Herbarium of South Australia (AD). AD numbers (AD-C #####) are given in the Taxonomy section together with the Collector's number (PSC #####); in other sections only the Collector's number is used.

DNA extraction, amplification and processing were as described in Catcheside *et al.* (2016); primers ITS1 and LR5 were used for amplification and ITS1, ITS4, LR0R, and LR5 for sequencing (White *et al.* 1990). Sequences were manipulated with the Geneious 8.1.9 and 11.0.3 suites of programmes using MUSCLE for alignment and MrBayes 3.2.6 and RAxML 8.2.11 plug-ins for tree building.

Antrelloides atroceracea 28S sequences were aligned with the top 100 blastn hits from GenBank on 7 Feb. 2017, and also 28S sequences from *Boudiera dennisii* Dissing & Sivertsen, *Cazia flexiascus* Trappe (Trappe 1989), *Eremiomyces echinulatus* (Trappe & Marasas) Trappe & Kagan-Zur, *Pachyella adnata* (Berk. & M.A.Curtis) Pfister, *P. babingtonii* (Berk. & Broome) Boud., *P. habrospora* Pfister, *P. punctispora* Pfister, *P. violaceonigra* (Rehm) Pfister, *Ruhlandiella peregrina* Lantieri & Pfister and *Sphaerosoma trispora* McLennan & Cookson. Redundant sequences were removed from the alignment and a phylogram constructed, rooted to *Ascobolus carbonarius* P.Karst. MrBayes used the HKY85 substitution model, 4 heated chains at a temperature of 0.2 for 1,100,000 iterations including a burn-in of 100,000 that was discarded. Following burn-in, trees were sampled every 200 iterations. The average standard deviation of split frequencies reached 0.011. RAxML used the GTR GAMMA nucleotide model with rapid bootstrapping for 1000 iterations and a search for the best scoring maximum likelihood tree.

Taxonomy

Antrelloides P.S.Catches. & D.E.A.Catches., *gen. nov.*

Type: *Antrelloides atroceracea* P.S.Catches. & D.E.A.Catches.

Mycobank number: MB825520.

Apothecial ascomata up to 40 mm diam. *Hymenium* convex; firm, waxy; black, violaceous-black. *Basal stipe* substantial; obconic; a chambered base of knobby

columnar ridges radiating from base; fragile, waxy. *Asci* amyloid; cylindrical; operculate; 8-spored. *Ascospores* ellipsoid; smooth under light microscope. *Paraphyses* longer than asci; septate; tips swollen and tending to aggregate, encrusted with brown amorphous matter; branching occasionally near tips. *Medullary excipulum* of several layers of interwoven hyphae, grading into ectal excipulum. *Ectal excipulum* of large globose to subglobose cells with interwoven hyphae. *Stipe* tissue of *textura globulosa* and chains of subglobose cells.

Etymology. From the Latin *antrellum*, a small grotto or cavern, and the Greek *-oides*, like.

Antrelloides atroceracea P.S.Catches. & D.E.A.Catches. *sp. nov.*

Holotype: South Australia. Flinders Chase National Park, Kangaroo Island: On soil surface in slight depressions on side of path in lateritic sandy soils, 35° 56' 25"S, 136° 43' 58"E, alt. c. 65 m, heath with *Banksia marginata* Cav., *Leptospermum continentale* Joy Thomps., *Melaleuca gibbosa* Labill., *Isopogon ceratophyllus* R.Br., *Petrophile multisecta* F.Muell., *Lepidosperma semiteres* F.Muell. ex Boeck., *Hakea mitchellii* Meisn., 6 July 2007, P.S. Catcheside PSC 2710 & D.E.A. Catcheside (AD-C 55811).

Mycobank number: MB825521.

Apothecia solitary, scattered; occasional to frequent; shiny to dull; black, violaceous-black 38; forming circular to irregular cushion-like mounds above soil surface or amongst laterite nodules (Figs 1A & 1B). Whole fruit body broadly obconic, turbinate; diameter (10–) 15–40 mm, height above ground 6–15 mm, total height 15–30 mm. In cross section, the whole fruit body resembles a miniature cavern of continuous columns like stalactites and stalagmites fused at the base and radiating upwards and outwards to the capping hymenium (Figs 1C & 1D). *Disc* convex, irregularly domed; black, violaceous-black 38; shiny to matt; smooth to wrinkled, undulating, occasionally pitted; waxy, brittle; margin smooth to irregularly lobed. *Flesh* 0.6–1 mm thick; exterior black, lower layers pale grey. *Stipe* continuing below soil surface; diameter 17–38 mm, depth 16–24 mm; deeply and irregularly lacunose; forming a series of knobby columns fused at the base and radiating out from base; height of columns 15–28 mm, diameter of columns 2.5–5 mm; brown-black-grey 5F3, 6F3-5 at top, grading to grey 7E3, 6D3 at base (dark red-brown 6F5-7F5 in WA specimens); texture waxy, fragile. *Asci* cylindrical-clavate (250–) 272–316 (–340) × (8.5–) 11–15 μm, average (264–) 287.8 (–297) × 9.14 (–13) μm (Figs 2B & 2C); 8-spored; amyloid over entire length but more strongly amyloid at apex (Figs 2A & 2D); operculate; tips rounded; base forked, arising from croziers (Fig. 2E). *Ascospores* long ellipsoid; (16.8–) 17.6–22.4 (–24) × 6.4–8.8 μm, average (18.29–) 20.33 (–21.2) × (7.12–) 7.74 (–8.09) μm; Q range 2.4–2.8 (–3.0), Q average (2.35–) 2.61 (–2.76); appearing smooth under light microscope (× 1000) (Fig. 2H), but densely verrucose when viewed with SEM (Fig. 2I); thick-walled; often



Fig. 1. A–E *Antrelloides atroceraea*. **A** Two fruit bodies *in situ*; **B** single fruit body *in situ* (collection FMKI 145); **C** section of fruit body (holotype); **D** section of fruit body (collection PSC 4292); **E** habitat of *Antrelloides atroceraea* in heath. **F** Section of *Ruhlandiella berlinensis* (collection PSC 4322). Scale = 10 mm. Photos: D.E.A. Catcheside.

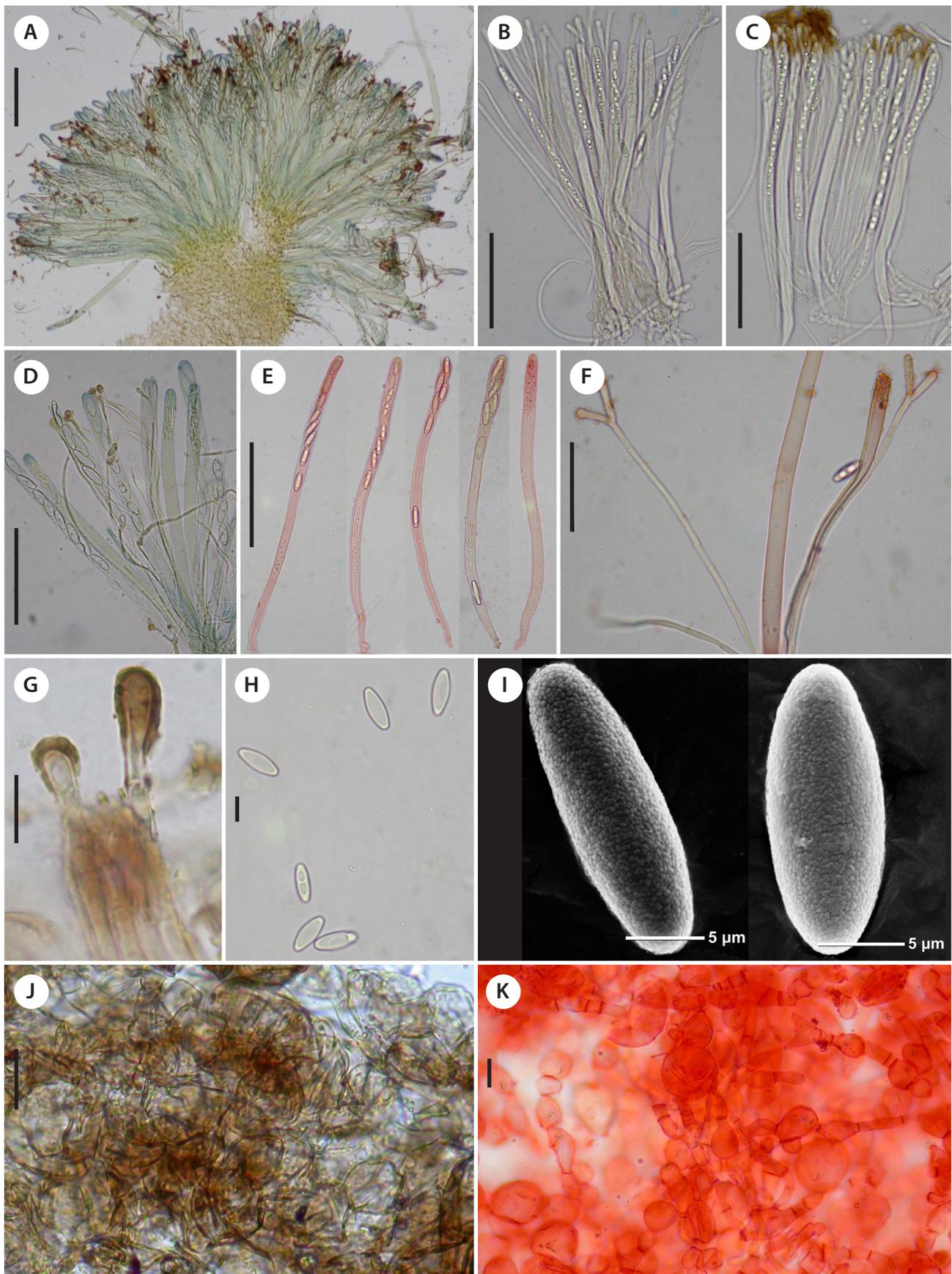


Fig. 2. *Antrelloides atroceraea*. **A** Hymenium showing asci, ascospores, paraphyses and excipular tissue (in Melzer's solution); **B** hymenium showing asci, ascospores, paraphyses (in 5% KOH); **C** hymenium showing asci, ascospores, paraphyses (in water); **D** asci (in Melzer's solution); **E** asci (in Congo Red); **F** bifurcating paraphyses (in Congo Red); **G** tips of paraphyses (in water); **H** ascospores (in 5% KOH); **I** scanning electron micrographs of ascospores; **J** ectal excipulum (in water); **K** stipe tissue (in Congo Red). Scale: A–F 100 µm; G, H, J, K 10 µm; I 5 µm Photos: P.S. Catcheside.

with two largish globules; mostly in upper part or with occasional ascospore in lower half of ascus; uniseriate, irregularly uniseriate, biseriate near top in some asci. *Paraphyses* straight; longer than asci; septate; tips slightly swollen 5–8 µm at tip; tips brown and encrusted with brown amorphous matter (Fig. 2G), brown pigment occasionally extending down into upper part of paraphysis; tips separate or clumped; occasionally bifurcate at tip (Fig. 2F). *Subhymenium* 25–40 µm thick, of densely woven septate hyphae and small cells to 6 µm in length. *Medullary excipulum* a mixture of four types of tissue: i. densely interwoven hyphae of diameter 5–10 µm and not swollen at septa; ii. hyphae composed of cells swollen at septa and appearing ‘knuckled’; iii. chains of ‘balloon’ cells joined by short hyphal cells; iv. regularly and irregularly globose and subglobose cells 15–45 µm diameter. Medullary excipulum grading into the larger cells of the ectal excipulum. *Ectal excipulum* (Fig. 2J) of globose, subglobose, sub-polygonal cells approx 20–65 (–80) µm diameter; cells thin- to thick-walled, contents clear to brown-pigmented, some cells encrusted. *Stipe tissue* mostly of globose, subglobose cells 20–60 (–70) µm diameter but intermixed with chains of small, irregular globose cells and hyphae swollen at septa and appearing ‘knuckled’ (Fig. 2K).

Habitat. Occurring on sandy and sandy lateritic soils.

Etymology. Latin *ater*, black, *ceracea*, waxy.

Additional specimens examined

WESTERN AUSTRALIA. North of Bow Bridge, Willmott Forest Block on Roe Road, in grey sand on track, 34° 58'S, 116° 57'E, 4 June 2008, *Eucalyptus marginata* Sm. (jarrah), *Andersonia caerulea* R.Br., *Astartea fascicularis* (Labill.) DC., *Melaleuca* sp., *Taxandria parviceps* (Schauer) J.R.Wheeler & N.G.Marchant, *Katrina Syme* & *Julie Fielder* KS2094/08 (AD-C 56009).

SOUTH AUSTRALIA. All collections from: Kangaroo Island, Flinders Chase National Park, Platypus Waterholes Walk in similar soils; on soil surface or in slight depressions on side of path in lateritic sandy, soils, heath with *Banksia marginata* Cav., *Leptospermum continentale* Joy Thomps., *Melaleuca gibbosa* Labill., *Isopogon ceratophyllus* R.Br., *Petrophile multisecta* F.Muell., *Lepidosperma semiteres* F.Muell. ex Boeck., *Hakea mitchellii* Meisn. 35° 56' 25"S, 136° 43' 58"E, alt. c. 60 m, 4 June 2008, *P.S. Catcheside* PSC 2899 & *D.E.A. Catcheside* (AD-C 59830); 35° 56' 26"S, 136° 43' 58"E, alt. c. 60 m, 27 June 2008, *P.S. Catcheside* & *Katrina Syme* (FMKI 145; AD-C 55361); 35° 56' 25.5"S, 136° 43' 58"E, alt. c. 60 m, 28 June 2010; *P.S. Catcheside* PSC 3422 & *D.E.A. Catcheside* (AD-C 57285); 35° 56' 5.6"S, 136° 44' 41.6"E, alt. c. 65 m, 30 June 2011, *P.S. Catcheside* PSC 3600 & *D.E.A. Catcheside* (AD-C 57335); 35° 56' 5.7"S, 136° 43' 41.8"E, alt. c. 65 m, 23 June 2013, *P.S. Catcheside* PSC 3745 & *D.E.A. Catcheside* (AD-C 58504); 35° 56' 8"S, 136° 43' 45.7"E, alt. c. 65 m, 23 June 2013, *P.S. Catcheside* PSC 3751, *D.E.A. Catcheside* & *H.P. Vonow* (AD-C 58378); 35° 56' 23.5"S, 136° 44' 57.5"E, alt. c. 65 m, 24 June 2015, *P.S. Catcheside* PSC 4292, *D.E.A. Catcheside* & *H.P. Vonow* (AD-C 60144); 35° 56' 23.5"S, 136° 44' 57.5"E, alt. c. 65 m, 24 June 2015, *P.S. Catcheside* PSC 4386, *D.E.A. Catcheside* & *A. Winston* (AD-C 60145).

Results of molecular analysis

A 1566bp sequence for *Antrelloides atroceracea* (GenBank MH722261), encompassing 18S part, ITS1, 5.8S, ITS2, 28S part, was obtained from PSC 2710 and PSC 3600, which were identical in sequence, and showed no heterozygosity. Bayesian and maximum likelihood phylogenetic analysis places *A. atroceracea* in the Pezizaceae with the closest known relatives being *Peziza natrophila* and *Lepidotia hispida* (Fig. 3). *Antrelloides atroceracea* differs by 4.8% over 835bp in snps, indels and other mismatches in 28S ribosomal sequences from *P. natrophila* (AF335152.1 [isotype] and AF335153.1) and *L. hispida* (as *P. quelepidotia* AY640959.1 and KT869021.1 in GenBank), which are identical over the available 28S sequence. *Lepidotia hispida* (as *P. quelepidotia* KT869020.1 in GenBank) and *A. atroceracea* differ by 5 snps in their 5.8S ribosomal genes and diverge by 31% in ITS1 and 51% in ITS2.

Discussion

Morphological form of *Antrelloides atroceracea*

When we first found ‘Black Shoe Leather’ we were puzzled about its placement within the Pezizales. *Antrelloides atroceracea* is clearly a member of this order: its ascomata are apothecial and its asci are operculate, paraphyses are present and its ascospores are non-septate. However, its unusual morphological characteristics pose particular challenges when determining its taxonomic affiliations. *Antrelloides atroceracea* has individual morphological characters similar to those of taxa from a number of genera, but the fungus as a whole does not conform to any described genus that we know.

With its above-ground disc and its buried stipe *Antrelloides atroceracea* presents problems as to how to classify its form. Some members of the Pezizales are epigeous, others hypogeous and the ascomata exhibit very varied forms. Weber *et al.* (1997), Moreno *et al.* (2014) and Frey *et al.* (2016) have proposed terms, including apothecium, stereothecium, pulverothecium, cleistothecium and ptychothecium, as well as the less common exothecium, to describe the various fruit body forms. Stereothecia, pulverothecia and cleistothecia are closed structures containing indehiscent asci. The asci may be scattered but they are not organised in a definite hymenium. Stereothecia and pulverothecia are macroscopic and usually hypogeous, while cleistothecia are minute and may be on dung, plants, animals or other fungi. A ptychothecium is hypogeous, has an internal but organised hymenium which may be unfolded or folded and may have one or more openings and its asci are generally indehiscent.

Apothecia at maturity are epigeous with an open exposed hymenium and active ascospore expulsion, are usually discoid or cupulate and may be sessile or stipitate. A few of the Pezizales have exothecia. These

comprise a strongly convex external hymenium with paraphyses longer than the asci that often form a tissue, an epithecium, covering the asci.

The ascomata of *Antrelloides atroceraea* are not closed hypogaeal structures, so cannot be considered to be stereothecia, pulverothecia or cleistothecia. The sterile base of *Antrelloides atroceraea* is distinct from the hymenium, therefore the fruit body cannot be described as a ptychothecium. Nonetheless, its chambered base does bear some resemblance, albeit without asci, to the convoluted and folded inner structure of hypogean fungi such as *Mycoclelandia* Trappe & G. Beaton Trappe (Beaton & Weste 1982; Trappe & Beaton 1984; Hansen *et al.* 2001), *Peziza whitei* (Gilkey) Trappe (Korf 1973; Trappe 1975; Beaton & Weste 1982; Trappe & Claridge 1975; Hansen *et al.* 2001) and *P. ellipospora* (Gilkey) Trappe (Hansen *et al.* 2001; Desjardin *et al.* 2015).

The exposed hymenium of *Antrelloides atroceraea* suggests the apothecial form, one of the most common forms amongst the Pezizales. However, its convex above-ground hymenium bears similarities to the exothecium of *Ruhlandiella* (Fig. 1F).

Other taxa: similarities and differences

The definition of an apothecium may be extended to genera such as the stipitate *Helvella* and *Gyromitra* with their often convoluted pilei. Fungi in these genera show some similarities with *Antrelloides atroceraea*. Its convex disc is not convoluted as are the pilei of many species of *Helvella* and *Gyromitra* but its chambered base or stipe is reminiscent of the stipe of some species of those genera, particularly those of *Helvella umbraculiformis* Seaver (family Helvellaceae) (Seaver 1942) and *Gyromitra californica* (W. Phillips) Raitv. (family Discinaceae) (Phillips 1880; Seaver 1942; Kuo 2012; Mykowiec; Beug *et al.* 2014). Neither taxon is known to occur in

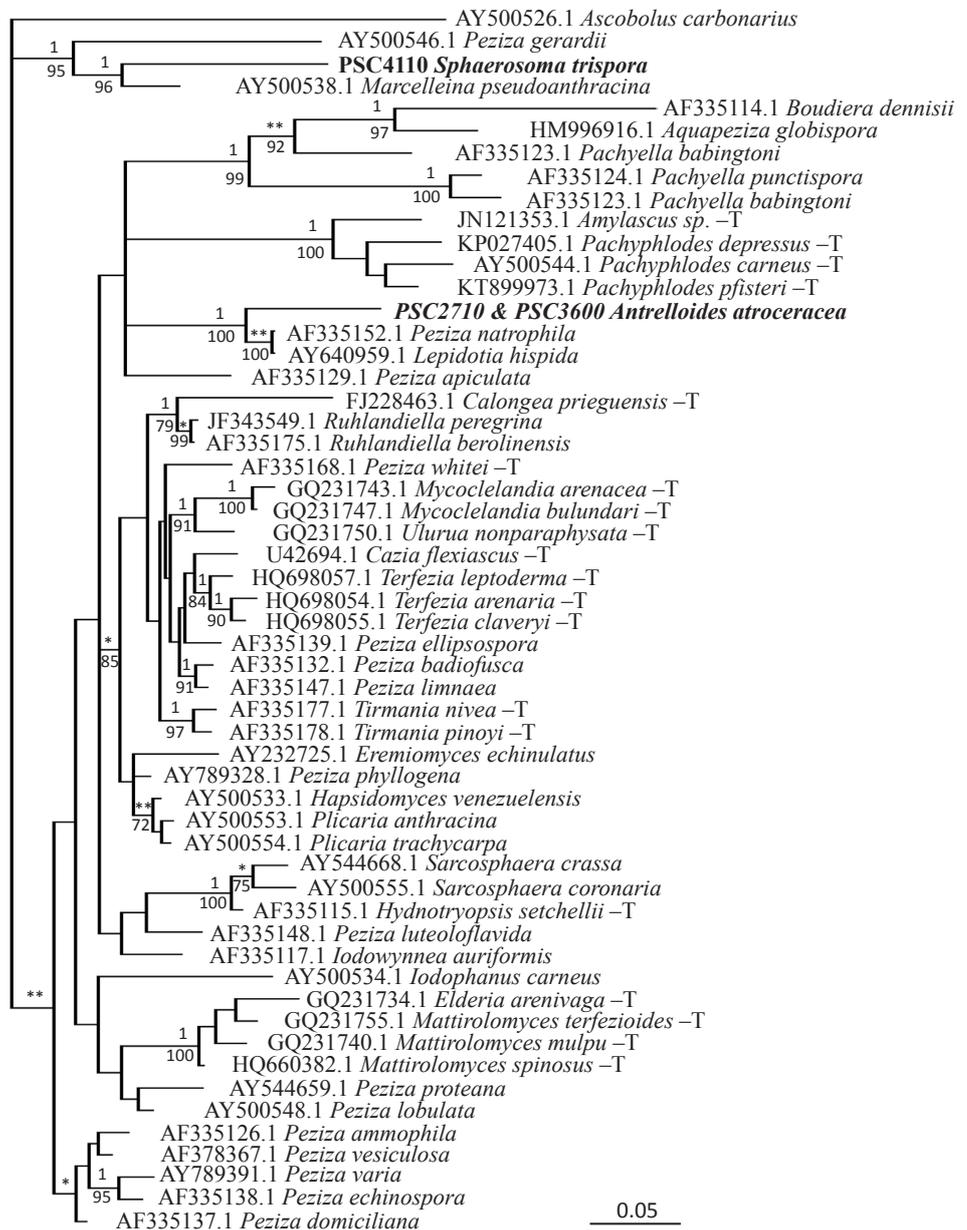


Fig. 3. A Bayesian tree based on sequences of the 28S ribosomal gene showing phylogenetic relationship of *Antrelloides atroceraea* with representative species from genera in the Pezizaceae. Posterior probabilities of ≥ 0.999 , ≥ 0.99 and ≥ 0.95 are shown by 1, **, and * respectively above nodes and maximum likelihood values greater than 70% are shown below the nodes. The sequence for PSC 4110 *Sphaerosoma trispora* was derived in this study (GenBank MH722262), other numbers identify GenBank sequences. Truffle like taxa are indicated by -T.

Australia. Both species have convoluted pilei and the surface of the columns or ribs of the above-ground stipe are dry, relatively smooth and whitish. The internal structure of the erect columnar fruit bodies of the Australian species *Underwoodia beatonii* Rifai (family Helvellaceae) (Rifai 1968) is also somewhat similar to the South Australian and Western Australian collections of *Antrelloides atroceraea*. The columns of *U. beatonii* are divided internally by longitudinal ridges separated by alveolar cavities but the ridges are smooth, whitish and not as brittle as those of *A. atroceraea*. A major difference with taxa in the families Helvellaceae and Discinaceae is that they have inamyloid asci (Frey *et al.* 2016), in contrast to the amyloid asci of *A. atroceraea*.

Two families within the Pezizales have amyloid asci, the Pezizaceae (Hansen *et al.* 2001; Hansen *et al.* 2005; Hansen & Pfister 2006; Læssøe & Hansen 2007; Hansen *et al.* 2013) and the Ascobolaceae (Hansen & Pfister 2006; Hansen *et al.* 2013; Frey *et al.* 2016). *Antrelloides atroceraea* may be excluded from the Ascobolaceae since its asci do not protrude at maturity, its opercula are small not large and its spores do not darken on maturity. The asci of *Antrelloides atroceraea* are amyloid along their length but more strongly amyloid at the tips, conforming most closely with type (i) asci (Hansen *et al.* 2001).

The Pezizaceae is a large and very diverse family with an estimated thirty-two genera (Frey *et al.* 2016). It was possible that *Antrelloides atroceraea* was a member of one of these genera. We looked for similarities with genera with apothecia within the Pezizaceae. Such genera include *Pachyella* Boud., *Scabropezia* Dissing & Pfister, *Boudiera* Cooke, *Hapsidomyces* Krug & Jeng, *Iodophanus* Korf, *Iodowynnea* Medel, Guzmán & Chacón, *Sarcosphaera* Auersw., as well as the more common genera *Peziza* Fr. and *Plicaria* Fuckel. We did not discount genera that had not been recorded from Australia since there is a lack of extensive collections of Ascomycetes in this country (Rifai 1968; Hyde 2001).

Pachyella, *Plicaria* and *Scabropezia* (Hansen & Knudsen 2000) have epigeal, sessile fruit bodies, hence differing from *Antrelloides atroceraea* with its substantial subterranean base. While species of *Pachyella* and *Plicaria* are known from Australia, there are no species of *Scabropezia* in the recorded data of the Atlas of Living Australia.

Iodowynnea is a monotypic genus which was described from Africa and tropical America (Medel *et al.* 1996). *Iodowynnea auriformis* (Pat. ex Le Gal) Medel, Guzmán & Chacón does have a hypogeous stipe but this bears caespitose clumps of individual apothecia. The ellipsoid spores are ornamented with warts arranged in longitudinal bands differing from the spores of *A. atroceraea* whose verruculose ornamentation can be detected only with scanning electron micrography.

The coprophilous *Hapsidomyces venezuelensis* J.C.Krug & Jeng and species of *Iodophanus* differ

from *A. atroceraea* not only in their ecology but in their size: apothecia seldom reach more than 3 mm in diameter. Moreover the spores of *Hapsidomyces venezuelensis* are globose and reticulate (Krug & Jeng 1984), those of species of *Iodophanus*, though ellipsoid, are covered with a mucilaginous sheath bearing callose-pectate ornamentation (Kimbrough *et al.* 1969). Only *Iodophanus carneus* (Pers. ex Pers.) Korf apud Kimbrough & Korf has been described from Australia (ALA).

The apothecia of *Sarcosphaera* are hypogeous during development, closed at first but split open in a stellate manner when mature to expose a smooth, whitish to pale violaceous hymenium, characters differing from *A. atroceraea*. Asci are amyloid and spores are ellipsoid. The genus has not been recorded in Australia.

Although some truffle-like genera share the amyloidity of asci and smooth, ellipsoid spores, their hypogeous habit and internal hymenium separate them from *Antrelloides atroceraea*.

While the above-ground, broadly convex disc of *Antrelloides atroceraea* may resemble discs of either *Peziza* or *Plicaria*, its distinctive below-ground, chambered base is not like any pseudostipe of any species of those genera. They share the amyloid character of asci but *Plicaria* species have globose spores, thus separating species in that genus from *Antrelloides atroceraea* with its ellipsoid spores, a character they share with species of *Peziza*.

Exothecial taxa

The few genera considered to have exothecial fruit bodies are *Ruhlandiella* P. Henn. (Lantieri *et al.* 2012; Læssøe & Hansen 2007; Frey *et al.* 2016), *Sphaerozone* Zobel (Beaton & Weste 1978; Hansen *et al.* 2001; Læssøe & Hansen 2007) and *Sphaerosoma* Klotzsch. Dissing & Korf (1980) discussed relationships amongst these genera and also *Boudiera* Cooke, separating genera whose spores are actively discharged, *Boudiera* and *Sphaerosoma*, from *Ruhlandiella* and *Sphaerozone* whose asci are indehiscent. All are epigeous.

The genus *Ruhlandiella* is considered native to Australia (Lantieri *et al.* 2012). However, the type species, the mycorrhizal *Ruhlandiella berolinensis* Henn. occurs not only in Australia but in plantings of *Eucalyptus* in Spain (Galán & Moreno 1998), Greece (Agnello & Kaounas 2010), the Canary Islands and California (Dissing & Korf 1980). The tiny fruit bodies from our single collection of *R. berolinensis* were draped over the soil surface (Fig. 1F). Although the hymenium has a similar form to that of *Antrelloides atroceraea*, with paraphyses forming a semi-cover over the asci in both taxa, the sterile lower surface of *R. berolinensis* is miniscule when compared with the large chambered base of *A. atroceraea*. Moreover, the walls of the asci fragment and release the ascospores within the hymenium while the walls of the asci of *A. atroceraea* are not evanescent. Its asci are amyloid, as are those of *R. berolinensis* and *R. reticulata* (P.H.B. Talbot) E. Rubio, Tena, Ormad & A. Suárez, but asci of *R. peregrina*

Lantieri & Pfister and *R. truncata* are inamyloid (Warcup & Talbot 1989; Galán & Moreno 1998; Rubio *et al.* 2010; Lantieri *et al.* 2012).

Sphaerozone has amyloid asci (Dissing & Korf 1980; Læssøe & Hansen 2007); the genus is monotypic, the type species being *S. ostiolatum* (Tul. & C. Tul.) Setch. Zhang & Minter (1989) transferred two species, *Sphaerozone echinulatum* G.W.Beaton and *S. ellipsosporum* Cribb that had previously been included in the genus to the new genus *Gymnohydrotrya*, the new combinations being *Gymnohydrotrya echinulata* (G.W.Beaton) B.C.Zhang & Minter and *G. ellipsospora* (Cribb) B.C.Zhang & Minter. *Sphaerozone ostiolatum* has globose, ornamented spores and its asci are indehiscent (Dissing & Korf 1980; Pegler *et al.* 1993), characters that separate it from *A. atroceracea*, though its subhypogeous and convoluted and infolded fruit body bears some slight resemblance to that taxon. Species of *Gymnohydrotrya* have a subglobose to irregularly lobed ascoma with several internal chambers and canals. The hymenium is external but often extends internally. They differ from *Antrelloides atroceracea* in their totally hypogeous, globose ascomata, inamyloid asci and ornamented ascospores, though the infolded chambers bear some resemblance to the chambered base of *A. atroceracea*.

Dissing & Korf (1980) recognised that *Sphaerosoma* is a particularly problematic genus. *Antrelloides atroceracea* bears little resemblance to the two species that they accepted: *S. fuscescens* Klotzsch and *S. trispora* McLennan & Cookson (McLennan & Cookson 1923). Both have inamyloid asci and globose, highly ornamented spores, while *A. atroceracea* has amyloid asci and ellipsoid spores. Ascomata of the South Australian collections examined were olive-brown to black, irregularly cushion- to saucer-shaped, sessile and attached to the soil surface by a central soil pad (Catcheside 2012). This under-collected genus requires further investigation, though the cryptic nature and probable rarity make this problematic.

Phylogenetic associations of *Antrelloides atroceracea*

Based on the studies of Hansen *et al.* (2001, 2005), Hansen & Pfister (2006), Læssøe & Hansen (2007) and Hansen *et al.* (2013), Frey *et al.* (2016) divide the class Pezizomycetes sensu O.E. Erikss. & Winka, Order Pezizales J. Schröt. into four lineages with lineage A / suborder Pezizinae Rifai (asci often amyloid) divided into two families: Ascobolaceae with asci protruding from the hymenium when mature and Pezizaceae with non-protruding asci. Lineage B covers the *Morchella-Helvella* clade, lineage C the Pyrenomataceae s.l. and lineage D the suborder Sarcoscyphinae Rifai. *Sphaerosoma* is amongst genera *incertae sedis*. The phylogenetic data presented here include taxa from all four lineages.

There are some genera which lie in lineages other than the Pezizaceae that have infolded ascomata bearing some resemblance to the chambered base of

Antrelloides atroceracea. These include *Hydnotrya* Berk. & Broome in lineage B, the *Morchella-Helvella* clade (Trappe 1979; O'Donnell *et al.* 1997; Frey *et al.* 2016). *Hydnocystis* Tul., *Genea*, Vittad. and *Geopora* Harkn. are in Lineage C/Pyrenomycetaceae s.l. (Trappe 1979; Læssøe & Hansen 2007; Moreno *et al.* 2014; Frey *et al.* 2016). However, as well as being hypogean, they are phylogenetically distant from *Antrelloides atroceracea* (Fig. 3).

Phylogenetic analysis of *Antrelloides atroceracea* shows that it is nested within the Pezizaceae (Fig. 3). It is most closely related to *Lepidotia hispida* (Quél.) Boud. (Norman & Egger 1999; Hansen *et al.* 2001, 2005; Hansen & Pfister 2006; van Vooren *et al.* 2015) and *Peziza natrophila* A.Z.M. Khan (Hansen *et al.* 2001; van Vooren *et al.* 2015). Morphologically however, although sharing the amyloidity of asci and globose excipular tissue, they differ in structure and colour. *Lepidotia hispida* is yellow-green, stipitate but its stipe is simple, not chambered (Korf 1973; van Vooren *et al.* 2015). *Peziza natrophila* is olive-brown, later dark brown to black, shallow-cupulate to discoid and sessile (Nowsher & Khan 1976). The habitats of both taxa, *Lepidotia hispida* in peat bogs or swampy areas (Korf 1973; van Vooren *et al.* 2015) and *Peziza natrophila* known mostly from plots treated with sodium and potassium carbonates in pine plantations but also from an old peat bog (Korf 1973; O'Donnell & Beneke 1973; Hansen *et al.* 2001; van Vooren *et al.* 2015) differ substantially from that of *A. atroceracea*, which, although fruit bodies may be subject to inundation, is found in dry sandy to sandy-clay soils. It is possible that *Lepidotia hispida* and *Peziza natrophila* are con-specific (Hansen *et al.* 2001; van Vooren *et al.* 2015).

The 4.8% difference of the 28S ribosomal gene sequence of *Antrelloides atroceracea* to that shared by *Peziza natrophila* and *Lepidotia hispida*, coupled with the very large differences in ITS1 and ITS2 sequence (31% and 51% respectively) from that of *L. hispida*, argue for the erection of the new genus *Antrelloides*.

Taxa in adjacent branches of the phylogenetic tree include species of *Pachyphlodes*, *Amylascus*, *Boudiera*, *Aquapeziza* and *Pachyella*. The truffle-like *Pachyphlodes* and *Amylascus* have globose and echinulate spores, differing from the epigean *Antrelloides atroceracea* with its ellipsoid, faintly verruculose spores. Species of *Boudiera*, *Aquapeziza* and *Pachyella* lie in neighbouring branches. The latter genus has sessile ascomata thus differing from the stiped *A. atroceracea*, *Boudiera* has tiny apothecia which seldom reach more than 3 mm diameter and spores are spiny or reticulate. The monotypic *Aquapeziza globispora* D.M.Hu, L.Cai & K.D.Hyde (Hu *et al.* 2012) has sessile, white apothecia and smooth, globose spores. Its habitat on submerged wood in freshwater streams excludes it from *Antrelloides*. *Peziza apiculata* Cooke is sessile and has ellipsoid spores with needle-like apicules at each end. It grows on rotten wood or moist soil (Moravec 1977).

General discussion

The form of the fruit body and the habitat of *Antrelloides atroceracea* are interesting. Over a limited area fruit bodies are not uncommon. They are almost always on the edges of slightly raised, bare tracks and are subject to inundation, with standing water at least up to the margins of the fruit bodies. One population of immature fruit bodies was found on sticky, sandy clay soil in a slight depression where it was obvious that the water level had reached the margins of the discs. The substantial ribbed base anchors the fruit body in the soil, preventing it from being washed away. Species of *Boudiera* and *Pachyella* grow in swampy ground and have ascumata that are able to withstand flooding. *Boudiera* species are mostly on sand, *Pachyella* species on water-soaked wood or decaying plant debris (Pfister 1973; Hansen *et al.* 2001). Species of both genera are sessile, lacking the chambered base of *A. atroceracea* which anchors that taxon in the ground. The hymenium of species of *Boudiera* occupies the upper surface or covers the whole exposed surface of the apothecium and its asci protrude beyond the paraphyses when mature (Seaver 1942; Eckblad 1968), possibly facilitating spore dispersal in wet conditions. *Pachyella* species have gelatinous tissues, an adaptation to its wet habitat.

Placement of new fungal taxa always presents challenges. When the new fungus has no obvious characters that fit it into any group it becomes more problematic. Phylogenetic analysis is essential, especially in these circumstances. However, molecular data are often not available, especially for cryptic and thus often, in Australia, under-collected taxa such as the Discomycetes. Its genetic characters and the amyloidity of the asci enable *Antrelloides atroceracea* to be placed firmly in the Pezizaceae. Molecular sequencing and phylogenetic analyses enable relationships between species and genera to be understood but demonstrate that, as in this case, there is little relationship between morphological and genetic characters. In addition, Rifai (1968) commented on the lack of extensive collections of Australian Pezizales. From our experience, this has changed little since Rifai's observation.

Additional species examined

Sphaerosoma trispora

SOUTH AUSTRALIA: Mays Cottage to Platypus Walking Track, Flinders Chase National Park, Kangaroo Island, 35° 56'S, 136° 44'E, 27 June 2011, *P.S. Catcheside PSC 3570*, *D.E.A. Catcheside, T.P. Bridle & H.P. Vonow* (AD-C 56992); 35° 56'S, 136° 43'E, 28 June 2014, *P.S. Catcheside PSC 3583*, *D.E.A. Catcheside, H.P. Vonow, T.P. Bridle & P. Bridle* (AD-C 56993); Mount Rescue Conservation Park near Tintinara, 35° 55'S, 140° 17'E, 17 Aug. 2014, *P.S. Catcheside PSC4110 & D.E.A. Catcheside* (AD-C 58768) (GenBank MH722262); Meningie, on ground, 29 June 1961, *L.D. Williams 1173* (AD-C 47697); Meningie, on ground, 7 Sep. 1961, *L.D. Williams 1246* (AD-C 47693); Wood's Well, on ground, 27 Aug. 1961, *L.D. Williams 1236* (AD-C 47691).

Ruhlandiella berolinensis

SOUTH AUSTRALIA: Kaiserstuhl Conservation Park, S34° 34', E139° 1', 22 Aug. 2016, *P.S. Catcheside PSC 4322*, *D. Catcheside & members of Adelaide Fungal Studies Group* (AD-C 59899).

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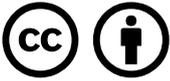
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The *Ptilotus murrayi* species group: synonymisation of *P. petiolatus* under *P. murrayi* and description of the new Western Australian species *P. unguiculatus* (Amaranthaceae)

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Abstract: The *Ptilotus murrayi* F.Muell. species group encompasses the morphologically similar *P. murrayi*, *P. gomphrenoides* F.Muell. ex Benth. and *P. petiolatus* Farmar. These three species overlap in distribution in Western Australia, where they are easily confused with one another. A critical examination of specimens shows that there are no consistent morphological characters to justify the separation of *P. murrayi* and *P. petiolatus*, and therefore the latter is formally synonymised under the former. *Ptilotus* sp. Edaggee Station (T.E.H.Aplin 3208) is found to be a distinctive new species and described as *Ptilotus unguiculatus* T.Hammer. Updated descriptions are given for *P. murrayi* and *P. gomphrenoides*.

Keywords: Amaranthaceae, Australia, new species, *Ptilotus*, taxonomy

Introduction

Ptilotus R.Br. (Amaranthaceae) is a genus of c. 120 species native to Australia, mostly occurring in arid or semi-arid regions of Australia, with the highest diversity in Western Australia (Hammer *et al.* 2015). A recent molecular phylogeny by Hammer *et al.* (2015) resolved several molecular clades within the genus, including the large clade informally named ‘clade B’. Within clade B, *Ptilotus murrayi* F.Muell. and *P. gomphrenoides* F.Muell. ex Benth. were resolved as sister species. The morphologically similar *P. petiolatus* Farmar was not included in the phylogeny (Hammer *et al.* 2015). Together these species comprise the *P. murrayi* species group.

Ptilotus murrayi was described by Mueller (1863) based on a type from Will’s Creek (the Diamantina River, incorrectly noted in the protologue as ‘Cooper’s Creek’) near the border of South Australia and Queensland, collected by J. Murray on the Howitt expedition (Fig. 1A). Specimens of *P. murrayi* from Western Australia were not available to Mueller, but he did mention having seen similar specimens from Western Australia that had pedunculate inflorescences:

Vidi etiam specimina manca plantae persimilis ad montes Hamersley Range sub expeditione Francisci Gregorii collecta, spicis pedunculatis praecipue divellenda.

Mueller (1863: 145)

Bentham (1870) formally described *P. gomphrenoides* based on these pedunculate specimens from Gregory’s

expedition in the Hamersley Range (Fig. 1B). Farmar (1905) erected *P. petiolatus* from specimens collected by E. Clement in north-western Western Australia in 1897. He separated *P. petiolatus* from *P. murrayi* on the basis that the former has inflorescences with acute apices, shorter staminal filaments and larger anthers:

[...] *quod flores P. murrayi simillimus sed spicis acutis filamentis brevioribus antheris majoribus differt*
Farmar (1905: 1089)

He went on to say that *P. murrayi* was incompletely known, and that only a few fragments (‘an inch in length’) were available at K, however he felt confident that these differences were sufficient to erect the new species.

Farmar (1905) also erected *P. roseo-albus* Farmar within this species group, differing from *P. gomphrenoides* in having shortly pedunculate spikes (as opposed to long-pedunculate) and a denser abaxial sepal indumentum. Within *P. roseo-albus* he described var. *conglomeratus* Farmar, which differed from the typical variety in having cylindrical inflorescences in clusters, as opposed to conical and loosely arranged inflorescences. The two varieties of *P. roseo-albus* were recombined under *P. gomphrenoides* by Benl (1962) as *P. gomphrenoides* var. *roseo-albus* (Farmar) Benl and var. *conglomeratus* (Farmar) Benl, stating that the characters that Farmar used were common characteristics of *P. gomphrenoides*. Hammer & Davis (2017) recently synonymised these varieties under the typical *P. gomphrenoides*, as these varieties were found to intergrade imperceptibly into one another. Black (1923) described *P. murrayi* var. *major* J.M.Black from the Diamantina River, South

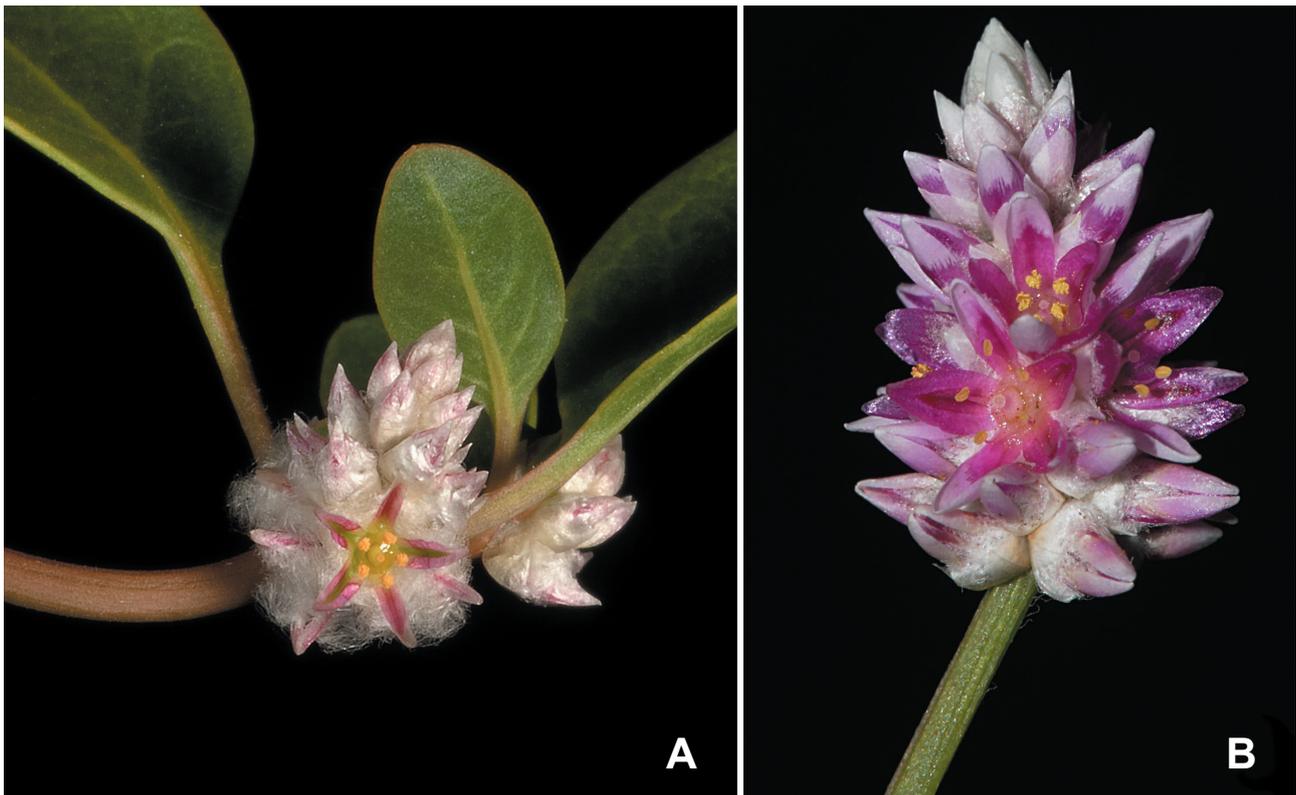


Fig. 1. Comparative morphology of flowering inflorescences. **A** *Ptilotus murrayi*; **B** *P. gomphrenoides*. Photos: A K.R. Thiele; B R. Davis.

Australia, on the basis of its larger leaves, longer stems and inflorescences, and slightly longer sepals. This variety was synonymised by Bean (2008), who recognized that the characters attributed to *P. murrayi* var. *major* were within the typical variability of var. *murrayi*. In a manuscript by Benl (unpubl.), *P. petiolatus* subsp. *limbatus* Benl MS was included as a manuscript name based on a specimen from Edaggee Station, Western Australia (Fig. 2), which he primarily differentiated from subsp. *petiolatus* by the new subspecies having clawed sepals. While the new taxon was never formalised, it was included under the phrase name *Ptilotus* sp. Edaggee Station (T.E.H.Aplin 3208) at the Western Australian Herbarium awaiting evaluation of its taxonomic status.

The geographic distributions of taxa in the *P. murrayi* species group overlap significantly in Western Australia, and this, coupled with the strong morphological similarities, has led to some confusion between them. *Ptilotus murrayi* has a disjunct distribution, occurring in Western Australia from Carnarvon, Gascoyne, Murchison, Pilbara and Dampierland (Interim Biogeographic Regionalisation for Australia, IBRA; Department of the Environment 2018) regions and in south-western Queensland and north-eastern South Australia in the Mitchell Grass Downs and Channel Country IBRA regions. It has not been recorded from the Northern Territory or north-western South Australia (Fig. 3A). *Ptilotus petiolatus* and *P. murrayi* are sympatric throughout the range of the former. *Ptilotus petiolatus* is known from 15 specimens, ten from

Dampierland and five from the Pilbara IBRA regions. *Ptilotus gomphrenoides* is also almost entirely sympatric with *P. murrayi* in Western Australia, occurring in the Carnarvon, Gascoyne, Pilbara, and northern Murchison bioregions (Fig. 3B). *Ptilotus* sp. Edaggee Station (T.E.H.Aplin 3208) is known from a single collection on Edaggee Station, approximately 70 km SSE of Carnarvon, Western Australia and 75 km SW of the southwestern-most record of *P. murrayi*, which occurs near the Gascoyne River (Fig. 3B).

During the construction of an online identification key to all species in *Ptilotus* for the *Flowering Plants of Australia* project on *KeyBase* (available at <http://keybase.rbg.vic.gov.au/keys/show/6609>), *P. murrayi*, *P. gomphrenoides* and *P. petiolatus* were found to be difficult to discriminate due to unclear morphological boundaries, which was also noted by Burbidge (unpubl.) in a key constructed for *Ptilotus*. A thorough examination of the morphology of specimens for each species was conducted to critically evaluate the species boundaries within the group. This showed that specimens of *P. murrayi* and *P. petiolatus* could not be reliably separated, including those that Farmar had originally used to erect *P. petiolatus*. As a result, the later name of *P. petiolatus* is here formally synonymised under *P. murrayi*. *Ptilotus* sp. Edaggee Station (T.E.H.Aplin 3208) is also assessed and found to be a very distinctive species. The morphological differences between the two accepted species in the *P. murrayi* species group (i.e. *P. murrayi* and *P. gomphrenoides*) are clarified and descriptions are given for both.

Material and methods

This study was based on the examination of dried specimens of *P. gomphrenoides*, *P. murrayi*, *P. petiolatus* and *P. sp.* Edaggee Station (T.E.H.Aplin 3208) housed at PERTH and specimens of *P. murrayi* on loan from BRI and AD, covering the geographic range of all species. Scans of type specimens were assessed through *JSTOR Global Plants* (<https://plants.jstor.org/>). The specimens were critically evaluated irrespective of current determinations and matched to the protologues and type specimens, and when necessary, specimens were re-determined as a result of this study. Care was taken to evaluate the specimens based on their likely natural posture in the field, and when available, label data were used to infer the natural habit of the specimens. A distribution map of the species was produced using georeferenced records retrieved from the *Australasian Virtual Herbarium* (<https://avh.chah.org.au/>). The terminology used in this paper for the perianth of *Ptilotus* is different from what is conventionally used within Australia. The term 'sepal' is used here in place of 'tepal', as recent studies support the calycine origin of the uniseriate perianth for all Caryophyllales, the corolla having been lost (see Ronse De Craene 2013; Vrijdaghs *et al.* 2014).

Results and discussion

The examination revealed that *P. sp.* Edaggee Station (T.E.H.Aplin 3208) is clearly a distinctive species within the genus. Benl (unpubl.) intended to describe this taxon as a subspecies of *P. petiolatus*. While it is understandable that he believed the two entities were related, given their superficial similarities (e.g. habit, leaf size and shape, inflorescence size and shape; Fig. 2), *P. sp.* Edaggee Station (T.E.H.Aplin 3208) is significantly different from *P. petiolatus* in important floral characters. It may not be closely related to the *P. murrayi* species group. The sepals of *P. sp.* Edaggee Station (T.E.H.Aplin 3208) are conspicuously clawed (i.e. narrow at the base and dilated toward the apex), and more so in the outer sepals, where the dilated apex is 0.7–0.9 mm wider than the base. *Ptilotus petiolatus*, *P. murrayi* and *P. gomphrenoides* do not have clawed sepals. In other *Ptilotus* species, this trait is consistent within a species and is often shared between closely related species. Within clade B, several species groups possess clawed sepals, such as the species group including *P. latifolius* R.Br. and *P. chamaecladus* Diels and the species group including *P. conicus* R.Br. and *P. corymbosus* R.Br. *Ptilotus sp.* Edaggee Station (T.E.H.Aplin 3208) also differs from *P. petiolatus*, by possessing crisped nodose hairs on the inner margins of the sepals, which often become tangled and obscure the ovary and staminal cup. Sepals in *Ptilotus petiolatus*, *P. murrayi* and *P. gomphrenoides* are adaxially glabrous (see Fig. 1). *Ptilotus sp.* Edaggee Station (T.E.H.Aplin 3208) has longer staminal filaments (0.7–0.9 mm) and style (0.6–0.8 mm) than

P. petiolatus (0.3–0.6 and 0.3–0.5 mm, respectively), which ensure the anthers and stigma are raised above these obscuring hairs. Furthermore, the bracteoles of *P. sp.* Edaggee Station are much longer and wider than the bracts (by c. 1 mm), while the bracts and bracteoles of the other species are similar in size. These differences are sufficient to recognise *P. sp.* Edaggee Station (T.E.H.Aplin 3208) as a distinct species, and therefore *P. unguiculatus* T.Hammer is erected to accommodate it (see below).

Ptilotus murrayi and *P. petiolatus* can both be segregated from *P. gomphrenoides* in Western Australia by the latter species having pedunculate inflorescences; peduncles are short but present on some specimens (e.g. those previously included under *P. roseo-albus*). *Ptilotus gomphrenoides* could additionally be segregated from the other two species by examination of the midrib region of the sepals (i.e. the thickened prominent midrib flanked by two lateral veins that is clearly differentiated from the scarious region surrounding it). All *Ptilotus* species have five sepals that are arranged with two outer sepals and three inner sepals. Sometimes the outer and inner sepals are morphologically similar, but in the *P. murrayi* species group they are conspicuously different. The outer sepals in the *P. murrayi* species group are conspicuously different to the inner sepals in that they enclose the inner sepals and possess larger and more conspicuous scarious margin, particularly towards the apex. The midrib region and margin of the sepal usually vary in colour in these species, being either dark pink or green around the midrib and pink on the margin (Fig. 1). The outer sepal has a prominent and concaved midrib (thus allowing it to tightly enclose the inner sepals in bud), but the midrib region is much narrower and less starkly coloured. *Ptilotus gomphrenoides* has a much wider sepal midrib region (0.5–0.8 mm), which is usually pink to dark pink, whereas the *P. murrayi* and *P. petiolatus* consistently have a narrow (0.2–0.3 mm) and green sepal midrib region. The outer sepals in *P. gomphrenoides* have a longer scarious margin above the midrib (0.8–1.5 mm) and rounded apices (Fig. 1B), whereas *P. murrayi* and *P. petiolatus* have a shorter scarious margin above the midrib (0.5–1.0 mm) and more acute apices (Fig. 1A). Using the characters outlined above, specimens of *P. gomphrenoides* could be confidently segregated from *P. murrayi* and *P. petiolatus*.

The differences Farmar stated as separating *P. petiolatus* and *P. murrayi* do not withstand scrutiny with the specimens currently available. All collections of *P. petiolatus* have inflorescences with an acute apex, while collections of *P. murrayi* can have either an acute or truncated apex; it is likely that Farmar had only access to specimens of *P. murrayi* with the latter character. Farmar indicated that staminal filament length and anther length were both important in splitting *P. petiolatus* from *P. murrayi*. This study found, however, that throughout the geographic ranges of both species, they overlap in staminal filament length (0.3–0.6 mm) and anther length

(0.3–0.5 mm). Benl (1979) suggested that *P. petiolatus* could be identified based on its unusually short style, but *P. murrayi* and *P. petiolatus* were found to have the same range of style length (0.3–0.5 mm) with the specimens currently available.

Benl (1971) used leaf size to split *P. murrayi* from *P. petiolatus* and *P. gomphrenoides* in his key. Leaf size in these species imperceptibly intergrades, and is not correlated with geography and any other characters, rendering the use of this as a distinguishing character ineffectual. Benl (1971) furthermore noted a difference in phyllotaxis of *P. petiolatus* and *P. gomphrenoides*, considering the former to be subopposite ('annähernd gegenständig', p. 172) and the latter to be alternate. However, leaf arrangement in these species is not consistent across all specimens available. Each of the three species has specimens that have an alternate leaf arrangement, but some specimens can be found to have an apparent opposite or subopposite arrangement.

Bentham (1870) described *P. gomphrenoides* as 'apparently erect' and *P. murrayi* as 'apparently prostrate' (pp. 243–244). All three species were found to have prostrate specimens (this character being more common in *P. murrayi* than the other species), as well as specimens described on labels as ascending or erect. Habit could not be correlated with other characters (e.g. leaf size or the size of floral parts), to reliably discriminate between the species. Several specimens in *P. gomphrenoides* were found to exhibit the characters attributed by Farman (1905) and Benl (1971) to *P. petiolatus*, such as slightly smaller flowers, leaves and an overall more petite habit (e.g. *A.C. Beaughole* 48962), which may indicate that these characters attributed to *P. petiolatus* by previous authors are within the normal range variation for both *P. gomphrenoides* and *P. murrayi*. Furthermore, no differences between the habitats of the three species could be discerned, all typically occurring on flat floodplains or on the fringes of ephemeral wetlands, creeks or rivers, with clayey red or brown soils.

Given that there are no consistent characters with which to separate *P. petiolatus* from *P. murrayi*, the former encompassing the normal variation from throughout the range of *P. murrayi* (including in specimens available from eastern Australia), *P. petiolatus* is here synonymised under *P. murrayi*. No significant differences were found between the specimens of *P. murrayi* from Western Australia and eastern Australia, leaving the question open as to the significance of the large geographic disjunction in the records between Western Australia and eastern Australia (see Fig. 3A), which may be more appropriately investigated with an in-depth molecular study. Full descriptions for the modern concepts of *P. murrayi* and *P. gomphrenoides* are given below. A key to all accepted species of *Ptilotus* in Western Australia, including those described here, is currently under review by the journal *Nuytsia* and is expected to be forthcoming.

Taxonomy

Ptilotus unguiculatus T.Hammer, *sp. nov.*

Type: Edaggee Station, Western Australia [precise locality withheld for conservation reasons], 3 July 1970, *T.E.H. Aplin* 3208 (holo: PERTH 04073819!, **Fig. 2**; iso: M 0241497 image!).

Ptilotus sp. Edaggee Station (T.E.H. Aplin 3208) Western Australian Herbarium, in FloraBase, <https://florabase.dpaw.wa.gov.au/> [accessed: 9 May 2018].

Decumbent *annual herb* to 8 cm high, 20 cm wide. *Stems* terete, ribbed, with dense nodose hairs on young growth and the hairs becoming sparse with age. *Basal leaves* not seen. *Cauline leaves* alternate, lanceolate to ovate, entire, 8–30 mm long, 5–11 mm wide, glabrous; base narrowly attenuate or petiolate, 5–10 mm long; apex mucronate, mucro c. 0.1 mm long. *Inflorescences* solitary or in clusters of 2–3, terminal, sessile, spiciform, conical, 5–12 mm long, 7–8 mm wide, white, subtended by leaves; apex acute. *Bracts* broadly ovate, 1.8–1.9 mm long, 1.4–1.5 mm wide, translucent, glabrous; midrib obscure; apex acute. *Bracteoles* broadly ovate, 3.0–3.1 mm long, 2.4–2.5 mm wide, translucent, glabrous; midrib obscure; apex acute. *Outer sepals* spatulate, strongly clawed, 3.5–3.6 mm long, 0.4–0.5 mm wide at base, 1.1–1.4 mm wide at dilated apex; midrib region prominent, green, 1.5–2.5 mm long, 0.1–0.3 mm wide; basal outer surface with long, wavy, nodose hairs, not exceeding sepal apex; inner surface glabrous apart from crisped nodose hairs on margins becoming dense and tangled within; apex acute, the scarious margin 1.0–1.2 mm long, glabrous, translucent, serrate, in-rolled. *Inner sepals* narrowly spatulate, clawed, 2.5–3.1 mm long, 0.3–0.4 mm wide at base, 0.6–0.8 mm wide at the dilated apex; midrib region prominent, green, 1.7–2.2 mm long, 0.2–0.3 mm wide; basal outer surface with long, wavy, nodose hairs at base, becoming densely woolly with age, not exceeding sepal apex; inner surface glabrous apart from crisped nodose hairs on margins becoming dense and tangled within; apex acute, the scarious margin 0.3–0.7 mm long, glabrous, translucent, serrate, in-rolled. *Fertile stamens* 5; *filaments* 0.7–0.9 mm long; *anthers* 0.4–0.5 mm long, 0.2–0.3 mm wide, yellow. *Staminal cup* 0.3–0.4 mm long, unlobed. *Ovary* globular, 0.6–0.7 mm long, 0.6–0.8 mm wide, glabrous. *Style* straight, 0.6–0.7 mm long, centrally placed on the ovary apex. *Stigma* unlobed, capitate. *Fruit* not seen. *Seed* not seen.

Diagnostic characters. *Ptilotus unguiculatus* can be distinguished from other members of the genus by the following combination of characters: decumbent habit, dense pubescence on young stems, glabrous and petiolate leaves, sessile and terminal inflorescences (subtended by leaves), bracts that are c. 1 mm shorter and narrower than bracteoles, conspicuously clawed (dilated at the apex) sepals, crisped nodose hairs on the abaxial margin of the sepals that obscure the ovary, base of sepal adaxial surface with long silky nodose hairs that do not exceed the sepal apices, five fertile stamens, staminal cup appendages absent, a central style centrally placed on the ovary apex, and a glabrous ovary.

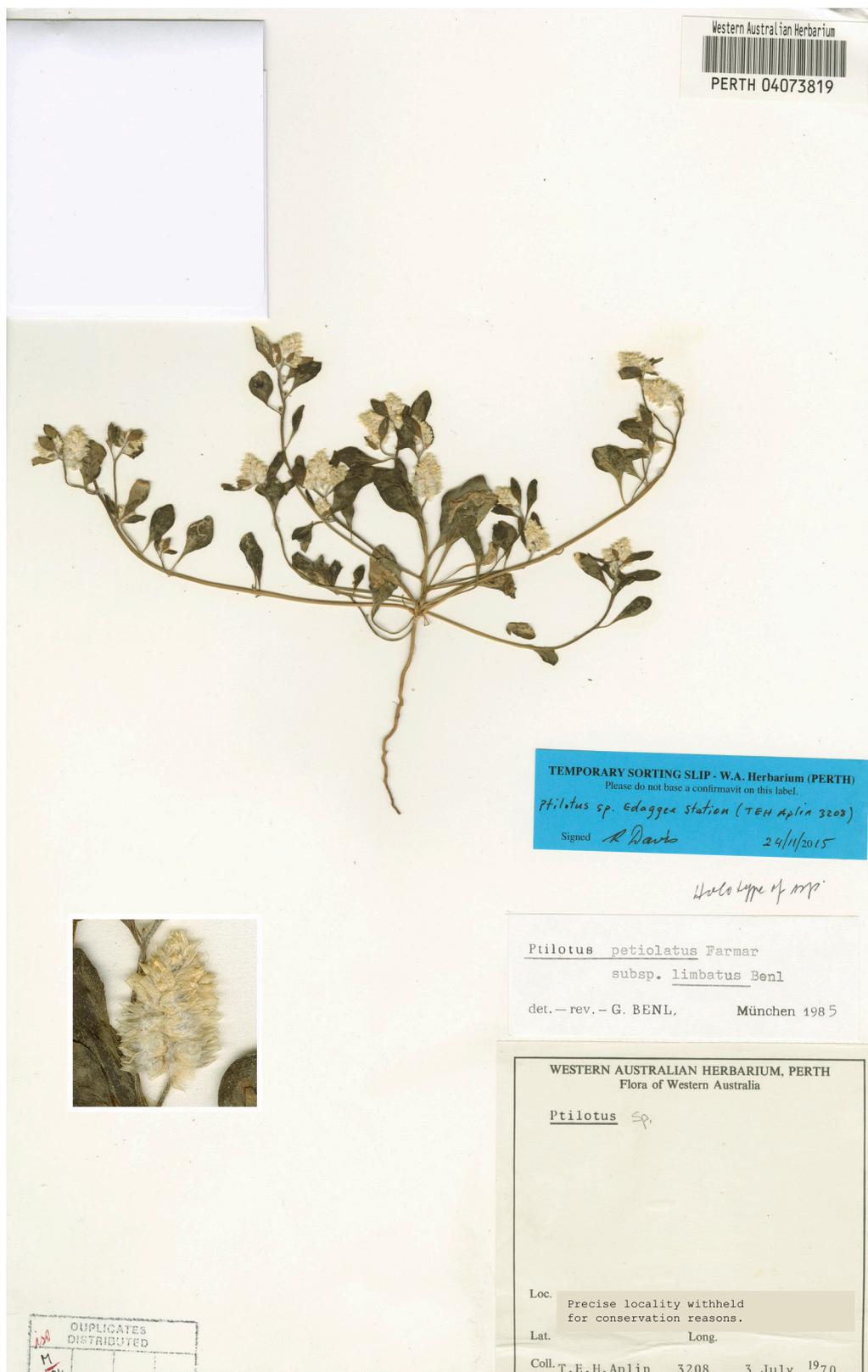


Fig. 2. Scan of *Ptilotus* sp. Edaggee Station (T.E.H. Alpin 3208), the proposed holotype of *P. unguiculatus* (PERTH 04073819). Insert: Close-up of inflorescence.

Phenology. The only examined specimen was collected as flowering, but not fruiting, in early July. It is likely that this species has a similar flowering and fruiting time to other annual *Ptilotus* species in region, which is typically from June to September.

Distribution and habitat. *Ptilotus unguiculatus* is currently known only from Edaggee Station, in the Carnarvon bioregion of Western Australia, where it was collected from a disturbed area. No habitat description was included with the specimen. Inspection of the

locality from aerial satellite images indicates it to be a plain with open shrubs.

Conservation status. *Ptilotus unguiculatus* is listed as Priority 1 under Conservation Codes for Western Australian Flora, under the name *P.* sp. Edaggee Station (Smith & Jones 2018). It is only known from the type specimens, collected in 1970 from a disturbed area on Edaggee Station, Western Australia.

Etymology. The specific epithet is from the Latin *unguiculatus* (having claws), referring to the conspicuously clawed sepals of the new species.

Notes. This new species may be potentially confused with *P. villosiflorus* F.Muell., which is also a small herb with greenish-white flowers, but which differs by typically occurring on coastal dunes, having sepals that are not clawed and abaxial sepal hairs that exceed the sepal apex. *Ptilotus latifolius* and *P. chamaecladus* are species closely related to *P. villosiflorus* that do have clawed sepals. *Ptilotus latifolius* is a large rounded, upright herb or subshrub with tangled branches that has bracteoles that are longer than the sepals. Both *P. chamaecladus* and *P. latifolius* have staminal cup lobes alternating with the stamens, while the new species has an unlobed staminal cup. The fruit of *P. villosiflorus*, *P. chamaecladus* and *P. latifolius* is hard and indehiscent, while those of the *P. murrayi* species group are membranous and irregularly dehiscent. Due to the similarity of the new species to the *P. latifolius* species group and despite Benl (unpubl.) considering the taxon to be closely allied with the *P. murrayi* species group, I could not confidently place the new species in either group. The difference in the fruit between these two groups is an important diagnostic character, but there was no fruit available for *P. unguiculatus*.

***Ptilotus murrayi* F.Muell.**

Fragm. 3: 145 (1863). — **Type:** ‘From the flooded tracts of Will’s Creek [=Diamantina River], beyond desert’ [state unknown], 1861, *J. Murray s.n.* (syn.: BM 000895594 image!, K 000357020 image!, MEL 2235243 image!, MEL 2235244 image!, PERTH 01558226!).

Ptilotus murrayi var. *major* J.M.Black, *Trans. & Proc. Roy. Soc. S. Austral.* 47: 368 (1923). — **Type:** ‘Between Herrgott [=Marree] and Innamincka’, South Australia, Jun. 1916, *R. Cockburn s.n.* (holo.: AD 97747822A image!).

Ptilotus petiolatus Farman, *Bull. Herb. Boissier* ser. 2, 5: 1089 (1905), syn. nov. — **Type:** ‘North West Australia, Between the Ashburton and De Grey rivers’, Western Australia, [purchased] Aug. 1900, *E. Clement s.n.* (syn.: K 000349177 image!, K 000349178 image!, K 000349179 image!).

Prostrate mat-forming or decumbent annual herb 5–20 cm high, 20–100 cm wide. *Stems* terete, ribbed, glabrous. *Basal leaves* not seen. *Cauline leaves* alternate or subopposite, narrowly lanceolate to broadly lanceolate or spatulate, entire, 5–30 mm long, 3–9 mm

wide, glabrous; base narrowly attenuate or petiolate, 5–10 mm long; apex mucronate, mucro c. 0.1 mm long. *Inflorescences* solitary or in clusters, axillary or terminal, sessile, spiciform, cylindrical, 5–30 mm long, 4–8 mm wide, white; apex acute or truncate. *Bracts* ovate, 1.0–1.8 mm long, 0.8–1.1 mm wide, translucent, glabrous; midrib obscure; apex rounded. *Bracteoles* ovate, 1.5–2.1 mm long, 0.7–1.0 mm wide, translucent, glabrous; midrib obscure; apex acute. *Outer sepals* narrowly lanceolate, 2.0–3.3 mm long, 0.4–0.7 mm wide; midrib region prominent, green, 1.5–2.5 mm long, 0.1–0.3 mm wide; basal outer surface with long, wavy, nodose hairs at base, becoming densely woolly with age; inner surface glabrous; apex acute, scarious margin 0.5–1.0 mm long, glabrous, white. *Inner sepals* lanceolate, 1.8–2.8 mm long, 0.3–0.7 mm wide; midrib region prominent, green, 1.7–2.2 mm long, 0.2–0.3 mm wide; basal outer surface with long, wavy, nodose hairs at base, becoming densely woolly with age; inner surface glabrous; apex acute, scarious margin 0.3–0.7 mm long, glabrous, pink. *Fertile stamens* 5; *filaments* 0.3–0.6 mm long; *anthers* 0.3–0.5 mm long, 0.1–0.2 mm wide, yellow. *Staminal cup* 0.3–0.5 mm long, unlobed. *Ovary* globular, 0.7–1 mm long, 0.5–0.9 mm wide, glabrous. *Style* straight, 0.3–0.5 mm long, centrally placed on the ovary apex. *Stigma* unlobed, capitate. *Fruit* smooth, membranous, irregularly dehiscent. *Seed* round, black, glossy, c. 0.9 mm long, c. 0.7 mm wide. **Fig. 1A.**

Diagnostic characters. *Ptilotus murrayi* may be distinguished from all other members of the genus by the following combination of characters: a prostrate or decumbent annual herb with glabrous stems and leaves, sessile axillary inflorescences, sepals not clawed, outer sepals with acute apices, a glabrous adaxial sepal surface, densely woolly hairs on the base of the abaxial sepal surface, 5 fertile stamens, staminal cup appendages absent, a central style centrally placed on the ovary apex, and a glabrous ovary.

Phenology. *Ptilotus murrayi* typically flowers from April to August throughout its range, extending into late October in Queensland and South Australia.

Distribution and habitat. *Ptilotus murrayi* occurs in the Carnarvon, Gascoyne, Murchison, Pilbara and Dampierland IBRA regions in Western Australia, and in south-western Queensland and north-eastern South Australia in Mitchell Grass Downs and Channel Country IBRA regions, with several outlying collections in the Simpson-Strzelecki Dunefields (Fig. 3A). The typical habitat is a flat floodplain or on the fringes of ephemeral wetlands, billabongs or rivers with silty or more commonly clayey red or brown soils.

Conservation status. *Ptilotus murrayi* is not listed as of conservation concern in any state in which it occurs.

Selected specimens examined

QUEENSLAND: 5.6 km W of turnoff to Birdsville along Windorah to Bedourie road, 27 June 2010, *D. Halford QM116* (BRI); Elizabeth Springs Conservation Park,

24 Oct. 2010, *R.Moore 1304* (BRI); Carlo, 16 June 2010, *J.Silcock JLS263* (BRI); 18 km E of Mount Leonard Station Homestead, 9 June 2010, *G.P.Turnpin GPT1333* (BRI).

SOUTH AUSTRALIA: Cordillo Downs on track near S. boundary c. 1 km S of Bluebush Dam, 6 May 2011, *D.C.Bickerton, P.J.Lang & D.J.Duval 76* (AD).

WESTERN AUSTRALIA: Liveringa Station near Fitzroy River, 20 Apr. 1985, *T.E.H.Aplin 179* (PERTH); track behind station to Yanarrie River within 200 m of homestead Yanrey Station, 6 May 2004, *G.Byrne 943* (PERTH); Maitland Road, Bullgarra Cell, Karratha, 20 Aug. 1986, *K.Glennon 239* (PERTH); on the side of North West Coastal Highway on a mound in a recently burnt flood plain, 2 km W of Yule River, 17 Aug. 2015, *T.Hammer, S.Dillon & K.Thiele TH 25* (PERTH); c. 800 m ENE of Balmoral Caravan Park, Balmoral Road, Nickol, Karratha, 14 Apr. 2011, *V.Long VLK tall-11* (PERTH); c. 20 km E of Nanutarra Station homestead, c. 200 km W of Paraburdoo, 15 May 1997, *A.A.Mitchell 4735* (PERTH); 8.7 km NNW of Whim Creek, Mallina Station, Pilbara, 19 Apr. 2006, *S.van Leeuwen PBS 5816* (PERTH).

***Ptilotus gomphrenoides* F.Muell. ex Benth.**

Fl. Austral. 5: 244 (1870). — **Type:** ‘Hamersley Range, N.W. coast, F. Gregory’s Expedition’, *F.Mueller s.n.* (syn: K 000357029 image!, MEL 2281815 image!).

Ptilotus roseo-albus Farmar var. *roseo-albus*, *Bull. Herb. Boissier* ser. 2, 5: 1090 (1905). — *Ptilotus gomphrenoides* var. *roseo-albus* (Farmar) Benl, *Mitt. Bot. Staatssamml. München* 4: 277 (1962). — **Type:** ‘N.-W. Division, W. Australia, E. Clement, 1897’ [between the Ashburton and De Grey rivers, Western Australia, 1897, *E.Clement s.n.*] (syn: K 000357024 image!, K 000357025 image!, K 000357026 image!, K 000357027 image!).

Ptilotus roseo-albus var. *conglomeratus* Farmar, *Bull. Herb. Boissier* ser. 2, 5: 1090 (1905). — *Ptilotus gomphrenoides* var. *conglomeratus* (Farmar) Benl, *Mitt. Bot. Staatssamml. München* 4: 278 (1962). — **Type:** ‘N.-W. Division, W. Australia, E. Clement, 1897’ [between the Ashburton and De Grey rivers, Western Australia, 1897, *E.Clement s.n.*] (holo: K 000357028 image!).

Erect, decumbent or less-commonly prostrate *annual herb* (2–) 10–30 cm high, 35–100 cm wide. *Stems* terete, ribbed, glabrous or with sparse nodose hairs. *Basal leaves* not seen. *Cauline leaves* alternate, narrowly lanceolate to broadly lanceolate, entire, 5–30 mm long, 1–5 mm wide, glabrous; base narrowly attenuate or petiolate, 3–10 mm long; apex mucronate, mucro 0.1–0.2 mm long. *Inflorescences* solitary or in clusters, axillary or terminal, pedunculate (peduncle 1–10 mm long) or rarely sessile, spiciform, cylindrical, 4–20 mm long, 6–7 mm wide, pinkish white; apex acute or truncate. *Bracts* ovate, 1.1–1.4 mm long, 0.8–0.9 mm wide, translucent, glabrous; midrib obscure; apex rounded. *Bracteoles* ovate, 1.2–1.5 mm long, 0.8–0.9 mm wide, translucent, glabrous; midrib faint or obscure; apex acute. *Outer sepals* narrowly lanceolate, 2.0–3.0 mm long, 0.5–0.8 mm wide; midrib region prominent, pink or rarely greenish, 1.2–1.5 mm long, 0.4–0.8 mm wide; basal outer surface with long, wavy, nodose hairs at base, becoming densely woolly with age; inner surface glabrous; apex rounded, scarious

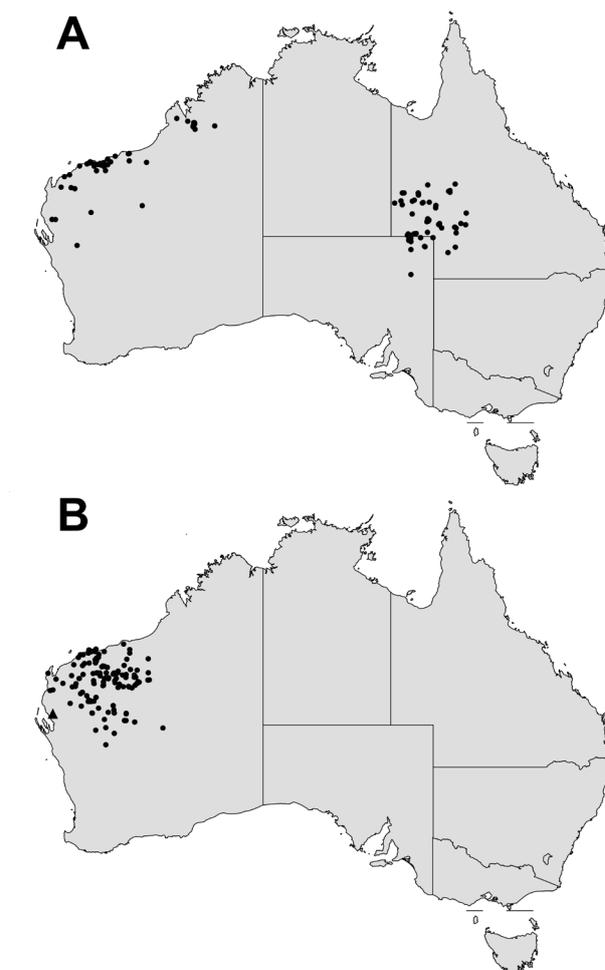


Fig. 3. Occurrence of herbarium records. **A** *Ptilotus murrayi*; **B** *P. gomphrenoides* (circles) and *P. unguiculatus* (triangle).

margins 0.8–1.5 mm long, glabrous, white. *Inner sepals* lanceolate to broadly lanceolate, 1.8–2.5 mm long, 0.7–1.2 mm wide; midrib region prominent, pink or rarely green, 1.0–1.5 mm long, 0.5–0.8 mm wide; basal outer surface with long, wavy, nodose hairs at base, becoming densely woolly with age; inner surface glabrous; apex rounded, scarious margin 0.5–0.8 mm long, glabrous, pink. *Fertile stamens* 5; *filaments* 0.3–0.7 mm long; *anthers* 0.2–0.4 mm long, 0.2–0.3 mm wide, yellow or pink. *Staminal cup* 0.1–0.2 mm long, unlobed. *Ovary* globular, 0.6–0.7 mm long, 0.5–0.7 mm wide, glabrous. *Style* straight, 0.2–0.4 mm long, centrally placed on the ovary apex. *Stigma* unlobed, capitate. *Fruit* smooth, membranous, irregularly dehiscent. *Seed* round, black, glossy, c. 0.8 mm long, c. 0.7 mm wide. **Fig. 1B.**

Diagnostic characters. *Ptilotus gomphrenoides* can be distinguished from other species in the genus by the following combination of characters: an erect or decumbent annual herb with glabrous stems and leaves, pedunculate axillary or terminal inflorescences, sepals not clawed, outer sepals with rounded apices, a glabrous adaxial sepal surface, densely woolly hairs on the base of the abaxial sepal surface, 5 fertile stamens, staminal cup

appendages absent, a central style centrally placed on the ovary apex, and a glabrous ovary.

Phenology. *Ptilotus gomphrenoides* flowers from April to September, with a few outlying specimens having been collected from October to January.

Distribution and habitat. *Ptilotus gomphrenoides* occurs in the Carnarvon, Gascoyne, Pilbara and northern Murchison IBRA regions of Western Australia (Fig. 3B). The typical habitat is flat seasonally-inundated floodplains, riverbanks or creek lines with clayey red or brown soils.

Conservation status. *Ptilotus gomphrenoides* is not listed as of conservation concern in Western Australia.

Selected specimens examined

WESTERN AUSTRALIA: Callina Creek c. 40 km WSW of Marble Bar, 30 Apr. 2006, *A.Bean* 25214 (PERTH); Chichester Ranges, 20 July 2011, *S.Chalwell* 379 (PERTH); Turn off to Python Pool near Tom Price railway road, 16 July 2013, *R.Davis* 12261 (PERTH); 1.1 km S along fenceline from Mount Brockman road and 22 km W of Hamersley Station homestead, 24 Sep. 2006, *D.Halford* Q9265 (PERTH); Nammuldi/Silvergrass lease area near Mt Brockman, WNW of Tom Price, 28 Aug.–7 Sep. 1998, *M.Maier s.n.* (PERTH 05986389); N of Catho Well mesa, Mount Stuart Station, West Pilbara Iron project area, 7 Aug. 2008, *K.McMaster* LCH 25882 (PERTH); 14 miles S of Nullagine, Sep. 1971, *R.Mirrington* 710919 (PERTH); Gascoyne River crossing at Yinnetharra, Western Australia, 14 Aug. 2002, *S.Patrick* 4291 (PERTH); Karijini National Park, 900 m NNW of the summit of Mt Hyogo and 13.3 km SW of Mt Bruce and 31.1 km NNE of Mt Bennett, Hamersley Range, 24 Aug. 1995, *S.van Leeuwen* 2053 (PERTH); E side of track, 5.3 km N of Ripon Hill Road on track of abandoned Braeside Station Homestead, 10.5 km W of Pulgorah Cone, 119.9 km ESE of Marble Bar, Warrawagine Station, Pilbara, 22 Apr. 2004, *S.van Leeuwen et al.* PBS 7047 (PERTH).

Acknowledgements

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CORRIGENDUM to: A new species of small black disc fungi, *Smardaea australis* (Pezizales, Pyronemataceae), is described from Australia

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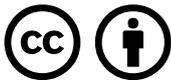
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The description of the new species *Smardaea australis* P.S.Catches. & D.E.A.Catches. (Catcheside *et al.* 2017) contained one error. Inadvertently, the asci were described as “amyloid”. This is not correct, the species has inamyloid asci, as do other species of the genus.

We thank Dr Mario Filippa for alerting us to the mistake.

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- Catcheside, P.S., Qaraghuli, S. & Catcheside, D.E.A. (2017). A new species of small black disc fungi, *Smardaea australis* (Pezizales, Pyronemataceae), is described from Australia. *Swainsona* 31: 17–26.



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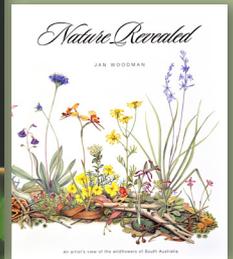
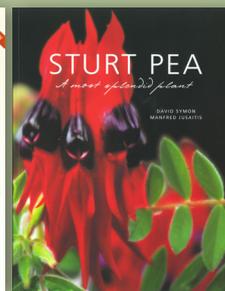
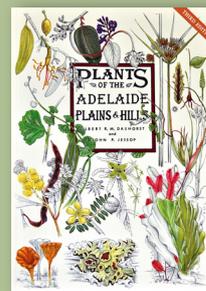
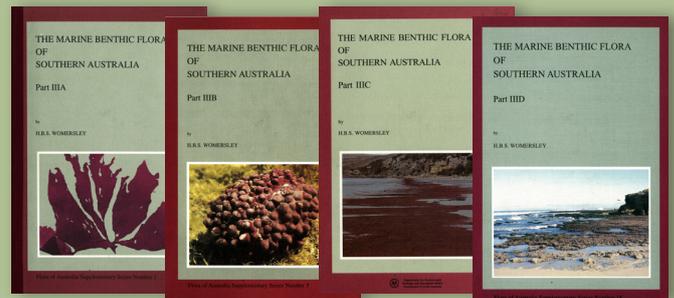
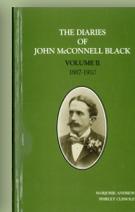
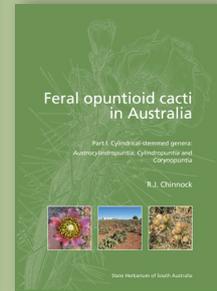
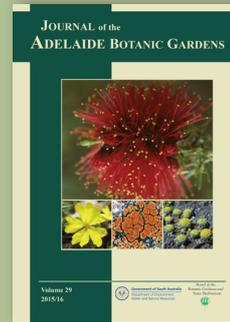
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Volume 31 — 2017 / 18

Contents

| | |
|---|-----|
| <i>Leptecophylla</i> in Tasmania: a reassessment of four species <i>S.J. Jarman & G. Kantvilas</i> | 1 |
| A new species of small black disc fungi, <i>Smardaea australis</i> (Pezizales, Pyronemataceae), is described from Australia <i>P.S. Catcheside, S. Qaraghuli & D.E.A. Catcheside</i> | 17 |
| <i>Tephromela baudiniana</i> sp. nov. (lichenised Ascomycetes) from Kangaroo Island <i>G. Kantvilas & J.A. Elix</i> | 27 |
| Two species of <i>Bacidia</i> De Not. with pruinose apothecia from Kangaroo Island <i>G. Kantvilas</i> | 31 |
| <i>Goodenia asteriscus</i> (Goodeniaceae), a new arid zone species from north-western South Australia and eastern Western Australia <i>P.J. Lang & R.J.-P. Davies</i> | 37 |
| <i>Pertusaria crassilabra</i> Müll. Arg. – a reinstated name for an Australasian lichen <i>G. Kantvilas</i> | 45 |
| The type of Sturt pea found <i>A.S. George</i> | 49 |
| <i>Micarea kartana</i> sp. nov. (lichenised Ascomycetes) from Kangaroo Island, South Australia <i>G. Kantvilas</i> | 55 |
| Notes on the taxonomy of Australian <i>Lindernia</i> subg. <i>Didymadenia</i> (Linderniaceae) <i>W.R. Barker</i> | 59 |
| <i>Antrelloides atroceraea</i> , a new genus and species in the Pezizaceae (Pezizales) from Australia <i>P.S. Catcheside & D.E.A. Catcheside</i> | 81 |
| The <i>Ptilotus murrayi</i> species group: synonymisation of <i>P. petiolatus</i> under <i>P. murrayi</i> and description of the new Western Australian species <i>P. unguiculatus</i> (Amaranthaceae) <i>T.A. Hammer</i> | 93 |
| CORRIGENDUM to: A new species of small black disc fungi, <i>Smardaea australis</i> (Pezizales, Pyronemataceae), is described from Australia <i>P.S. Catcheside & D.E.A. Catcheside</i> | 101 |