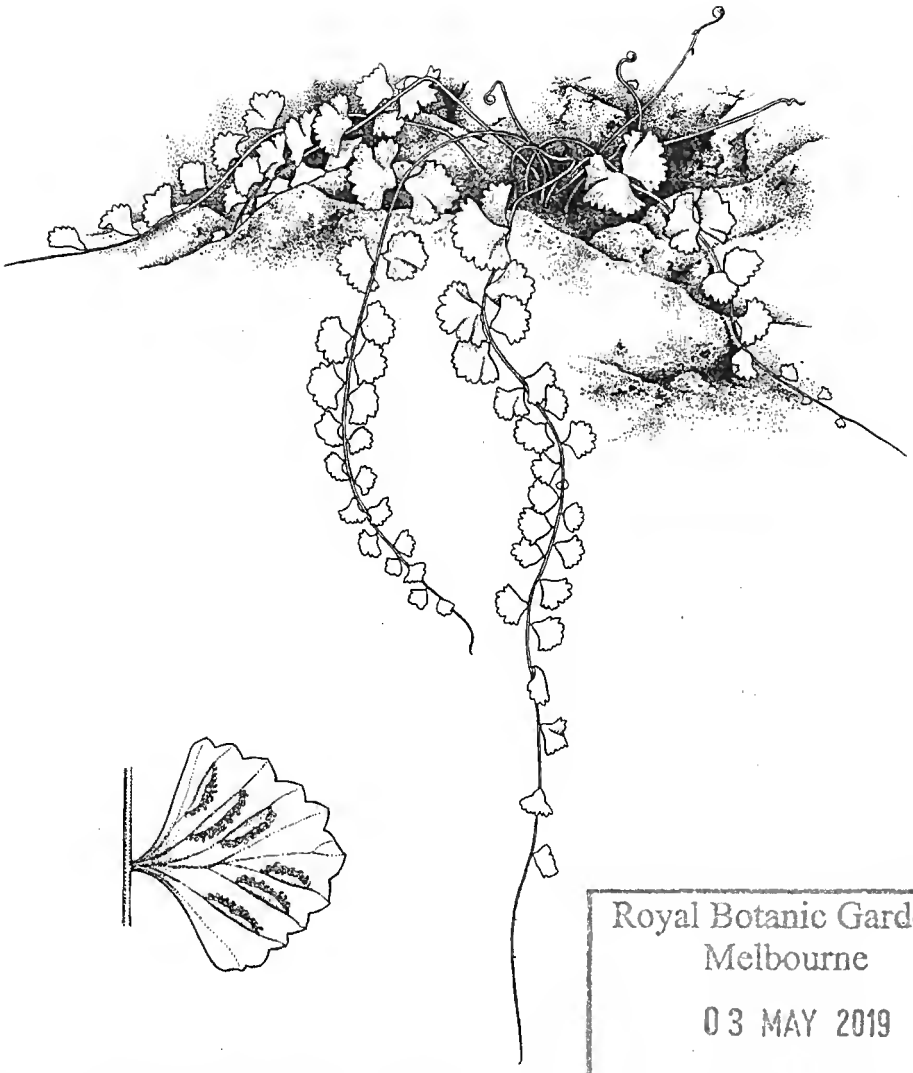
ROYAL
BOTANIC GARDENS
VICTORIA

Muelleria

Plant, Algal and Fungal Taxonomy and Systematics

Vol 37, 2018–2019



***Asplenium flabellifolium* Cav., *Descripcion de las Plantas* 1: 257 (1801)**
Source: State Botanical Collection
Illustration: Anita Barley (1985?)

The necklace fern, *Asplenium flabellifolium*, occurs in open forest or rainforest in temperate regions of Australia and New Zealand. *Hymenasplenium wildii*, a rare species endemic to tropical northern Queensland, was recently transferred from *Asplenium*. *Asplenium* and *Hymenasplenium* are members of the cosmopolitan spleenwort fern family Aspleniaceae, which contains over 700 species.

Muelleria publishes research papers on Southern Hemisphere plant, algal and fungal taxonomy and systematics, particularly relating to Australia. Acceptable submissions include: taxonomic revisions; phylogenetic and biogeographical studies; short papers describing new taxa (including overseas members of genera represented in the indigenous flora of Australia), documentation of nationally significant new records, or resolutions of nomenclatural matters; historical analyses relevant to systematics; and any research contributing to our knowledge of plant, algal or fungal diversity. Special issues or reviews can be considered upon discussion with the Editor in Chief. Book reviews are included as space permits. All papers undergo external peer review.

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Subscription Manager	Sally Stewart, Librarian library@rbg.vic.gov.au
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Instructions to authors	Please consult the instructions to authors at the website below. A concise version is printed inside the back cover of each issue. www.rbg.vic.gov.au/science/publications/muelleria
Publication frequency	One issue per year
Subscription rates	The following rates include postage and GST. All payments must be in $AUD. Cheques should be made payable to the Royal Botanic Gardens Victoria. Contact the Subscription Manager for additional payment options.

	Australia	International
Individuals	$40	$62
Organisations	$50	$77

Where a paper in this issue was first published online, the publishing date is specified on the title page.

ISSN 0077-1813

***Muelleria* volume 36 was distributed on 16 May 2018.**

Muelleria

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Published online in advance of the print edition, 28 June

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A conspectus of *Teucrium* (Lamiaceae) in Queensland

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Introduction

Teucrium L. is a large cosmopolitan genus of around 260 species, with a centre of diversity in the Mediterranean region (Li and Hedge 2017). It is the largest genus of the Tribe Ajugoideae, which also includes e.g. *Clerodendrum* L., *Aegiphila* Jacq., *Rotheca* Raf. and *Ajuga* L. (Stevens 2001 onwards). In its traditional circumscription, *Teucrium* is characterised by its terminal style, dry fruits comprising four mericarps, and the corolla in which the upper lip is lacking or highly reduced. The recent phylogenetic study by Salmaki et al. (2016) has demonstrated the paraphyletic nature of the traditional circumscription, and they advocated an expansion of the generic limits to include *Spartothamnella* Briq. and *Oncinocalyx* F.Muell. This has made *Teucrium* more difficult to define morphologically, as most species from the other two genera feature corollas that are close to being actinomorphic, and the fruit of the former is a drupe.

Toelken (1985), Conn (2002), Conn (2006), Toelken and Cunningham (2008), Walsh and O'Brien (2013) and Shepherd and Thiele (2017) are the most recent taxonomic papers dealing with Australian *Teucrium*.

Twenty formally named species are currently accepted for Australia (15 spp. of traditional *Teucrium*, 4 spp. of *Spartothamnella* and *Oncinocalyx betchei* F.Muell.), nine of which are indigenous to Queensland. In this paper, a further five species are newly described (*T. daucoides* A.R. Bean, *T. fallax* A.R. Bean, *T. irroratum* A.R. Bean, *T. modestum* A.R. Bean and *T. sagittatum* A.R. Bean), bringing the Queensland total to 14 species.

Lectotypes are chosen for *T. argutum* R.Br., *T. corymbosum* R.Br., *T. integrifolium* Benth. and *T. racemosum* R.Br.

Abstract

The 14 species of *Teucrium* L. indigenous to Queensland are listed with full nomenclatural data and notes on distribution and habitat. Five species (*T. daucoides* A.R.Bean, *T. fallax* A.R.Bean, *T. irroratum* A.R.Bean, *T. modestum* A.R.Bean and *T. sagittatum* A.R.Bean) are newly described; full descriptions, distribution maps and illustrations are provided, with notes on related species, conservation status and habitat. Lectotypes are chosen for *T. argutum* R.Br., *T. corymbosum* R.Br., *T. integrifolium* Benth. and *T. racemosum* R.Br. An identification key for the Queensland species of *Teucrium* is provided.

Keywords: new species, taxonomy, lectotypes, Queensland flora, conservation status.

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

Materials and methods

This paper is based on a morphological study of specimens at BRI and MEL, and high resolution images of type specimens from BM, CANB, K and MEL examined on the JSTOR Global Plants website (JSTOR 2017). Measurements of leaves, bracteoles, calyx and mericarp are based on dried material, whereas measurements of the corolla, stamens and style are based on material preserved in spirit or reconstituted in boiling water. For the cymose inflorescences considered here, the pedicel is defined as the a_1 axis plus the anthopodium, as in Conn (1984), i.e. the stalk of the flower/fruit including portions above and below the bracteoles. The peduncle is the most basal 'stalk' of the inflorescence, arising from the leaf axil.

The distribution map was compiled using DIVA-GIS Version 7.5.0 (http://www.diva-gis.org), from localities or geocodes given on the labels of specimens at BRI. Species treatments are arranged in alphabetical order.

Abbreviations used in the specimen citations include N.P. for National Park and S.F. for State Forest.

Key to Queensland species of *Teucrium*

1	Branchlets with dendritic or branched hairs	2
1:	Branchlets glabrous or with simple (unbranched) hairs	4
2	Leaves and calyx with simple (unbranched) hairs; pedicels 1.5–2.3 mm long	*T. fallax*
2:	Leaves and calyx with branched hairs; pedicels 0.4–1.0 mm long	3
3	Larger leaves 3–6 mm long; fruit comprising four mericarps, enclosed in calyx tube	*T. micranthum*
3:	Larger leaves 6–20 mm long; fruit a red drupe, exceeding calyx tube	*T. puberulum*
4	Branchlets glabrous	5
4:	Branchlets sparsely to very densely hairy	7
5	Inflorescence a terminal many-flowered spike or raceme	*T. sagittatum*
5:	Inflorescences axillary, 1–3-flowered	6
6	Branchlets longitudinally striate; leaves absent or rudimentary; pedicel and calyx glabrous; corolla lobes all of similar size and shape	*T. junceum*
6:	Branchlets not longitudinally striate; leaves well developed, longer ones 26–55 mm long; pedicel and calyx sparsely hairy; corolla strongly zygomorphic	*T. integrifolium*
7	Inflorescence a terminal spike or raceme; corolla mauve to purple	8
7:	Inflorescences axillary, solitary or cymose; corolla white	10
8	Leaves linear to sagittate, 5–12 times longer than broad; calyx tube 1.7–2.2 mm long at anthesis; stamens 3.5–4.3 mm long	*T. sagittatum*
8:	Leaves ovate to orbicular, 1.1–2.6 times longer than broad; calyx tube 2.3–4.6 mm long at anthesis; stamens 7–9 mm long	9
9	Leaves pinnatifid to pinnatisect or bipinnatifid, usually with glandular hairs; petioles winged	*T. daucoides*
9:	Leaves serrate, without glandular hairs; petioles not winged	*T. argutum*
10	Flowers sessile; calyx lobes slender, hooked at apex	*T. betchei*
10:	Flowers pedicellate; calyx lobes deltate, not hooked	11
11	Branchlets, pedicels and calyces densely covered with glandular hairs	*T. irroratum*
11:	Branchlets, pedicels and calyces without glandular hairs	12
12	Calyx with patent hairs 0.4–0.6 mm long	*T. modestum*
12:	Calyx hairs antrorse to appressed, 0.05–0.20 mm long	13
13	Inflorescence 5–20-flowered; calyx hairs curved; leaf margins serrate	*T. corymbosum*
13:	Inflorescence 1–3-flowered; calyx hairs straight; leaf margins entire or undulate	14
14	Pedicels 1.5–3.5 mm long; spindly shrub; leaves sparse, ± deciduous; fruit a succulent drupe	*T. teucriiflorum*
14:	Pedicels 4.5–20 mm long; compact shrub; leaves numerous, persistent; fruit consisting of four dry mericarps	15
15	Branchlets densely hairy (obscuring surface); longest leaves 10–25(–45) mm long, at least some with scalloped or undulate margins; pedicels at an angle of 40–90 degrees to the branchlet	*T. racemosum*
15:	Branchlets sparsely hairy or almost glabrous; longest leaves 26–55 mm long, all entire; pedicels at an angle of 20–50 degrees to the branchlet	*T. integrifolium*

Taxonomy

Teucrium argutum R.Br., *Prodr.* 504 (1810)

T. argutum R.Br. var. *argutum*, *Fl. Austral.* 5: 135 (1870). ***Type:*** **NEW SOUTH WALES.** Hawkesbury, undated, *R. Brown s.n.* (Bennett Number 2390) (lecto: BM 001040994, here designated; isolecto: BM 001040995, CANB 278995, K 000881573, MEL 2294209, MEL 2294211).

Illustration: Leiper et al. 2017 p. 144

Distribution and habitat: Extending from just south of Sydney, Central Coast, New South Wales, to Lakeland Downs (near Cooktown) in Queensland. It grows in forest and woodland in loamy or clay-loam soils, mainly on hillsides.

Typification: The specimen chosen as the lectotype comprises several plants, all very similar in appearance and all in full flower. There is a label in Brown's handwriting, and another label displaying the number assigned by Bennett.

Teucrium betchei (F.Muell.) Kattari and Salmaki, *Taxon* 65: 818 (2016)

Oncinocalyx betchei F.Muell., *S. Sci. Rec.* 3: 70 (1883). ***Type:*** **NEW SOUTH WALES.** Namoi River near Gunnedah, January 1883, *E. Betche s.n.* (lecto: MEL 583547, fide Munir (1991); isolecto: NSW145058).

Distribution and habitat: Confined to the southern Darling Downs area Queensland, but widespread on the north-western slopes of New South Wales. It grows on grassy flats in eucalypt woodland.

Teucrium corymbosum R.Br., *Prodr.* 504 (1810)

Type: **NEW SOUTH WALES.** Port Jackson, undated, *R. Brown s.n.* (Bennett Number 2389) (lecto: BM 001040992, here designated; isolecto: BM 001040993, CANB 278996, K 000881583, K 000881584, MEL 2294212).

Illustrations: Leiper et al. 2017 p. 481

Distribution and habitat: Scattered in the south-eastern part of Queensland, extending as far north as Cudmore National Park, north-west of Alpha. Widespread in New South Wales, Victoria, Tasmania and South Australia. It inhabits eucalypt woodland or open forest on deep red-brown soils or shallow sandy soils on stony hills.

Typification: The specimen chosen as the lectotype bears a label in Robert Brown's handwriting, and a blue label with the number '2389'. It is a flowering specimen in good condition, and it is in accord with the description in the protologue.

Teucrium daucoides A.R. Bean sp. nov.

Type: **QUEENSLAND.** DARLING DOWNS DISTRICT: Pittsworth-Milmerran road, at Elsden Road turnoff, 20.i.2002, *A.R. Bean 18338* (holo: BRI AQ553327 (1 sheet + spirit); iso: K, MEL 2280551, NSW).

With affinity to *T. argutum*, but differing by the usually glandular hairy leaves and branchlets, the deeply divided leaves, the winged petioles and the generally longer calyces.

Teucrium argutum var. *incisum* Benth., *Fl. Austral.* 5: 135 (1870). ***Type:*** **QUEENSLAND.** Dawson River, undated [1856], *F. Mueller s.n.* (syn: K 000881577); Darling Downs, undated, *H. Lau* (syn: K 000881575); Armadilla, undated [1867–1871], *W. Barton s.n.* (syn: MEL 2241834).

Teucrium sp. (Pittsworth A.R. Bean 18338), in Bean and Forster (2016). ***Illustration:*** Leiper et al. 2017 p. 144, as *Teucrium* sp. aff. *argutum*

Erect shrub 0.2–0.4 m high, often with several stems from ground level. *Branchlets* quadrangular, faces grooved; indumentum very dense with patent glandular hairs 0.10–0.25(–0.40) mm long, and moderately dense, simple, retrorse, eglandular, ± transparent hairs, 0.05–0.20 mm long; sessile glands sparse. *Leaves* opposite, petiolate. Lamina discolorous, dark green above, broadly-ovate in outline, pinnatifid, pinnatisect or bipinnatifid, the largest leaves 11–41 × 7.5–20 mm, 1.1–1.8 times longer than broad; apex acute; base broadly cuneate; venation obscure. Upper surface not bullate, with dense indumentum of patent glandular hairs and retrorse eglandular hairs (as per branchlets), rarely glabrous. Lower surface pale green, with raised venation, with dense indumentum of patent glandular hairs and retrorse eglandular hairs (as per branchlets), rarely glabrous; sessile glands abundant throughout. Petioles 2.5–15 mm long, 24–47% of the lamina length, winged. Inflorescences terminal, spicate or racemose, spikes 4–11 cm long; bracts opposite, narrowly elliptic to elliptic, sometimes toothed, 6–14 mm long, persistent, apex acute. Pedicel (1.0–)1.5–3.0 mm long. *Calyx* campanulate, 10-veined, with 5 subequal deltate lobes;

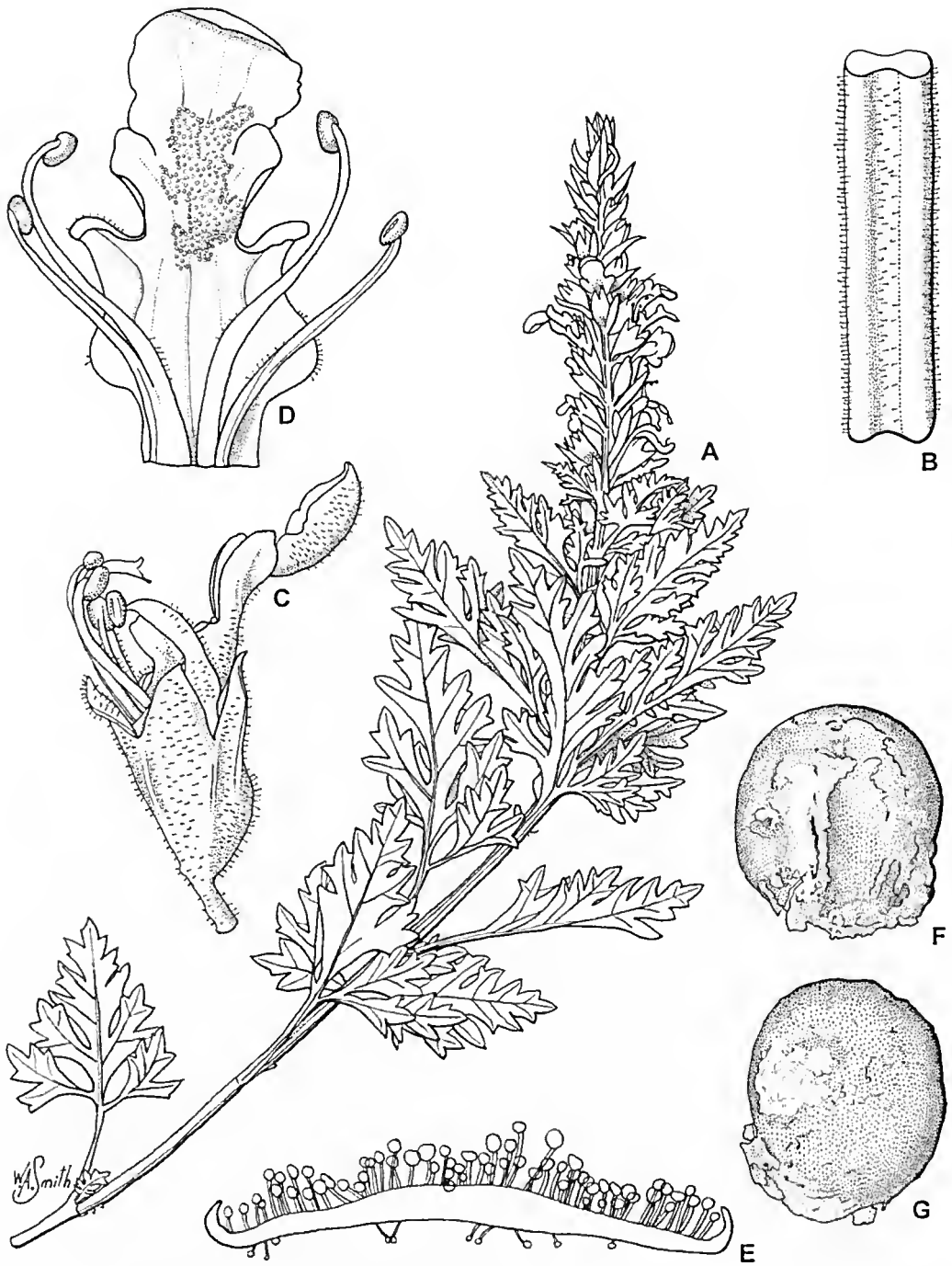

Figure 1. *Teucrium daucoides*. A. flowering branchlet (× 1). B. small section of young stem showing cross-sectional shape (× 6). C. lateral view of flower (× 6). D. dissected (opened-out) corolla with attached stamens (× 6). E. cross-section of corolla showing the vesicular hairs (above) and scattered glandular hairs (below) (× 32). F. mericarp, ventral view (× 24). G. mericarp, dorsal view (× 24). A,B from *Menkins ILM0581* (BRI); C-E from *Bean 18338* (BRI); F,G from *Menkins ILM0491 and Leiper* (BRI).

exterior surface with indumentum of dense patent glandular hairs 0.10–0.25 mm long, and moderately dense eglandular hairs 0.10–0.25 mm long, sessile glands present; interior surface with moderately dense glandular hairs; calyx tube 3.0–4.6 mm long at anthesis; calyx lobes 1.5–2.8 mm long at anthesis, 0.8–1.5 times longer than wide. *Corolla* 1–lipped, 5-lobed, white, outer surface with eglandular hairs and glandular hairs, inner surface with abundant vesicular hairs, mainly on central portion of corolla (where lobes intersect); terminal lobe broadly elliptic, 2.5–5.0 mm long, slightly concave; lateral lobes elliptic, 1.0–1.5 mm long; basal lobes elliptic, 1.4–1.8 mm long; tube 4.0–4.8 mm long. *Stamens* attached c. 1 mm above base of corolla tube, 8–9 mm long; filaments gently curved, with some glandular and eglandular hairs on the proximal half; anthers 4, cells medifixed, 0.7–0.8 mm long, with sparse glands around attachment point of filament; style glabrous, straight or slightly curved, 8.5–9.0 mm long; stigma 2-fid, the lobes 0.3–0.5 mm long. *Mericarps* 4, brown, ± globular, c. 1.5 mm long, surface smooth, glabrous, apical one-third with scattered sessile glands; ventral surface with large areole c. 0.9 mm long, glabrous. (Figure 1)

Selected specimens examined: **QUEENSLAND.** LEICHHARDT DISTRICT: Mount Playfair, 1894, *H.S. Biddulph s.n.* (MEL 1512018); 'Walton Downs', 20 miles NE of Clermont on Mackay road, 14.iii.1957, *W.J. Bisset E86* (BRI); Fitzroy Development Road, c. 18.2 km N of the Dingo rail crossing, adjacent to Taunton N.P., 3.vii.2011, *I.L. Menkins ILM0491 and G. Leiper* (BRI); Blackwater Creek, 1879, *P. O'Shanesy 3041* (MEL); Brigalow Research Station, Theodore, 18.i.1964, *J. Gillieatt s.n.* (BRI, AQ161300); c. 4 miles [6 km] E of Moura, 1.iii.1967, *R.J. Henderson 221* (BRI). BURNETT DISTRICT: Wondai, 18.ii.1966, *E. Hancock s.n.* (BRI, AQ161303). MARANOA DISTRICT: Roma, 29.iii.1936, *S.T. Blake 10875* (BRI); Clerk Creek, via Hodgson Lane North, c. 15 km WNW of Roma, 27.iv.2011, *R. Aisthorpe RHA004* (BRI); Hamilton Park South, 29 km N of Yuleba, 14.ii.2011, *C.P. Eddie CPE1786 et al.* (BRI). DARLING DOWNS DISTRICT: 'Wallumba', at Condamine River, c. 18 km SSE of Miles, 19.vii.2010, *C.P. Eddie CPE1695* (BRI); 3.7 km along Lyndley Lane, N of Jimbour, 6.xii.1997, *A.R. Bean 12618* (BRI, MEL); 8.3 km WSW of Dalby on Myall Creek, 11.iv.2011, *E.J. Thompson EJT339 and M. Edginton* (BRI); SE corner of Bowenville Fishing Reserve, 21.xii.2011, *I.L. Menkins ILM0581* (BRI); Jondaryan, 22.ii.193S, *S.T. Blake 7737* (BRI); Warrego Highway near Oakey, 27° 21' 20"S 151° 34' 13"E, 4.iii.2013, *R.J. Fensham 6350* (BRI); 1.7 km SSW of Clifton, Clifton Dump, 2.ii.1995, *D.A. Halford Q2421* (BRI); Goondiwindi, 30.v.2001, *M. Fea s.n.* (BRI, AQ718902).

Distribution and habitat: Clermont, Queensland, south to Goondiwindi, usually 200–400 km from the east coast (Figure 6); also extending south to Dubbo in New South Wales. It inhabits black cracking clay soil, often on alluvium, in grassland or associated with *Eucalyptus camaldulensis* Dehnh., *Casuarina cristata* Miq. or *Acacia harpophylla* F.Muell. ex Benth.

Phenology: Flowers have been recorded from every month of the year; fruits have been recorded in July.

Affinities: *Teucrium daucoides* appears to be related to *T. argutum*, but differs by the presence of glandular hairs on the branchlets and leaves (rarely lacking), while *T. argutum* has eglandular hairs only on the branchlets and leaves; *T. daucoides* has finely divided pinnatifid or bipinnatifid leaves while the leaves of *T. argutum* are serrate; the calyx tube (3.0–4.6 mm long) and calyx lobes (1.5–2.8 mm long) of *T. daucoides* are generally longer than *T. argutum* (mostly 2.3–3.2 mm and 1.0–1.6 mm respectively), although some populations of *T. argutum* exist with calyx tubes up to 4.2 mm long and lobes to 2.9 mm long; the petioles of *T. daucoides* are winged (with green tissue extending to its base (not winged in *T. argutum*). The habitat of *T. daucoides* (cracking black clays in alluvial grassland or open woodland) differs from that of *T. argutum*, which favours freely draining loam or clay-loam soil in a woodland or open-forest hillside habitat.

Conservation status: A common and widespread species. Least Concern according to the Red-list criteria of the IUCN (IUCN 2012).

Etymology: The epithet refers to the highly divided leaves possessed by this species, which resemble the leaves of *Daucus* spp. (Apiaceae).

Notes: Considerable variation is evident in this species. Populations in the Roma district have leaves that bear only eglandular hairs. Specimens from the northern end of the range have leaves that are smaller than the type and strictly pinnatifid (no tendency for pinnatisect or bipinnatifid leaves), and the bracts and flowers are somewhat smaller.

Teucrium fallax A.R. Bean sp. nov.

Type: **QUEENSLAND**. LEICHHARDT DISTRICT: Lonesome Holding, on northern side of Candlesticks Gully, NE of Injune, 26.iv.2004, *C.P. Eddie Lot 1, G. Graham and W. McDonald* (holo: BRI AQ579706).

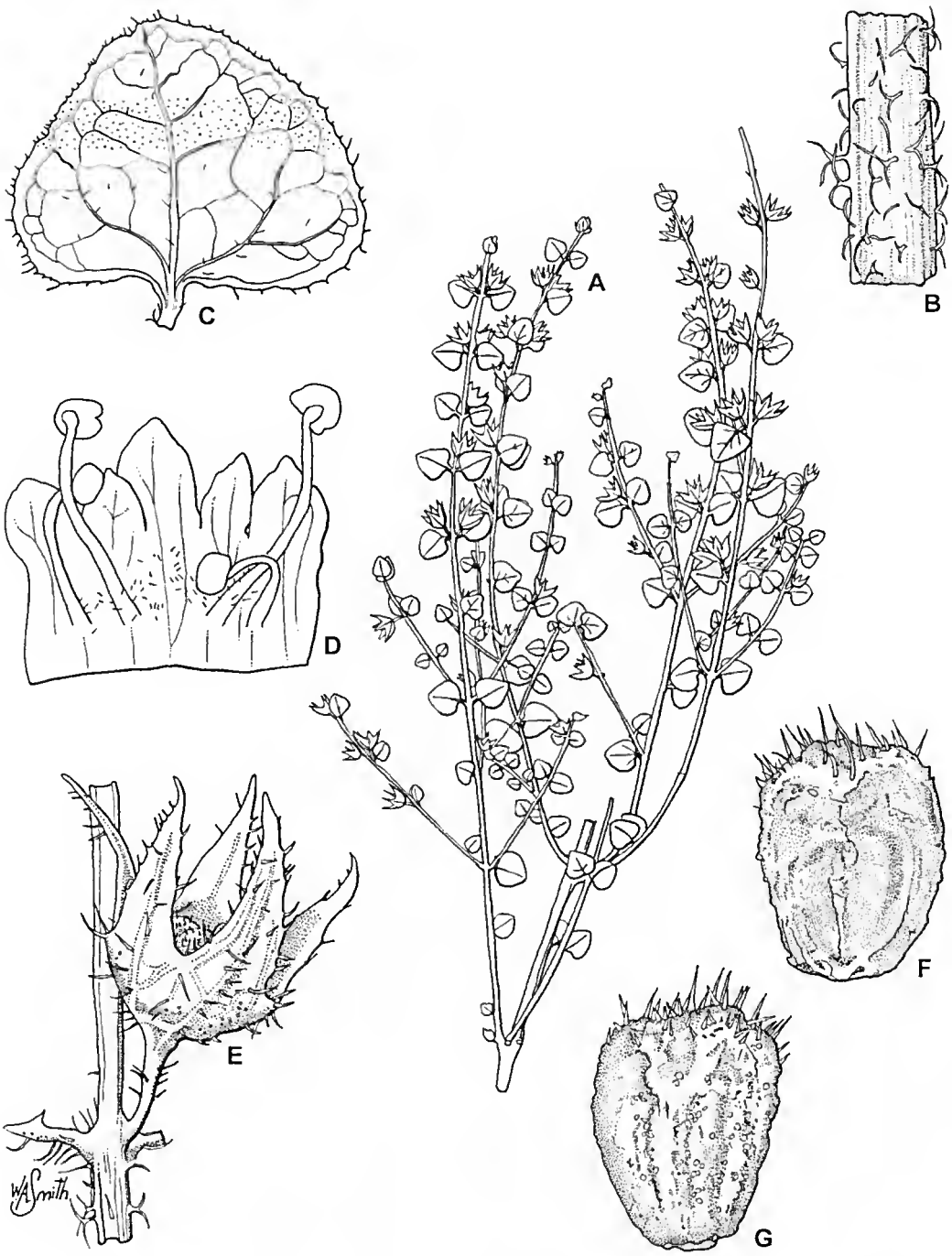

Figure 2. *Teucrium fallax*. A. fruiting branchlet (× 1). B. small section *af* yaung stem shawing branched hairs (× 16). C. abaxial surface of leaf (× 6). D. opened-aut *caral*la with attached stamens (× 16). E. fruiting calyx and pedicel (× 10). F. mericarp, ventral view (× 24). G. mericarp, dorsal view (× 24). All from *C.P. Eddie Lat 1, G. Graham and W. McDanald* (BRI, AQ 579706).

With affinity to *T. micranthum*, but differing by the unbranched hairs on the leaves and calyx, the longer pedicels, and the shorter mericarps bearing many simple hairs.

Erect shrub 0.3–1.0 m high, densely branched. *Branchlets* quadrangular; hairs sparse to moderately dense to dense, branched, mostly 2-armed, occasionally 3- or more armed, eglandular, multicellular, ± transparent, longest hairs 0.1–0.3 mm long, usually broader than long; glands absent. *Leaves* opposite, petioles 0.6–1.3 mm long, 12–20% of the lamina length, not winged; lamina discolorous, dark green above, broadly deltate to rhomboid, the largest ones 3.0–7.2 × 3.3–7.0 mm, 0.8–1.2 times longer than broad; margins entire; apex obtuse; base broadly cuneate to obtuse; venation penninerved, veins obscure on upper surface, visible on lower surface. Upper surface not bullate, with sparse indumentum of simple (rarely branched) patent eglandular hairs, 0.2–0.5 mm long. Lower surface with raised veins, simple eglandular hairs very sparse to sparse, 0.10–0.25 mm long, mainly along veins; sessile glands abundant throughout. Inflorescences axillary, solitary; bracteoles opposite to subopposite, linear, 0.3–0.9 mm long, somewhat persistent, apex acute. Pedicel 1.5–2.3 mm long. *Calyx* campanulate, 10-veined, with 5 subequal deltate lobes; indumentum on exterior surface of sparse simple patent eglandular hairs 0.2–0.3 mm long, and scattered sessile glands; interior surface glabrous or rarely with a few simple hairs; calyx tube c. 1.0 mm long at anthesis, 1.0–1.7 mm long in fruit; calyx lobes 1.0–1.3 mm long at anthesis, 2.0–3.2 mm long in fruit, 1.5–2.5 times longer than wide. *Corolla* 1-lipped, 5-lobed, white, outer surface with eglandular hairs and sessile glands, inner surface with eglandular hairs on the tube only; terminal lobe broadly ovate, 1.0–1.2 mm long, slightly concave; lateral lobes broadly ovate, 0.7–1.1 mm long; basal lobes broadly ovate, 0.8–0.9 mm long; tube 0.9–1.2 mm long. *Stamens* attached midway along length of corolla tube, 2–3 mm long; filaments gently curved, with a few eglandular hairs in the proximal half, anthers 4, cells medifixed, 0.4–0.5 mm long, with sparse glands around attachment point of filament; style glabrous, curved, 2.5–3.5 mm long; stigma 2-fid, the lobes 0.6–0.9 mm long. *Mericarps* 4, light brown, ellipsoid, 1.5–1.6 mm long, surface smooth, apical one-third with patent eglandular hairs 0.10–0.25 mm long and numerous sessile glands extending almost to base on dorsal side; ventral surface with large areole 0.8–1.1 mm long, glabrous. (Figure 2)

Specimens examined: **QUEENSLAND.** NORTH KENNEDY DISTRICT: 7.1 km N of Broken River, 3.vi.2000, *R.J. Cumming 19682* (BRI); Broken River, 16.vi.1993, *R.J. Fensham 1036* (BRI). LEICHHARDT DISTRICT: Palmgrove Fauna Reserve [now Palmgrove N.P.], Duaringa, 6.vi.1989, *S. Barry PG25* (BRI); near northern boundary of Palmgrove N.P., c. 3 km NE of Bakers Peak, 28.viii.1999, *M. Watson and C. Appelman s.n.* (BRI, AQ 553693).

Distribution and habitat: Endemic to Queensland. Known from three localities: Broken River (S of Greenvale), Palmgrove National Park (W of Theodore) and Lonesome Holding (NE of Injune) (Figure 6). It inhabits semi-evergreen vine thicket, or communities dominated by *Acacia harpophylla* (Brigalow), or a mixture of the two. At the Broken River site, growing on limestone karst, with little soil, elsewhere, growing in cracking clay or loamy-clay soil.

Phenology: Flowers are recorded for April and June; fruits in April, June and August.

Affinities: *Teucrium fallax* is similar in appearance to *T. micranthum*, but differs by the mericarps 1.5–1.6 mm long with many simple hairs on the apical one-third and with sessile glands almost throughout the dorsal surface (vs. 1.8–2.0 mm long, glabrous or with one or two branched hairs on apical one-third, and no glands on dorsal surface for *T. micranthum*), the inner surface of the calyx glabrous (vs. many branched hairs present for *T. micranthum*), the fruiting pedicels 1.5–2.3 mm (vs. 0.4–0.6 mm for *T. micranthum*), the hairs on the leaves and calyx all simple (all branched for *T. micranthum*). Furthermore, the inflorescence in *T. micranthum* comprises a very short lateral branchlet (0.5–0.7 mm long) which bears two leaves, then a single flower on a pedicel 0.4–0.6 mm long and lacking bracteoles. That does not occur in *T. fallax*, where there is just a single bracteolate flower/fruit emerging from the axil, without any leaf or branchlet development.

Conservation status: A status of Vulnerable (VU B2ab(ii)(iii)) is recommended based on Red-list criteria (IUCN 2012). The species is threatened by land clearing and weed incursion.

Etymology: The epithet is from the Latin *'fallax'* meaning deceitful or false. This refers to its close resemblance to *T. micranthum* in general form and flower size.

Note: Conn (2002), in the protologue of *T. micranthum*, cited some specimens here regarded as *T. fallax*. However, his description appears to be based solely on material of *T. micranthum*.

Teucrium integrifolium Benth., *Fl. Austral.* 5: 133 (1870).

Type: **QUEENSLAND**. BURKE DISTRICT: Flinders River, undated, *J. Sutherland 84* (lecto, here designated: MEL 2294216).

Distribution and habitat: Widespread in Queensland except in the far north and coastal areas, found from Thurulgoonia (S of Cunnamulla) to Gregory Downs (N of Mount Isa), and east as far as Biloela and Dalby. Also widely distributed in the Northern Territory. It inhabits plains and alluvial systems on black cracking clay soils. It may be associated with Mitchell grass (*Astrebla* spp.) in grassland communities, or as a component of open woodland dominated by *Eucalyptus coolabah* Blakely and Jacobs, *E. orgadophila* Maiden and Blakely or *Acacia harpophylla* commonly associated with the shrub *Duma florulenta* (Meisn.) T.M.Schust.

Typification: The specimen chosen as the lectotype is one of the specimens cited by Bentham in the protologue. It is a good quality flowering specimen, and it is in accord with the description in the protologue.

Note: This species has not been recorded for New South Wales, but as there is an occurrence at Thurulgoonia, S of Cunnamulla, about 30 km from the New South Wales border, its occurrence in that state is highly likely.

Teucrium irroratum A.R. Bean sp. nov.

Type: **QUEENSLAND**. PORT CURTIS DISTRICT: Table Mountain, 6 km S of Kabra, 8.ii.1997, *P.I. Forster PIF20299 and M. Watson* (holo: BRI AQ652787; iso: NSW, to be distributed).

Erect shrub 0.5 m high. *Branchlets* almost terete, not markedly quadrangular; with moderately dense, simple, patent, eglandular, multicellular, ± transparent hairs 0.4–1.2 mm long; and abundant glistening patent glandular hairs, mostly <0.1 mm long, but with some up to 0.5 mm. *Leaves* opposite or in whorls of three; petioles 1-2 mm long, 1-4% of lamina length; lamina discolorous, dark green above, elliptic to ovate, the largest ones 39–51 × 15–21 mm, 2.1–2.8 times longer than broad; margins serrate, with 6–8 pairs of lobes, confined to the distal half of the lamina; apex acute; base narrowly cuneate; venation penninerved, veins obscure on upper surface, obvious on lower surface. Upper surface smooth except for sunken major veins, with moderately dense indumentum of patent transparent eglandular hairs, 0.2–0.8 mm long. Lower surface with raised veins, eglandular hairs sparse to moderately dense, 0.25–0.60 mm long, mainly along veins; sessile glistening glands and glandular hairs (to 0.15 mm long) abundant throughout. Inflorescences axillary, cymose, 4–9-flowered, dichasial; bracts opposite, elliptic to ovate, 3–4 mm long, persistent. Pedicel 4.5–7.0 mm long; inflorescence branches similar in length to pedicel; peduncle 17–28 mm long. *Calyx* campanulate 10-veined, with 5 subequal deltate lobes; indumentum on peduncles, pedicels and exterior surface calyx comprising dense patent glandular hairs 0.05–0.40 mm long, and some patent eglandular hairs to 0.6 mm long; interior surface of lobes with scattered sessile glands and short glandular hairs, interior surface of tube glabrous; calyx tube 2.0–2.3 mm long at anthesis, 2.0–2.4 mm long in fruit; calyx lobes 1.8–2.1 mm long at anthesis, 3.2–4.1 mm long in fruit, 1.5–3.0 times longer than wide. *Corolla* 1-lipped, 5-lobed, white (fide O'Shanesy), outer surface with scattered glandular and eglandular hairs, inner surface tube with eglandular hairs on the tube only; terminal lobe broadly ovate, 2.5–3.2 mm long, lateral lobes ovate, 1.8–2.2 mm long, basal lobes ovate, 2.5–3.2 mm long; tube 3.5–4.0 mm long. *Stamens* attached midway along length of corolla tube, 3.5–5.0 mm long; filaments with some glandular hairs on the distal half; anthers 4, cells medifixed, 0.7–0.8 mm long, with dense glands around attachment point of filament; style glabrous, 7.5–9.0 mm long; stigma 2-fid, the lobes c. 0.5 mm long. *Mericarps* 4, dark brown, ellipsoid, 1.6–2.0 mm long, surface smooth to faintly ridged, apical one-third with patent eglandular hairs 0.10–0.15 mm long and numerous sessile and subsessile glands; ventral surface with large areole 0.9–1.1 mm long, glabrous. (Figure 3)

Specimens examined: **QUEENSLAND**. PORT CURTIS DISTRICT: Table Mountain, undated [1866-67], *E.M. Bowman 66* (MEL 63753); Table Mountain, iv.1867, *E.M. Bowman 88* (MEL 2242919); near Rockhampton, 20.vlii.1868, *P. O'Shanesy No. 16, ser. 12* (MEL 2242907).

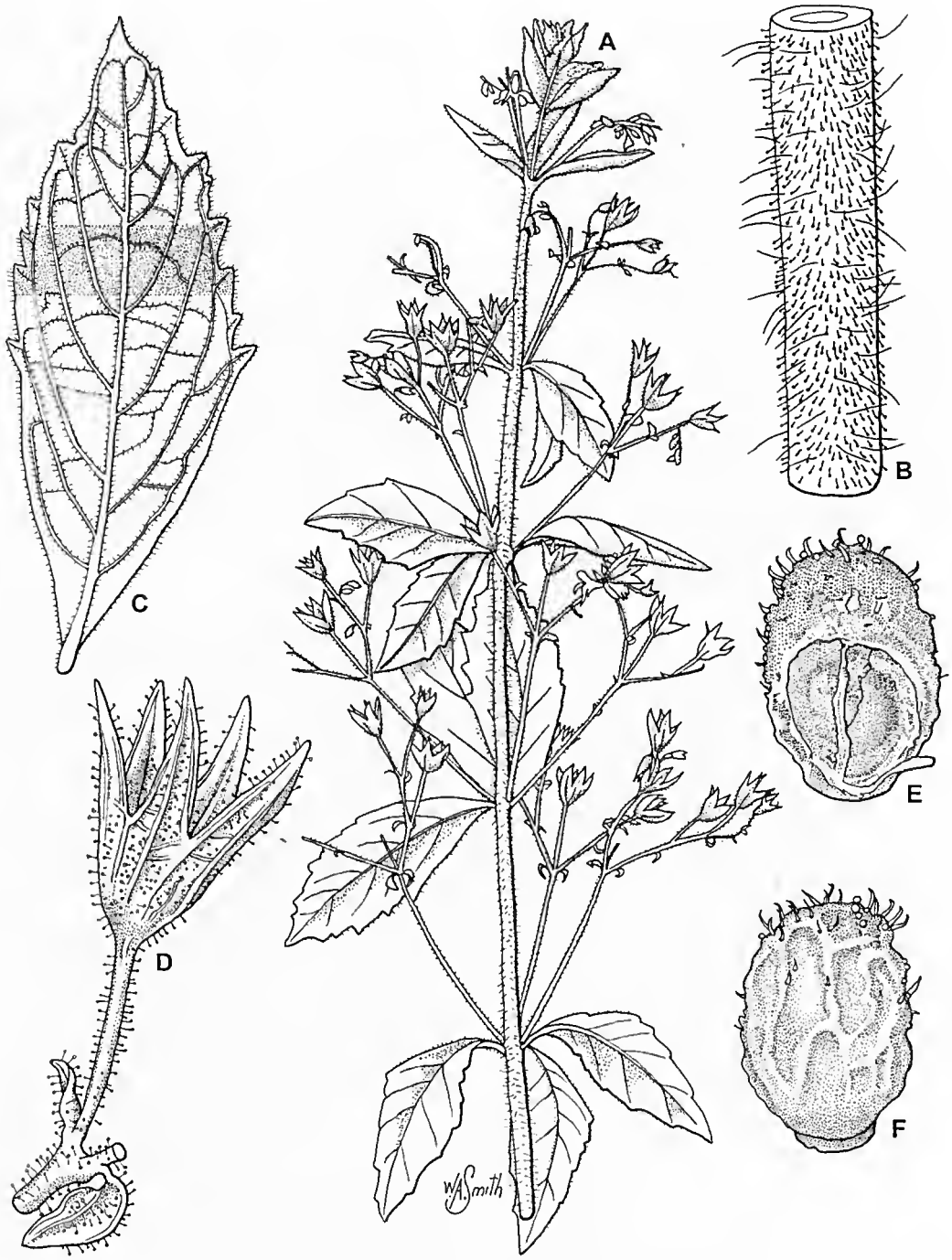

Figure 3. *Teucrium irroratum*. A. fruiting branchlet (× 1). B. small section of young stem showing cross-sectional shape (× 6). C. abaxial surface of leaf (× 2). D. fruiting calyx and pedicel (× 6). E. mericarp, ventral view (× 24). F. mericarp, dorsal view (× 24). All from *Forster PIF20299 and Watson* (BRI).

Distribution and habitat: Endemic to Queensland. The type was collected from Table Mountain, near the railway siding of Kabra, about 25 km SW of Rockhampton (Figure 6), where it grows in semi-evergreen vine thicket dominated by *Strychnos*, *Gyrocarpus*, *Archidendropsis* and *Planchonella cotinifolia* var. *pubescens* P.Royen, on a steep southerly slope with granite rocks. The 'Table Mountain' of Edward Bowman is 12–14 km to the south-east of this, near the present town of Boulder combe (A.R. Bean, unpublished data).

Phenology: Flowers and fruits are recorded for February, April and August.

Affinities: *Teucrium irroratum* is apparently related to *T. corymbosum* R.Br. The latter is a very widespread and highly variable species, in need of taxonomic revision. Such a task is beyond the scope of this paper. For this reason, comparisons have been made only with the Queensland populations of *T. corymbosum*. From these populations, *T. irroratum* differs in several respects. The branchlets are more or less terete (strongly quadrangular for *T. corymbosum*); the longest branchlet hairs 0.4–1.2 mm long (0.15–0.25 mm long for *T. corymbosum*); branchlets with a mixture of glandular and eglandular hairs (eglandular only for *T. corymbosum*); the broader leaves, 2.1–2.8 times longer than wide (leaves narrower, 4–6 times longer than wide for *T. corymbosum*); the fruiting calyx lobes 3.2–4.1 mm long (2.0–2.7 mm long for *T. corymbosum*); the interior surface of calyx lobes with scattered sessile glands and short glandular hairs (glabrous for *T. corymbosum*); and the mericarps with eglandular hairs and sessile glands (sessile glands only for *T. corymbosum*).

Conservation status: Currently known only from a single population, although a field search may yet rediscover populations documented by Bowman and O'Shanesy in the 1860s. A status of Endangered (EN B2ab(ii)(iii); C2a(ii)), based on the Red-list criteria (IUCN 2012), is recommended. The species is threatened by land clearing and weed incursion.

Etymology: The epithet is from the Latin *irroratus* meaning 'bedewed, with dew drops'. This is in reference to the abundant glands and glandular hairs on most parts of the plant, resembling droplets of dew.

Notes: The indumentum pattern of *T. irroratum* is similar to *T. thieleanum* B.J.Conn, a Victorian species (Conn 2006), but *T. irroratum* differs by the shorter petioles, longer peduncles, and mericarps with a smooth or faintly ridged surface.

Teucrium junceum (A.Cunn. ex Walp.) Kattari and Heubl., *Taxon* 65: 818 (2016)

Spartothamnus junceus A.Cunn. ex Walp., *Rep. Bot. Syst.* 6: 694 (1847); *Spartothamnella juncea* (A.Cunn. ex Walp.) Briq. in Engl. and Prantl., *Pflanz.* 4(3a): 161 (1895). ***Type:*** **QUEENSLAND**. MORETON DISTRICT: Brisbane River, x.1824, *A. Cunningham 78* (lecto: K 000881359), fide Munir (1976).

Illustration: Leiper et al. 2017 p. 374, as *Spartothamnella juncea*.

Distribution and habitat: A very widespread species in eastern Queensland as far north as the Mount Surprise district. It is also common in New South Wales as far south as the Sydney hinterland (Central Coast) and Condobolin (South Western Plains). It usually grows in Brigalow or vine thicket communities in clayey soil.

Teucrium micranthum B.J.Conn, *Telopea* 9(4): 803 (2002).

Type: **QUEENSLAND**. LEICHHARDT DISTRICT: Carnarvon National Park (Ka Ka Mundi Section), Tom's Tank, 3.4 km E of Park Boundary, 25.v.1999, *B.J. Conn 4146, E.A. Brown and N.A. Leist* (holo: NSW428108; iso: BRI AQ781651).

Distribution and habitat: A species of restricted distribution between Springsure and Charleville in central-southern Queensland. It commonly grows in communities dominated by Brigalow (*Acacia harpophylla*), but also in eucalypt woodland dominated by *Eucalyptus orgadophila*, *E. cambageana* Maiden or *E. populnea* F.Muell. Soil is invariably clayey.

Teucrium modestum A.R. Bean sp. nov.

Type: **QUEENSLAND**. LEICHHARDT DISTRICT: Melaleuca Creek Scrub, Rookwood, grid ref. 8851-823292, 20.iv.1991, *P.I. Forster PIF7964 and W.J. McDonald* (holo: BRI AQ504874 (2 sheets + spirit); iso: AD, BISH, BM, CANB, CNS, DNA, E, HO, K, L, MEL, MO, NE, NSW, P, PERTH, PRE, US, Z), to be distributed.

Teucrium sp. (Ormeau G.Leiper AQ 476858), in Bean and Forster (2016). ***Illustration:*** Leiper et al. 2017 p. 374, as *Teucrium* sp. Ormeau

Erect shrub 0.4–1.5 m high, well branched. *Branchlets* quadrangular; hairs moderately dense to dense, simple,

antrorse, eglandular, multicellular, ± transparent, longest hairs 0.6–1.1 mm long; glands absent. *Leaves* opposite; petioles 0.7–5.0 mm long, 9–30% of the lamina length, not winged; lamina discolorous, dark green above, ovate, the largest leaves 7–54 × 4–25 mm, 1.4–2.2 times longer than broad; margins crenate, with 3–6(–10) pairs of lobes; apex obtuse; base broadly cuneate to obtuse; venation penninerved, veins obscure on upper surface, obvious on lower surface. Upper surface ± bullate, with dense indumentum of tubercle-based, antrorse eglandular hairs, 0.3–0.9 mm long. Lower surface pale green, with raised veins, eglandular hairs sparse to moderately dense, 0.6–0.9 mm long, mainly along veins; sessile to subsessile glands abundant throughout. Inflorescences axillary, solitary or cymose, 1–7-flowered, dichasial; bracts subopposite, linear to oblanceolate, 0.6–2.2 mm long, somewhat persistent, apex acute. Pedicel 2.5–6.0 mm long; peduncle 0.5–5.0 mm long. *Calyx* campanulate, 10-veined, with 5 subequal deltate lobes; indumentum on exterior surface of dense patent eglandular hairs 0.4–0.6 mm long, and many sessile glands; interior surface glabrous; calyx tube 1.2–1.6 mm long at anthesis, 1.3–2.0 mm long in fruit; calyx lobes 1.6–2.0 mm long at anthesis, 2.2–4.0 mm long in fruit, 2–4 times longer than wide. *Corolla* 1-lipped, 5-lobed, white, outer surface with eglandular hairs and sessile glands, inner surface glabrous; terminal lobe broadly elliptic to orbicular, 3–5 mm long, strongly concave; lateral lobes elliptic, 1.8–2.8 mm long; basal lobes broadly ovate, 1.5–2.3 mm long; tube 2.5–3.5 mm long. *Stamens* attached midway along length of corolla tube, 6–9 mm long; filaments gently curved, with many glandular and eglandular hairs, mainly in the proximal half, but with some glandular hairs extending to distal half; anthers 4, cells medifixed, 0.8–1.1 mm long, with dense glands around attachment point of filament; style glabrous, curved, 8–9 mm long; stigma 2-fid, the lobes 0.5–1.0 mm long. *Mericarps* 4, dark brown, ellipsoid, 1.4–1.5 mm long, dorsal surface with obscure to prominent ridges, apical one-third with patent eglandular hairs 0.10–0.25 mm long and numerous sessile glands; ventral surface with large areole 0.7–0.9 mm long, covered with minute white glands or glabrous. (Figure 4)

Selected specimens examined: **QUEENSLAND.** NORTH KENNEDY DISTRICT: Moroides Gorge, W of Townsville, 1.v.1996, *R.J. Cumming 14638* (BRI); Bluewater Gorge, 5.v.2002, *R.J. Cumming 20604* (BRI, NSW); 14km NE of Ravenswood, 27.vi.1993, *E.J. Thompson CHA378 and Figg* (BRI); Leichhardt Range, grid ref: 8357-069826, 27.vii.1993, *R.J. Fensham 1037* (BRI). SOUTH KENNEDY DISTRICT: Mount Jukes N.P., NW of Mackay, 16.v.1991, *A.R. Bean 3189* (BRI). LEICHHARDT DISTRICT: Goodedulla N.P., Mongrel scrub, NW of Rockhampton, 21.iv.2013, *J. Wang JW0420* (BRI); NW corner of Heritage block, Yarra Station, NW of Gogango, 16.xii.1998, *W.J. McDonald 6608* (BRI). PORT CURTIS DISTRICT: Western base of Pine Mt slope, Shoalwater Bay, 9.v.2006, *W. Harris and S. Fox s.n.* (BRI, AQ736802); Lower slopes of Pine Mountain, near Sabina Point, Shoalwater Bay Training Area, 9.iv.2011, *A.R. Bean 30849 and D.A. Halford* (BRI, CANB). WIDE BAY DISTRICT: S.F. 50 Glenbar, 1.5km N of Mt Urah, 15.xi.1988, *P.I. Forster PIF4832A* (BRI); S.F. 50 Glenbar, 1km WSW of Mt Urah summit, 27.ii.1993, *P.I. Forster PIF13138 and P. Machin* (BRI, CNS, MEL); SF 50, Parish of Glenbar, W slope of Mt Urah, Jamieson lease, 13.ii.1996, *P. Grimshaw PG2292 and G.P. Turpin* (BRI, NSW); Imbil, vii.1921, *W.D. Francis s.n.* (BRI, AQ161400). MORETON DISTRICT: Upper Ormeau, on a spur of the Darlington Range, 26.v.1989, *G. Leiper s.n.* (BRI, AQ476858); Mt Alford, Boonah District, i.1921, *W.D. Francis s.n.* (BRI, AQ161399).

Distribution and habitat: Endemic to Queensland. It extends from Townsville in the north to Boonah in the south, and all known populations are within 110 km of the coast (Figure 6). It grows on steep and rocky hillsides in rainforest, usually Araucarian notophyll or microphyll vine forest dominated by *Araucaria cunninghamii* Mudie, but sometimes in vine thicket.

Phenology: Flowers are recorded from December to July; fruits are recorded from November to June.

Affinities: *Teucrium modestum* is similar to Queensland populations of *T. corymbosum*, but differs by the peduncles only 0.5–5.0 mm long (5–25 mm long for *T. corymbosum*); the leaves 1.4–2.2 times longer than wide (4–6 times for *T. corymbosum*); inflorescence 1–7-flowered (5–20 flowered for *T. corymbosum*); hairs on the calyx patent, 0.4-0.6 mm long (0.05-0.20 mm long for *T. corymbosum*), and the mericarps with eglandular hairs and sessile glands (sessile glands only for *T. corymbosum*).

Conservation status: The Extent of Occurrence is about 192000 km^2, the Area of Occupancy is estimated at 5 km^2 and 15 subpopulations are known. The main threat is weed incursion. It does not currently qualify for Vulnerable status (IUCN 2012), but it is considered that those criteria may be met in the near future, hence a status of Near Threatened is considered appropriate.

Etymology: The epithet is from the Latin *modestus*

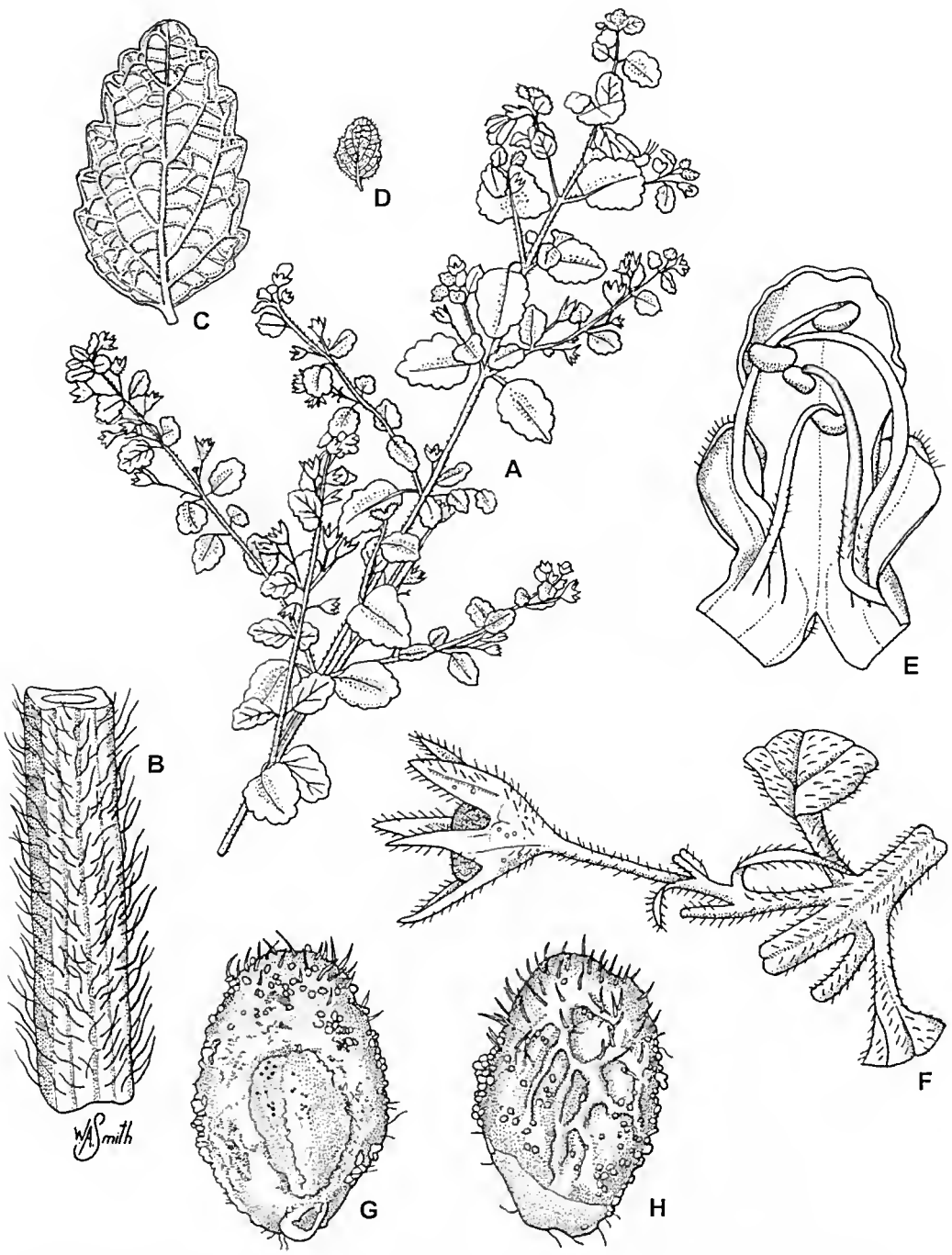

Figure 4. *Teucrium modestum*. A. flowering branchlet (× 1). B. small section of young stem showing cross-sectional shape (× 8). C. abaxial surface of leaf (large-leaved form) (× 1). D. abaxial surface of leaf (small-leaved form) (× 1). E. opened-out corolla with attached stamens (× 8). F. fruiting calyx and pedicel (× 6). G. mericarp, ventral view (× 24). H. mericarp, dorsal view (× 24). A from *Horris and Fox s.n.* (BRI, AQ736802); B,D from *Wong JW0420* (BRI); C, F-H from *Cumming 20604* (BRI); E from *Forster 7964 ond McDonold* (BRI).

meaning 'mild' or 'modest'. This is in reference to the inconspicuous nature of the plant and its relatively small flower clusters.

Note: *Teucrium modestum* exhibits extraordinary variation in leaf size. The leaves on any given specimen are more or less uniform, but some specimens have far larger leaves than others. The largest leaves are possessed by populations in the northern part of its range, but small-leaved populations also occur there. The variation in leaf size does not appear to correlate with any other morphological character.

Teucrium puberulum (F.Muell.) Kattari and Bräuchler, *Taxon* 65: 818 (2016)

Spartothamnus junceus var. *puberulus* F.Muell., *S. Sci. Rec.* 2: 55 (1882); *Spartothamnus puberulus* (F.Muell.) F.Muell., *Second Systematic Census Aust. Pl.* 171 (1889); *Spartothamnella puberula* (F.Muell.) Maiden and Betche, *Census N.S.W. Pl.* 177 (1916). ***Type:*** **QUEENSLAND.** Near the Suttor River, 1856, *F. Mueller* s.n. (lecto: MEL 68872; isolecto: K 000881361), fide *Munir* (1976).

Illustration: Cunningham et al. 2011 p. 571, as Spartothamnella puberula.

Distribution and habitat: This species is distributed in a continuous zone from central New South Wales to Charters Towers in Queensland, and there is a disjunct area of distribution in the southern Northern Territory. It grows in sandy or loamy soils on hills or plains, in association with a wide range of Eucalyptus spp. and Acacia spp.

Teucrium racemosum R.Br., *Prodr.* 504 (1810)

Type: **SOUTH AUSTRALIA.** Spencer's Gulf, 10.iii.1802, *R. Brown* s.n. (Bennett Number 2388) (lecto: BM001040990, here chosen; isolecto: BM001040991, CANB278997, K000881587).

Illustrations: Alexander 2005 p. 298; Cunningham et al. 2011 p. 577.

Distribution and habitat: Widespread in south-west Queensland, as far north as Boulia and east to Roma (with one record further east at Tara). Widely distributed in all other mainland states. It grows on a wide range of soils from brown clays to red sandy loams, on plains or along watercourses. Associated species include *Eucalyptus coolabah, Acacia cambagei* R.T.Baker, *A. stenophylla* A.Cunn. ex Benth. and *Chenopodium auricomum* Lindl.

Typification: The specimen chosen as the lectotype bears a label in Robert Brown's handwriting. It is a good quality flowering specimen, and it is in accord with the description in the protologue.

Teucrium sagittatum A.R. Bean sp. nov.

Type: **QUEENSLAND.** DARLING DOWNS DISTRICT: 'Riverside', near Chinchilla, 30.xii.1979, *V. Hando 127* (holo: BRI AQ319746).

With affinity to *T. daucoides*, but differing by the slender sagittate leaves, the shorter bracts, the shorter calyx tube, the branchlets glabrous or with retrorse eglandular hairs only, and the shorter stamens.

Teucrium sp. 1 in Stanley and Ross (1986: 385).

Erect shrub 0.1–0.3 m high, sparsely branched. *Branchlets* quadrangular; glabrous or with sparse, simple, antrorse, eglandular, ± transparent, up to 0.1 mm long; glands sparse. *Leaves* opposite; petioles 1–7 mm long, 7–24% of the lamina length, winged; lamina discolorous, dark green above, linear to sagittate, the largest 12–33 × 1–6 mm, 5–12 times longer than broad; with a single pair of basal lobes, rarely entire or with 2–5 pairs of shallow lobes; apex acute; base broadly cuneate; venation obscure. Upper surface not bullate, glabrous or with sparse indumentum of patent glandular hairs 0.1–0.3 mm long. Lower surface pale green, with raised midvein; eglandular hairs sparse to moderately dense, restricted to midvein (lamina otherwise glabrous), 0.05–0.20 mm long; sessile glands abundant throughout. Inflorescences terminal, spicate or racemose, spikes 3–10 cm long; bracts opposite, elliptic, 1.3–3.5 mm long, persistent, apex acute. Pedicel 0.9–1.4 mm long. *Calyx* campanulate, 5-veined or veins obscure, with 5 subequal deltate lobes; indumentum on exterior surface of dense patent glandular hairs 0.10–0.25 mm long, eglandular hairs absent, sessile glands absent; interior surface with moderately dense glandular hairs; calyx tube 1.7–2.2 mm long at anthesis, 1.7–2.2 mm long in fruit; calyx lobes 0.9–1.3 mm long at anthesis, 1.1–1.4 mm long in fruit, 0.8–1.5 times longer than wide. *Corolla* 1-lipped, 5-lobed, mauve; outer surface with eglandular hairs and glandular hairs; inner surface with scattered eglandular hairs and abundant vesicular hairs, mainly towards terminal portion of corolla; terminal lobe broadly elliptic, 2.0–2.4 mm long, slightly concave; lateral lobes elliptic,

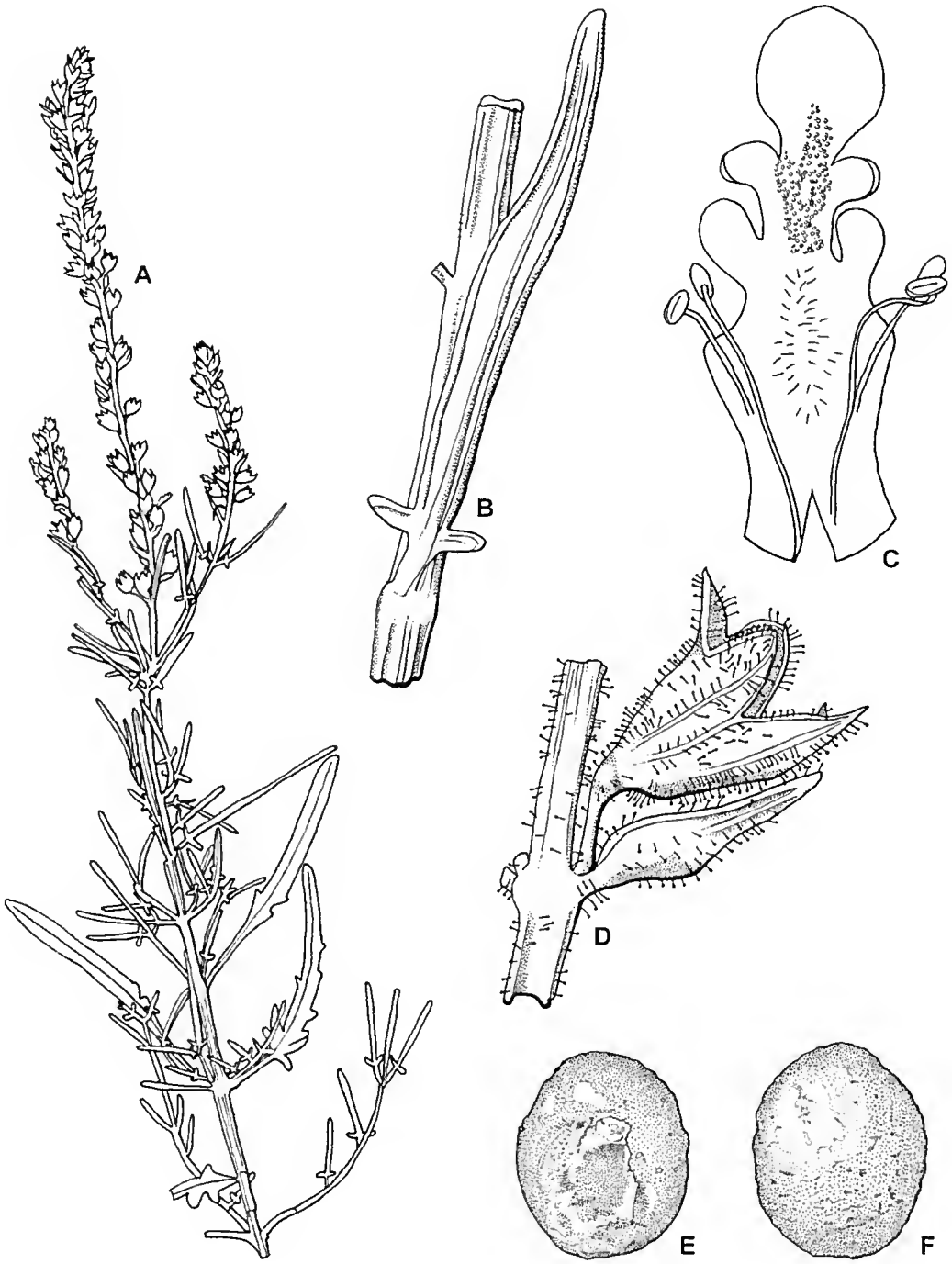

Figure 5. *Teucrium sagittatum*. A. flowering branchlet (× 1). B. small section of young stem and a leaf, showing abaxial surface (× 6). C. opened-out corolla with attached stamens (× 10). D. fruiting calyx and pedicel (× 10). E. mericarp, ventral view (× 24). F. mericarp, dorsal view (× 24). A, C-F from *collector unknown* (BRI, AQ161304); B from *Hando 127* (BRI).

0.7–0.8 mm long; basal lobes elliptic, 0.6–0.9 mm long; tube 2.7–3.2 mm long. *Stamens* attached c. 1 mm above base of corolla tube, 3.5–4.3 mm long; filaments gently curved, with some glandular and eglandular hairs on the proximal half; anthers 4, cells medifixed, 0.5–0.6 mm long, with sparse glands around attachment point of filament; style glabrous, straight or slightly curved, c. 3.5 mm long; stigma 2-fid, the lobes 0.3–0.4 mm long. *Mericarps* 4, brown, ellipsoid, c. 1.3 mm long, surface smooth, glabrous, apical one-third with scattered sessile glands; ventral surface with large areole 0.7–0.8 mm long, glabrous. (Figure 5)

Specimens examined: **QUEENSLAND.** DARLING DOWNS: Rywung, near Chinchilla, 24.iv.1953, *coll. unknown* (BRI, AQ 161304); 'Riverside', property of Mrs V. Hando, Chinchilla, 20.xi.1979, *V. Hando 119* (BRI). MORETON DISTRICT: Gatton Agricultural College, undated, *W.W. Bryan s.n.* (BRI, AQ161305).

Distribution and habitat: Recorded from three locations in southern Queensland, two close to Chinchilla and the other near Gatton (Figure 6). The habitat is unknown; the 1953 collection was growing as a "weed" in a grain-sorghum crop.

Phenology: Flowers and fruits have been collected in April, November and December.

Affinities: *Teucrium sagittatum* is similar to *T. daucoides*, but differing by the linear leaves with short basal lobes and upper surface often glabrous (pinnatifid to bipinnatifid leaves with persisting glandular and eglandular hairs for *T. daucoides*); the leaves 5–12 times longer than wide (1.1–1.6 times for *T. daucoides*); the bracts 1.3–3.5 mm long (6–14 mm long for *T. daucoides*); the outer surface of the calyx with glandular hairs only (glandular and eglandular hairs present for *T. daucoides*); the calyx tube 1.7–2.2 mm long at anthesis (3.0–4.6 mm long for *T. daucoides*); and the stamens 3.5–4.3 mm long (8–9 mm long for *T. daucoides*).

Conservation status: Searches by the author in the Chinchilla area for this species have been unsuccessful.

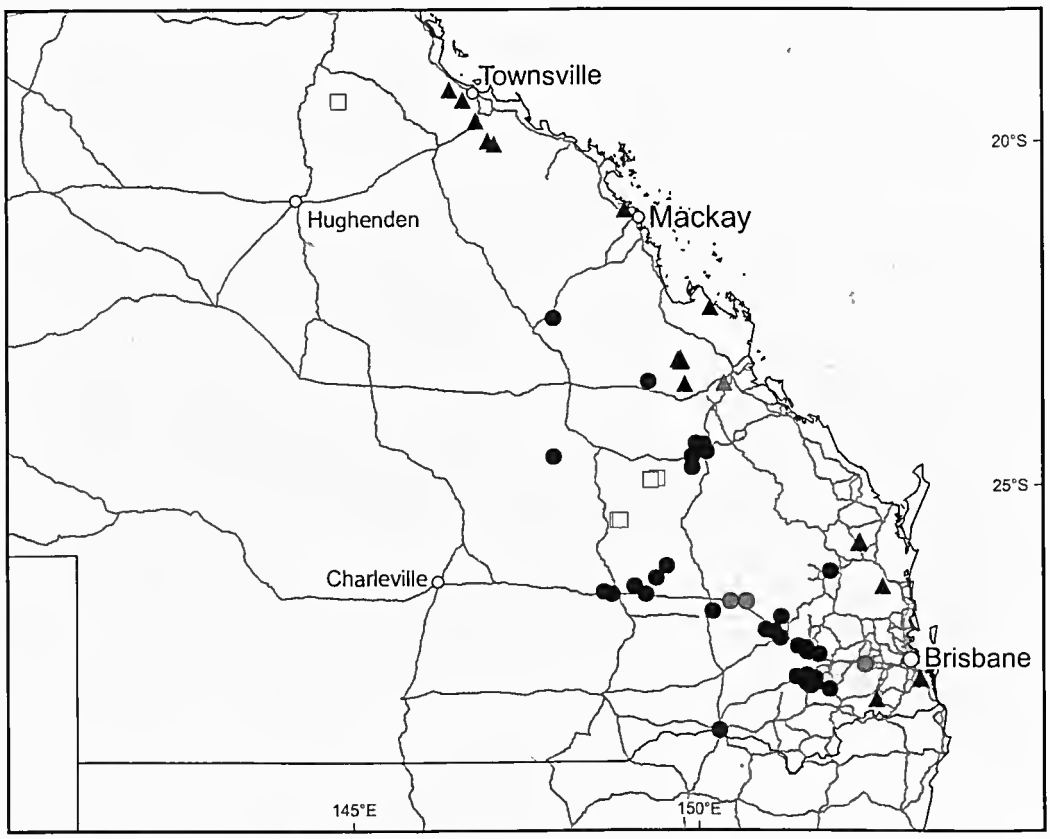

Figure 6. Distribution of *Teucrium* spp. *T. daucoides* (black circles), *T. fallax* (white squares), *T. irroratum* (grey triangle), *T. modestum* (black triangles), *T. sagittatum* (grey circles).

It perhaps would appear only after heavy rain or wildfire, although this remains to be confirmed. A status of Critically Endangered (CR B2b(i)(ii)(iii)(iv)c(iv)) is recommended based on the Red-list criteria (IUCN 2012). The species is threatened by land clearing, cropping, bovine grazing and weed incursion.

Etymology: The epithet refers to the sagittate or arrow-shaped leaves possessed by this species.

Note: Hando (1988) stated that the corolla is mauve in colour.

Teucrium teucriiflorum (F.Muell.) Kattari and Salmaki, *Taxon* 65: 818 (2016)

Spartothamnus teucriiflorus F.Muell., *S. Sci. Rec.* 2: 55 (1882); *Spartothamnella teucriiflora* (F.Muell.) Moldenke, *Phytologia* 1: 430 (1940). ***Type:*** **NORTHERN TERRITORY.** Near the Finke River, 1882, *H. Kempe 438* (lecto: MEL 68887), fide Munir (1976).

Distribution and habitat: Found in the south-west quarter of Queensland. It also occurs in Western Australia, Northern Territory and South Australia. It inhabits arid or semi-arid woodlands and shrublands.

Acknowledgements

I am grateful to Will Smith (BRI), who produced the illustrations and edited the distribution map, and the Director of the National Herbarium of Victoria for allowing me to examine specimens held there.

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Muelleria

37: 19–22

Published online in advance of the print edition, 28 June

ROYAL BOTANIC GARDENS VICTORIA

A new combination for an Australian fern: *Hymenasplenium wildii* (Aspleniaceae)

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Introduction

The Aspleniaceae is a species-rich family of ferns distributed on all continents except Antarctica, and includes more than 700 species (Kramer & Viane 1990; Smith et al. 2006), with 38 species currently recognised in Australian territory (DuPuy 1993; Green 1994; Jones 1996; Brownsey 1998; Short et al. 2003; Short et al. 2011). The combination of linear sori and clathrate scales that are possessed by all Aspleniaceae is usually sufficient to distinguish Aspleniaceae from other fern families (Kramer & Viane 1990). Apart from this unifying set of features, the Aspleniaceae are highly variable in morphology. Some authors have treated the Aspleniaceae as comprising a sole large and variable genus, *Asplenium* L. (e.g. Kramer & Viane 1990). However, the diverse morphology in the Aspleniaceae has prompted others to also acknowledge several small segregate genera. One of these segregates is *Hymenasplenium* Hayata, originally separated from *Asplenium* based on its differing rhizome anatomy (Hayata 1927) and later found to have distinct chromosome numbers in the family (e.g. Mitui et al. 1989; Cheng & Murakami 1998) and to comprise a molecular clade sister to the remaining Aspleniaceae (Murakami et al. 1999; Schneider et al. 2004). Of all the segregate genera, it is the only genus now generally accepted (Murakami 1995; Murakami et al. 1998; Murakami et al. 1999; Sasaki 2008; Brownsey & Perrie 2011;

Abstract

Hymenasplenium L. has not previously been recognised in Australia. Here we recognise *Asplenium unilaterale* Lam. and *A. excisum* C.Presl, which occur in Australia and other paleotropical areas, in *Hymenasplenium* (their combinations in *Hymenasplenium* have been made previously). Molecular phylogenetic analyses have confirmed that a third Australian species, *Asplenium wildii* F.M.Bailey, endemic to the Daintree area of northeast Queensland, also belongs to *Hymenasplenium*. The new combination *Hymenasplenium wildii* (F.M.Bailey) D.J.Ohlsen is made here.

Keywords: *Asplenium*, Systematics, Taxonomy

ISSN: 0077-1813 (print) • ISSN: 2204-2032 (online)

Gabancho & Prada 2011; PPG 1 2016). It includes at least 30 species (PPG 1 2016), but has not previously been recognised in Australia (Brownsey 1998; APC 2018). *Hymenasplenium* can be identified in the field by its thin creeping rhizome, pinnate fronds, thin membranous pinnae and its preference for constantly wet and humid sites such as waterway embankments.

In Australia two species referable to *Hymenasplenium* were previously known: the generic type *H. unilaterale* (Lam.) Hayata and *H. excisum* (C.Presl) S.Linds. However, in previous Australian treatments subsequent to the recognition of *Hymenasplenium* these two species have been placed in *Asplenium* (Brownsey 1998; APC 2018). Both species are widespread outside of Australia but are rare in Australia, particularly *H. unilaterale* which is known from a single locality. In Australia both species are only known to occur in the wet tropics of northeast Queensland on the Atherton Tableland. A third species, *A. wildii* F.M.Bailey (Figure 1), is morphologically similar to these species except that it is much smaller in overall size. The possibility that it represents a diminutive form of *H. unilaterale* has been mentioned (Brownsey 1998) but its affinity to *Hymenasplenium* has never been formally proposed through a combination in *Hymenasplenium*.

Figure 1 *Hymenasplenium wildii* on the embankment of an unnamed creek, Cape Tribulation section of Daintree National Park, north-east Queensland.

A chloroplast DNA phylogeny of Australian Aspleniaceae included *A. wildii* and both of the other Australian *Hymenasplenium* (Ohlsen et al. 2014). That phylogeny demonstrated the distinctiveness of *A. wildii* from *H. unilaterale* because *A. wildii* was resolved as sister to a clade of *H. unilaterale* and *H. excisum* (both represented by multiple accessions and forming monophyletic groups), rather than nesting in *H. unilaterale*. The phylogeny also clearly showed that *A. wildii* is placed with strong support (Bayesian posterior probability of 1; maximum likelihood bootstrap support of 100%) in the *Hymenasplenium* clade and, thus, should be classified in that genus. A new combination for *A. wildii* in *Hymenasplenium* is made here accordingly.

Taxonomy

The following species of *Hymenasplenium* are recognized as occurring in Australia:

Hymenasplenium unilaterale (Lam.) Hayata, *Bot. Mag.* (Tokyo) 41: 712 (1927)

Asplenium unilaterale Lam., *Encycl.* 2: 305 (1786).

Type: **MAURITIUS**, *P. Commerson*: n.v.

Hymenasplenium excisum (C.Presl) S.Linds., *Thai Forest Bull. Bot.* 37: 69 (2009)

Asplenium excisum C.Presl, *Epimel. Bot.* 74 ('1849') [1851].

Type: **PHILIPPINES**, Luzon, *H. Cuming 110*; syntypes: BM, K, PRC.

Hymenasplenium wildii (F.M.Bailey) D.J.Ohlsen comb. nov.

Basionym: *Asplenium wildii* F.M.Bailey, *Bot. Bull. Dept. Agric. Queensland* 4: 20, tt. 1–2 (1891).

Type: Queensland: on rocks, Daintree River, 1891, *C.J. Wild* (lectotype: BRI AQ0144732 image!; isolectotypes: BM 001045316 image!, P 00642905 image!).

This species has been thoroughly described and illustrated by Andrews (1990) and Brownsey (1998) and a further illustration is provided by Bailey (1892).

Distribution: Cape Tribulation and Daintree areas, north-east Queensland.

Three holdings (at BRI, BM and P) exist for the type but Bailey did not designate a holding that would serve as the holotype and technically the three holdings were originally syntypes. Brownsey (1998) listed the BRI specimen as the holotype, and as such inadvertently lectotypified the BRI specimen, rendering the BM and P specimens as isolectotypes (see Prado et al. 2015). The BRI specimen is from Bailey's home institution and includes one of the fronds illustrated in the protologue (in contrast to the BM and P sheets that were not illustrated).

Acknowledgements

We thank the two anonymous reviewers for their helpful feedback.

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Muelleria

37: 23–32

Published online in advance of the print edition, 28 June

ROYAL BOTANIC GARDENS VICTORIA

Examining the *Acacia boormanii* complex (Fabaceae: Mimosoideae); recognition of a new subspecies

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Introduction

The iconic genus *Acacia* Mill. (Leguminosae: Mimosoideae) is the largest angiosperm genus in Australia, consisting of over 1000 species (Miller et al. 2011, Maslin 2015). *Acacia boormanii* Maiden (syn. *A. hunteriana* N.A.Wakef.) was described as a species of scattered and restricted occurrence in south-eastern Australia (Maiden 1916). As currently understood, its natural range extends from south of Thredbo Village, New South Wales (NSW), to near Buchan, Victoria, mostly south of the Great Dividing Range, with isolated occurrences near Cooma, NSW, and Myrtleford, Victoria (Maslin 2001). It is common in cultivation and has become naturalised in a few areas outside its natural range (e.g. http://avh.ala.org.au/occurrences/search?taxa=acacia+boormanii#tab_mapView). While not considered at risk, it is regarded as 'rare' in Victoria (DEPI 2014). It is a bushy, slender shrub or (rarely) tree to 4.5 m high, readily coppicing (WorldWideWattle ver. 2. Published on the Internet at: www.worldwidewattle.com [1 Jan 2018]). It is phyllodinous, with a single main nerve in each phyllode, and has globular capitula in racemose inflorescences. These characters place the species in section Phyllodineae (Maslin 2001); however, more recent phylogenetic research has found section Phyllodineae to be polyphyletic, and from its possession of a range of features, *A. boormanii* is most likely a member of a diverse assemblage of taxa informally called the 'p.u.b. clade', and within that, the

Abstract

A morphometric analysis of specimens determined as *Acacia boormanii* Maiden and *A. infecunda* Molyneux & Forrester supported a distinctive population centred on Mt Typo in north-eastern Victoria, which is described here as *A. boormanii* subsp. *gibba* K.J.Tucker *subsp. nov.* The characters that best separate the new subspecies are the phyllode width, the indentation of the phyllode margins at the gland, and the shape of the phyllode apex. Neither *Acacia infecunda* nor an unusual population of *A. boormanii* from Gapsted in north-east Victoria could be confidently distinguished from *A. boormanii*. *Acacia boormanii* (in the broader sense) is considered rare in Victoria, but is not considered threatened.

Keywords: *Acacia infecunda*, Mt Typo variant, Gapsted variant, morphology, morphometric analysis

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

Botrycephalae subclade in the classification of Murphy et al. (2010).

Herbarium specimens in the National Herbarium of Victoria (MEL) identified as *A. boormanii* from on and near Mt Typo (herein referred to as *A.* 'Typo') and Gapsted (herein *A.* 'Gapsted') in north-eastern Victoria, had previously been noted to differ from typical *A. boormanii* (Maslin 2001). Phyllodes of *A.* 'Typo' are broader than typical *A. boormanii* while unpublished chemical data suggests *A.* 'Gapsted' differs from typical *A. boormanii* and potentially from *A.* 'Typo' (Maslin 2001). A morphometric analysis was undertaken to investigate the morphological variation within the *A. boormanii* complex, including specimens of *A.* 'Typo' and *A.* 'Gapsted'.

Acacia infecunda Molyneux & Forrester was segregated from *A. boormanii* based on its smaller phyllodes and capitula, its apparent sterility, and its root-suckering habit (Molyneux and Forrester 2008). *Acacia infecunda* is known from a single population near Wulgulmerang in eastern Victoria, isolated from populations of *A. boormanii* but within the same biogeographic region of that species. Because of the presumed close relationship between *A. infecunda* and *A. boormanii* (Molyneux and Forrester 2008) it was included in the morphometric analysis.

Specimens examined in this study were sampled from across the geographical range of *A. boormanii*, including the Mt Typo and Gapsted variants (Figure 1). The aims of this study were to determine:

1. if either or both of the *A. boormanii* variants at Mt Typo and Gapsted are sufficiently distinct from *A. boormanii* to be recognised as new taxa;
2. if *A. infecunda* is sufficiently distinct to be maintained at species rank.

Methods

Sampling regime

Specimens from across the geographic range of *Acacia boormanii* and *A. infecunda*, housed in the National Herbarium of Victoria (MEL), were examined in this study. Forty-seven pre-existing *A. boormanii* specimens, of which 32 were flowering (including a probable isotype: MEL 270793), were examined in the morphometric analysis. Both of the *A. infecunda* specimens at MEL were also analysed. Herbarium material was supplemented in the analysis with fresh collections representing the range of variation within populations of typical *A. boormanii*, as well as the *A.* 'Typo' and *A.* 'Gapsted' variants, bringing the total number of specimens assessed to 55. The supplementary specimens have been lodged at MEL.

Figure 1. Map showing locations of the specimens used in the current study; ● *Acacia boormanii* (including variants from Mt Typo and Gapsted areas), ○ *A. boormanii* type, ◊ *A. infecunda*.

Morphometric characters

Floral and vegetative characters were measured including those that have been employed to distinguish *A. boormanii* from similar species in keys and *Flora* accounts and those that have been suggested to distinguish *A. infecunda* and the Typo and Gapsted variants (Maslin 2001, Molyneux & Forrester 2008) (Table 1). For each specimen three phyllodes, inflorescences and capitula were scored and the means used for the analysis. To ensure that floral characters such as raceme length, capitulum diameter and peduncle length were comparable, inflorescence characters were not measured if the specimen was not at full anthesis. To enable comparison of vegetative structures at similar stages of development, phyllode characteristics were scored two or three nodes below the terminal inflorescence or three nodes below the distal mature phyllode on non-flowering specimens. Seed and pod characters were also measured, but there were too few fruiting specimens of *A.* 'Typo' or *A.* 'Gapsted' for statistical significance and there were no obvious differences in these features to suggest that they might be discriminatory. *Acacia infecunda* is not known to produce fruit (Molyneux and Forrester 2008).

Phenetic analyses

Morphological data were analysed phenetically using the computer package PATN (Belbin 2004). Floral and phyllode characters were analysed separately to eliminate distortion of the analysis through missing floral characters. The full dataset was range-standardised prior to applying the Gower metric to create an association matrix. An ordination was generated in three dimensions for each of the floral and phyllode characters, with 20 random starts and 100 iterations, using seml-strong hybrid multidimensional scaling. Dendrograms (one for each of the floral and vegetative datasets) were generated using the flexible unweighted pair-group method of arithmetic averages (UPGMA) classification strategy. Principal coordinate correlation (PCC) was used to evaluate the characters that strongly contributed to the observed ordination patterns.

Table 1. Characters measured for phenetic analysis and their variable types; Quantitative (Qn.), Qualitative (Ql.). Units are given in brackets where appropriate and the abbreviations used in the ordinations provided.

Character	Variable type	Abbreviation
Phyllode characters		
Phyllode apex shape (rounded or acute), ignoring mucro	Ql.	A
Density of phyllodes (phyllodes per cm)	Qn.	D
Distance from end of pulvinus to gland (mm)	Qn.	G
Hairs at base of phyllode (presence/absence)	Ql.	H
Indentation of phyllode margin where gland is positioned (presence/absence)	Ql.	I
Phyllode length (end of pulvinus to end of mucro) (mm)	Qn.	Ph.L
Phyllode width at widest section (mm)	Qn.	Ph.W
Pulvinus diameter (mm)	Qn.	Pu.D
Pulvinus length (mm)	Qn.	Pu.L
Wax on stem close to young developed phyllodes (presence/absence)	Ql.	W
Floral characters		
Phyllode angle immediately subtending inflorescence (<45°, 45–90°, 90–135°, >135°)	Ql.	A
Number of capitula per raceme	Qn.	C
Capitula diameter at anthesis (mm)	Qn.	CD
Number of flowers in each capitula (measured in mature buds)	Qn.	FN
Peduncle length (mm)	Qn.	P
Length of raceme rachis, excluding ultimate peduncle (mm)	Qn.	R

Results

The dendrogram based on phyllode characters, truncated at the two-group level (Figure 2) showed a cluster of *Acacia* 'Typo' specimens (Group 2) separating from the *A. boormanii*, *A.* 'Gapsted' and *A. infecunda* specimens (Group 1). There were also two *A.* 'Typo' specimens within Group 1. The grouping of the dendrogram based on phyllode characters was closely reflected in the ordination (Figure 3), with a stress value of 0.130. This moderate stress value indicates that the ordination is a reasonable representation of the similarity in the dataset (Clarke 1993). The PCC shows phyllode width, indentation of the phyllode margin, pulvinus diameter and shape of phyllode apices to account for the variation that separates *A.* 'Typo' from other specimens (Figure 3).

The dendrogram based on floral characters, also truncated at the two-group level, did not reveal *A.* 'Typo' specimens as a group separate from other specimens. The first group contained *A.* 'Typo' intermixed with *A. boormanii*, *A.* 'Gapsted', and *A. infecunda*, while the other group contained only *A. boormanii* specimens (figure not shown). The ordination based on floral characters had a stress value of 0.121, and did not show a strong pattern of separation between *A.* 'Typo' and other specimens (Figure 4). The relatively low stress value here also indicates that the ordination is a good representation of the data.

Discussion

The separation of specimens of *Acacia* 'Typo' from the typical form of *A. boormanii* in both ordinations and agglomerative hierarchical clustering of vegetative morphometric data indicated that *A.* 'Typo' is distinguishable from *A. boormanii*, based on a number of traits. On this basis, and previous assertions (e.g. Maslin 2001), we consider that *A.* 'Typo' is worthy of formal taxonomic recognition. Similar to Othman et al. (2013), who studied the *Correa lawrenceana* complex, we observed incomplete separation of *A.* 'Typo', from *A. boormanii* in the ordination analyses, and consequently we assign *A.* 'Typo' the rank of subspecies (see below). The delineation between species and subspecies can be unclear due to inconsistency in the application of the concepts and lack of objective criteria

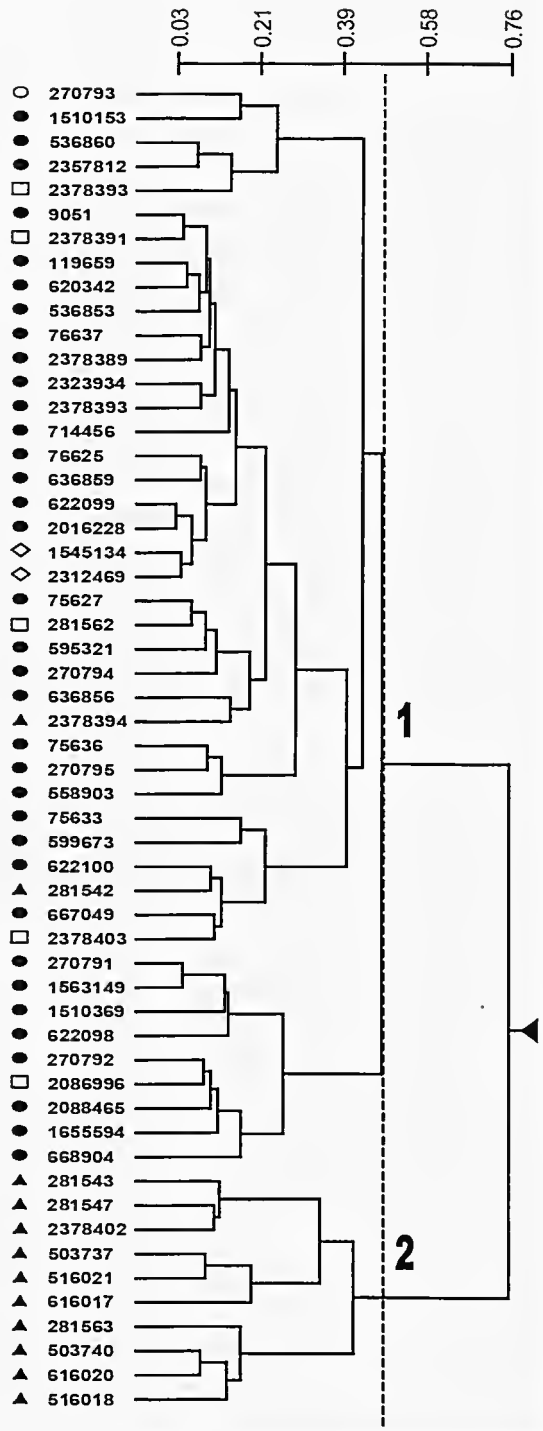
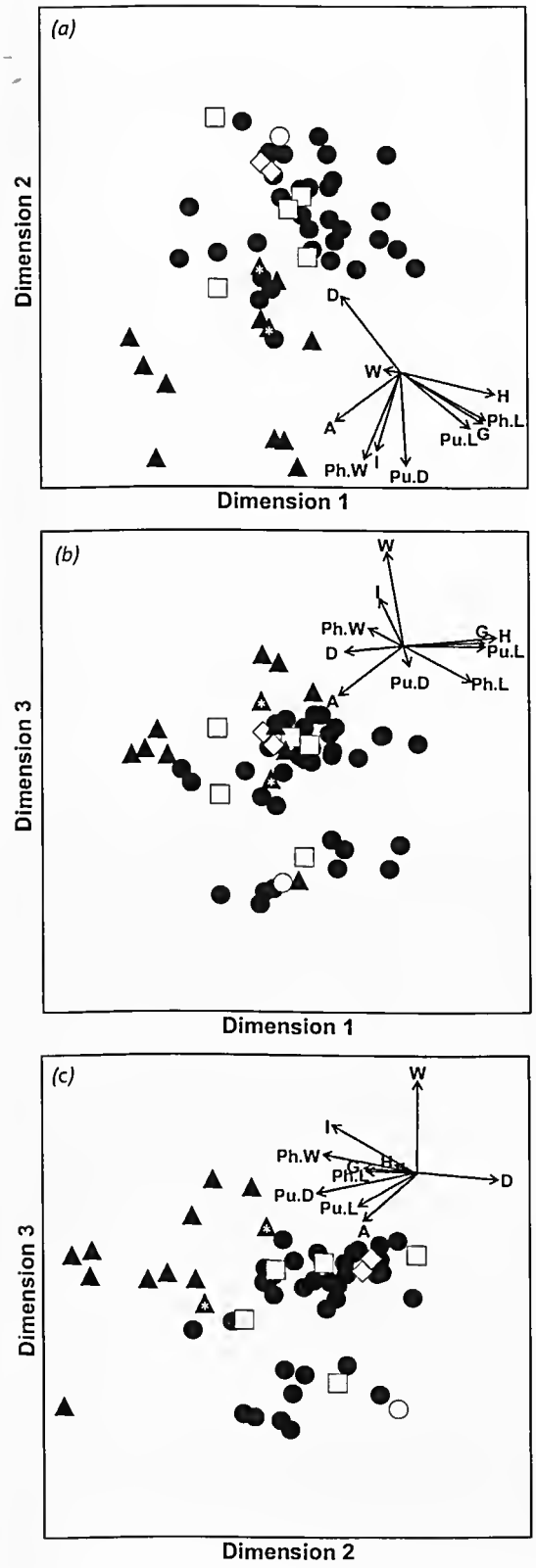


Figure 2. An agglomerative, hierarchical classification (Gower metric) of 55 specimens scored for ten phyllode characters. ● *A. boormanii*; ○ *A. boormanii* isotype; □ *A.* 'Gapsted'; ▲ *A.* 'Typo'; ⊠ *A. infecunda*. Group 1 is indicated by '1' and Group 2 is indicated by '2'. Each MEL specimen is labelled with its voucher number.



LEFT: Figure 3. Three-dimensional ordination of 55 individuals based on phyllode characters for dimensions 1, 2 and 3, stress = 0, 130: **3a.** Dimensions 1 vs 2; **3b.** 1 vs 3; **3c.** 2 vs 3. ● *A. boormanii*; ○ *A. boormanii* isotype; □ *A.* 'Gapsted'; ▲ *A.* 'Typo'; ⊠ *A. infecunda*. The two outlying specimens of *A.* 'Typo' (MEL2378394 and MEL281542) from Figure 1 are asterisked. The vector loadings based on principal co-ordinate correlation of phyllode characters for axes are shown. Abbreviation of character names are as follows; pulvinus length (Pu.L), pulvinus diameter (Pu.D), phyllode length (Ph.L), phyllode width (Ph.W), position of the gland (G), presence/absence of hairs (H), presence absence of wax (W), phyllode apices shape (A), indentation of phyllode margin (I), and phyllode density (D).

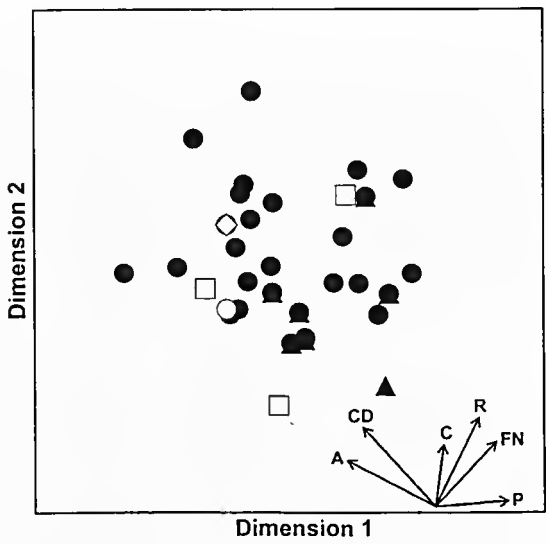


Figure 4. Three-dimensional ordination of 32 individuals based on floral characters axes 1 *v.* 2. ● *A. boormanii*; ○ *A. boormanii* isotype; □ *A.* 'Gapsted'; ▲ *A.* 'Typo'; ⊠ *A. infecunda*. Principal coordinate correlation of floral characters. Abbreviation of floral characters are as follows; phyllode angle subtending inflorescences (A), rachis length of raceme (R), number of capitula per inflorescence (C), peduncle length (P), capitulum diameter (CD), and number of flowers per capitulum (FN).

for classification (Braby et al. 2012), however, the rank of subspecies is often applied to taxa that are clearly closely related, differentiated by at least one morphological trait, but are largely or entirely allopatric (e.g. Stuessy et al. 2014, Braby et al. 2012), whereas ranks of variety or form are used for taxa of closer morphological similarity (e.g. differing by a single trait) or sympatric occurrence respectively. Accordingly, *A* 'Typo' is described here as a new subspecies differing from typical *A. boormanii* principally in its broader phyllodes, more pronounced indentation of the phyllode margin at the gland, and a rounded phyllode apex (ignoring the mucro). Two *A.* 'Typo' specimens grouped with typical *A. boormanii* in the dendrogram (Figure 2). Closer scrutiny of these two specimens revealed that they had less rounded phyllode apices and less pronouncedly indented marginal glands than were typical for *A.* 'Typo' and were scored accordingly, leading to their grouping with *A. boormanii* . They were otherwise similar to other *A.* 'Typo' specimens in phyllode characters. In ordination space (Figure 3), the same two specimens (indicated with asterisks in Figure 3) appear to overlap those of typical *A. boormanii* in two of the orientations (axes 1 vs 2, 1 vs 3; Figs 3a and 3b respectively), but rotation of this array more clearly groups these with the remainder of the *A.* 'Typo' specimens (Figure 3c).

Based on the dendrogram of phyllode characters, *A.* 'Gapsted' specimens grouped more closely with specimens of typical *A. boormanii* than with *A.* 'Typo' although the Gapsted population has more variable phyllode length and width than is typical for subsp. *boormanii*. Geographically, *A.* 'Gapsted' is much nearer *A.* 'Typo' than typical *A. boormanii* and might have been expected to resemble it morphologically. Although not scored in this study, it was also noted from field observations that the pattern of the branching varied within the Gapsted population, with certain plants featuring erect branches and others with a widely sprawling form not apparent in typical *A. boormanii* or *A.* 'Typo'. All plants within the *A.* 'Gapsted' population appear to be derived from root suckers. *Acacia* 'Gapsted' has not been observed to produce seed through at least 20 years of observation of the population (N.A.F. Gibb, pers. comm.) and, like *A. infecunda,* is likely to be a relictual population persisting solely via vegetative reproduction (Molyneux & Forrester 2008).

Acacia infecunda

Acacia infecunda was distinguished from *A. boormanii* by its inability to set seed, dwarfed features (habit, phyllode length, capitulum size) and isolation from *A. boormanii* populations (Molyneux and Forrester 2008). However, our measurements indicate that *A. infecunda* cannot be distinguished morphologically from *Acacia boormanii*. The ordination of morphometric data in our study found specimens of the species were nested within *A. boormanii* in ordination space. Therefore, based on our data, the distinction of *A. infecunda* relies largely on its apparently inability to set seed and extensive root-suckering habit, which are traits shared with the Gapsted population of *A. boormanii*. In cultivation, *A. boormanii* often suckers from roots at least up to a few metres from the 'mother' plant, so that trait, while expressed to an extreme in *A. infecunda* and the Gapsted population, exists to some extent within the species. Interestingly, *A.* 'Typo' is not known to spread by root suckers (pers. obs.). Other species of *Acacia* are known to develop populations that exhibit, to varying extents, dwarf or prostrate habit, root-suckers, infertile flowers etc. (e.g. *A. acinacea* Lindl., *A. baileyana* F.Muell., *A. dealbata* Link, *A. howittii* F.Muell., *A. iteaphylla* F.Muell.). However, none has been considered worthy of formal taxonomic recognition. It could be that *A. infecunda* represents one such population. O'Brien et al. (2014) found non-fruiting populations of *A. carneorum* Maiden to have lower genetic diversity than fruiting populations and inferred a long period of isolation. *Acacia infecunda* possibly represents a similarly long-isolated population of *A. boormanii*. Our study employed the only 2 herbarium specimens available to us of *A. infecunda* so we suggest further analysis, using a wider range of specimens, is warranted to verify its taxonomic integrity.

Non-morphological techniques (e.g. chemical, molecular) may shed further light on the relationships between the Gapsted population, *A. infecunda* and the remaining populations of *A. boormanii*

Taxonomy

Acacia boormanii Maiden, *J. & Proc. Roy. Soc. New South Wales* 49(3): 489 (1916).

Type: Macnally Ranges [= Macanally Mtn], **N.S.W.**, 25.ix.1913, *J.L.Boorman s.n.* (holo: NSW166396; probable

iso: BM, C, CANB, K, MEL (all '27.ix.1913') and NSW166408 ('ix.1913')).

Acacia hunteriana N.A.Wakef., *Victorian Nat.* 72: 92 (1956). T: Victoria: banks of Snowy River, near Deddick, 8.ix.1955, *N.A. Wakefield 4810* (holo: MEL 1508588; iso: BRI, CANB).

Foliose shrub to 4 m high; branchlets glabrous or sparsely and minutely hirsute, often pruinose at extremities. *Phyllodes* spreading to erect or deflexed, narrowly linear to narrowly oblanceolate, (1–)3–6(–7.5) cm long and 1.5–2(–4.6) mm wide, straight or slightly falcate, not rigid, glabrous except for adaxial side of pulvinus which is often sparsely hairy, green to grey-green or pruinose, at least when young, narrowed at base, normally obliquely and eccentrically mucronate; midrib and lateral veins indistinct; *gland* not prominent, 2–14 mm above pulvinus. *Racemes* with rachis (7–)10–20(–33) mm long, slender, straight to flexuose, glabrous to subglabrous, often pruinose; *peduncles* 2–4 mm long, slender, glabrous to subglabrous; heads prolific, globular, 3–5 mm diam., 5–11-flowered, yellow. *Flowers* 5-merous; sepals united. *Pods* linear, 3–9 cm long, 4–6 mm wide, firmly chartaceous, dehiscing unilaterally, glabrous; *seeds* mostly 3–11 per pod, longitudinal, oblong-elliptic, 3.8–5.6 mm long, 2–3 mm wide, somewhat shiny, black, aril half to two-thirds the length of seed. Flowers Aug.–Oct.

Acacia boormanii subsp. *boormanii*

Shrubs commonly suckering from roots. *Phyllodes* often deflexed below inflorescence, linear, 1.5–2(–2.5) mm wide, margin not or very indistinctly indented around gland; apex acute (rarely rounded), not pruinose, or sparsely to moderately pruinose.

Occurs disjunctly from Macanally Mtn, near Cooma New South Wales to south of Thredbo Village, New South Wales, and south to Buchan, Victoria, with an outlying occurrence at Gapsted in north-eastern Victoria.

Acacia boormanii subsp. *gibba* K.J.Tucker subsp. nov.

Acacia boormanii var. *Mount Typo* (F.E. Bienvenu 11) Vic. Herbarium sensu CHAH (2006); Maslin (2013).

***Type*: VICTORIA.** Mt Typo, just south of saddle crossed by vehicular track, 0.8 km N of summit, 22 km SE from

Figure 5. Flowering specimen of *Acacia boormanii* subsp. *gibba*. (photo N.A.F. Gibb, Sept. 2013)

Whitfield, 1.ix.2013, *K.J. Walsh s.n.* (holo: MEL 2385038A; iso: AD, CANB, NSW).

Shrubs, not root-suckering. *Phyllodes* mostly acutely inclined to stem, those immediately below the inflorescence sometimes spreading to ca. 90 degrees, oblong to narrowly elliptic or narrowly oblanceolate, straight to slightly falcate, 2.5–5 mm wide; margin commonly distinctly indented around the gland; apex usually asymmetrically rounded, typically distinctly pruinose. (Figures 5 & 6)

Figure 6. Fruiting specimen of *Acacia boormanii* subsp. *gibba*. (photo K.J. Tucker, Dec. 2013)

Specimens examined: Eastern slopes of Mt Typo, 12.ii.1976, *P.D. Cheal s.n.* (MEL); Mt Typo to Mt Warwick, iv.1976, *A. Gibb s.n. & F. Bienvenu s.n.* (MEL); Approx. 25 km SSE of Whitfield. Saddle south of Mt Typo summit, 19.ix.1976, *A. Gibb s.n.* (MEL); Approx. 12 km SE of Whitfield, 19.ix.1976 & 20.ii.1977, *A. Gibb s.n.* (MEL); c. 1.2 km along Upper Rose River Road, 20.viii.1977, *F. Bienvenu s.n.*, (CBG, MEL, NSW) and *E.M. Canning 4277* (AD, CBG, MEL, NSW); 2.4 km N of Bennies along Upper Rose River Rd, 20.viii.1977, *F. Bienvenu s.n.* (CBG, MEL, NSW); 4.8 km N of Bennies along Upper Rose River Rd, 20.viii.1977, *F. Bienvenu s.n.* (CBG, MEL, NSW); Mt Typo, knoll to the N end, 17.xii.2013, *K.J. Tucker 1* (AD, CANB, MEL, NSW).

Distribution: *Acacia boormanii* subsp. *gibba* is confined to Mt Typo and environs near Rose River, north-east Victoria.

Habitat: The plant community in which the main population of *A. boormanii* subsp. *gibba* occurs is mainly a shrubland with the wattle often dominant. Other common co-occurring species include *Dodonaea viscosa* subsp. *cuneata* (Sm.) J.G.West, *Calytrix tetragona* Labill., *Cassinia longifolia* R.Br., *Hibbertia obtusifolia* DC., *Stypandra glauca* R.Br., *Isotoma axillaris* Lindl., *Cheilanthes sieberi* Kunze and occasional eucalypts, e.g. *E. radiata* DC., and *E. rubida* H.Deane & Maiden. Soils are skeletal, overlying the Carboniferous conglomerate of which the prominent Mt Typo range is composed (Figure 7). Mean annual rainfall is ca. 1050 mm (although runoff is high and effective rainfall probably considerably less). The subspecies occurs over an altitude range of ca. 470–750 m. Small outlying subpopulations c. 1 km north and up to c. 5 km south-east of Mt Typo occur in open forest dominated by *Eucalyptus radiata* and *E. rubida*.

Conservation status: Given the very restricted areas of extent of occurrence and area of occupancy (sensu IUCN 2001), the risk category for *A. boormanii* subsp. *gibba* is calculated as CR (Critically Endangered) due to the vulnerability of the habitat to degradation primarily through projected increased fire frequency with climate change, jeopardising recruitment of the population in the medium- to long-term.

Etymology: The epithet derives from the latin *gibbus* - a hump, alluding to the prominently raised profile of Mt Typo, but also making reference to N.A.F.(Alan) Gibb, a local naturalist and *Acacia* expert who first made

Figure 7. Mt Typo with *Acacia boormanii* subsp. *gibba* dominant on upper slopes (the distinctive summit of Mt Cobbler left of Mt Typo). (photo K.J. Tucker, Dec. 2013)

collections of the subspecies in 1976. It is here modified to the feminine to agree with the gender of the genus and is treated as a substantive.

Notes: The new subspecies is separated from subsp. *boormanii* in having broader phyllodes (mean 2.8–4.6 mm wide for subsp. *gibba* vs 1.5–2.4 mm wide for subsp. *boormanii*) that have a rounded rather than acute apex (ignoring the short mucro which is present in both subspecies) and typically have the margin indented (not straight) at the gland. A number of other characters, while not utterly diagnostic are at least indicative and contribute further to the separation of the two subspecies: the stems of subsp. *gibba* are invariably glabrous and pruinose while this is not always the case in subsp. *boormanii*; the phyllodes of subsp. *gibba* are typically highly pruinose, especially when young while those of subsp. *boormanii* are rarely or indistinctly pruinose; the phyllodes immediately subtending the inflorescences are very often conspicuously reflexed in subsp. *boormanii*, but only rarely so in subsp. *gibba*; and subsp. *boormanii* commonly shoots from root-suckers, but this trait has not been observed in subsp. *gibba*.

While the distribution of subsp. *gibba* is believed to be concentrated on and near Mt Typo in north-east Victoria, three collections from the Bowen Range, East Gippsland (*Beauglehole 37163*, MEL 536856; *Cameron s.n.* MEL 1555594; *Cheal s.n.* MEL 1563149), some 185 km ESE of Mt Typo but under 20 km E from the nearest occurrence of *A. boormanii* subsp. *boormanii*, differed from other specimens retrieved as subsp. *boormanii* by their broader-than-typical phyllodes (means of 3.7 mm, 2.9 mm, 2.7 mm wide respectively). While on the basis of this character alone, these might be expected to group with subsp. *gibba*, most of the other characters of these specimens were not consistent with that taxon – e.g. presence of hairs on some branchlets, lack of wax on two specimens, and the phyllodes subtending inflorescences spreading to reflexed. There is no direct evidence to suggest these specimens were or were not root-suckering, but on one sheet (*Cameron s.n.*) it is noted that 'most plants sterile and none bearing fruit', which is a characteristic often associated with

root-suckering populations (e.g. at Gapsted, and in the population representing *A. infecunda*). In the absence of a more complete suite of specimens from this relatively remote area, these specimens are provisionally retained in subsp. *boormanii*.

Acknowledgements

We thank Tomas and Gaby Moritz for access to Mt Typo; Alan Gibb for assistance with field work, photographs and information on the taxa under study; Kate Walsh for collection of flowering Mt Typo specimens; Alison Vaughan for generating the distribution map from MEL data; and Niels Klazenga and Andre Messina for assistance with data analysis.

This study was undertaken as part of the Jim Willis Summer Studentship (RBGV). We are indebted to Roger Riordan, and Maggie and Max Richards for their generous support of this program.

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Muelleria

37: 33–38

Published online in advance of the print edition, Tuesday 2 October

ROYAL
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A review of *Iotasperma* (Asteraceae: Astereae)

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Introduction

The genus *Iotasperma* G.L.Nesom (Nesom 1994) was erected for two endemic Australian species that were previously classified in the genus *Erigeron* L. Nesom (loc. cit.) showed quite clearly that these species were misplaced in *Erigeron*, and that they differed significantly from the related Australian genera *Vittadinia* A.Rich., *Ixiochlamys* F.Muell. ex Sond., *Dichromochlamys* Dunlop, *Peripleura* (N.T.Burb.) G.L.Nesom and *Camptacra* N.T.Burb. Nesom's treatment, while establishing the need for a new genus, and satisfying the nomenclatural requirements, is deficient in several ways: there were no descriptions for the species, no types were seen and no lectotypes chosen, there was no key to species, no distribution map, no specimens cited and the illustration of the pappus is misleading and attributed to the wrong species.

In this paper, comprehensive species descriptions, specimen citations and an identification key are provided for the first time, and both species names are lectotypified. A distribution map is provided, and both species are illustrated.

Although not stated by Nesom (1994), *Iotasperma* appears to differ from all of the genera mentioned above by the uniseriate pappus, the very small achenes, and the very short ligules of the ray florets. These characters are sufficient to diagnose and circumscribe the genus.

Abstract

This paper provides species descriptions, specimen citations, identification key and illustrations for two species of the genus *Iotasperma* G.L.Nesom, namely *I. oustraliense* G.L.Nesom and *I. sessilifolium* (F.Muell.) G.L.Nesom. Both species names are lectotypified, and a distribution map is included.

Keywords: lectotype, identification key, illustration.

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

Materials and methods

The paper is based on a morphological examination of specimens at BRI, specimens received on loan from MEL, NT, DNA and PERTH, specimens examined at NSW in January 2018, images of a specimen at CANB, and an image of a type from K (Herbarium Catalogue 2018). All measurements are based on dried material, except for the florets, which were measured from material reconstituted in boiling water.

Taxonomy

Iotasperma G.L.Nesom, *Phytologia* 76: 144 (1994).

Type: *I. australiense*.

Annual herbs. *Stems* ± terete, but with faint longitudinal ridges extending from the base of each leaf, sessile oil glands absent. Leaves alternate, sessile. *Capitula* terminal, in corymbose or paniculate clusters, pedunculate, peduncle with a few leaf-like bracts along its length. *Involucral bracts* entire, outer bracts green, inner bracts white to pale yellow. *Receptacle* flat to slightly convex, without paleae. Ray florets multiseriate, female, corolla tube glabrous; ligules tightly coiled on dried material. *Disc florets* bisexual, yellow; corolla tube glabrous; anthers not basally caudate. Anthers strongly flattened, with broad glabrous thickened lateral ribs; surface with numerous antrorse transparent twin-hairs throughout; carpopodium conspicuous. Pappus a single whorl of barbellate bristles, fused at the base.

1. *Iotasperma australiense* G.L.Nesom, *Phytologia* 76: 146 (1994), as '*australiensis*'

Erigeron ambiguus F.Muell., Trans. Proc. Philos. Inst. Victoria 3: 58 (1859), *nom. illeg. non* Nuttall (1818). **Type: QUEENSLAND.** Gilbert River, 1856, *F. Mueller* (lecto: MEL 1553030, here chosen; isolecto: K 000890331).

Erect herb to 45 cm high. *Stems* with sparse indumentum of patent eglandular hairs to 0.3–0.5 mm long, and a dense covering of shorter gland-tipped hairs. *Leaves* elliptic to lanceolate or oblanceolate, 9–36 mm long, 2–11 mm wide, oil glands absent; apex acute; base cuneate; margins entire or sparsely dentate, with teeth 0.2–2.0 mm long; venation obscure or faintly visible throughout, mostly penninerved, but parallel-veined near base; dense indumentum of patent glandular hairs on both surfaces. *Capitula* 4–5 mm long, 6–8 mm diameter. Peduncles 12–32 mm long, with dense glandular hairs 0.05–0.10 mm long. *Involucral bracts* 30–40, graduated in length, 3–5-seriate; outer bracts linear to narrowly-lanceolate, 2.1–2.8 × 0.3–0.4 mm, with many short glandular hairs on outer surface, apex acute to acuminate; inner bracts linear, 3.5–3.7 × 0.3–0.4 mm, sparely glandular on outer surface, apex ciliate. *Receptacle* 2.3–3.6 mm across. *Ray florets* 60–100, corolla tube 1.9–2.1 mm long; ligules 0.8–1.4 mm long, white, apex obtuse. *Disc florets* 7–10, corolla tube 2.2–2.4 mm long, corolla lobes c. 0.25 mm long, acute. *Achenes* narrowly obovate in outline, 0.9–1.0 mm long, 0.35–0.40 mm wide. *Pappus* bristles 14–20, each 2.2–2.3 mm long; barbellae c. 0.05 mm long. (Figure 1a–c).

Selected specimens examined: **WESTERN AUSTRALIA.** Kimberley. King River road, 7.8 km N of Gibb River road, El Questro, 19.vi.2008, *G. Byrne 3410* (PERTH); between Picaninny car park and Western Creek, 13.vi.1993, *I. Solomon 804* (PERTH); 1 km SW of camp at Diversion Dam, Kingston Rest, 16.vii.2001, *D. Edinger DJE2595* (PERTH); Mount Elizabeth track to Munja, 28.vii.1996, *K.F. Kenneally 11816* (PERTH); Bungle Bungles; massive above Picaninny Gorge, 5.vii.1989, *K. Menkhorst 463* (DNA, PERTH); New Cockatoo sand site, CSIRO Kununurra, 7.vii.1978, *M.H. Andrew 94* (CANB, DNA, NT). **NORTHERN TERRITORY.** 3.4 km along Edith Falls road, NW of Katherine, 28.v.2005, *A.R. Bean 23918* (BRI, DNA); 20 miles [32 km] W of Borroloola Station, 26.vii.1948, *R.A. Perry 1773* (BRI, DNA); Cox River station, 23.vii.1977, *P.K. Latz 7214* (DNA, NT); Spirit Hills Conservation area, N of Nancy's Gorge, 25.viii.1996, *I. Cowie 7238 & C. Boehme* (DNA, MEL); Limmen N.P., Billengarah block, in valley at W edge of Tawallah Range, 6.viii.2009, *B.M. Stuckey 437* (DNA); west side of Skull Island, Pellew Islands, 10.viii.2009, *J. Westaway 3066* (DNA); Keep River N.P., 14.viii.2008, *K.G. Brennan 7798* (DNA). **QUEENSLAND.** Burke District: Adels

Key to the species of *Iotasperma*

1 Leaf bases cuneate; upper leaves usually entire; receptacle 2.3–3.6 mm across; peduncle with short glandular hairs only ..... ***I. australiense***

1: Leaf bases amplexicaule or obtuse; upper leaves toothed; receptacle 4.5–7.0 mm across; peduncle with predominantly long eglandular hairs, and some short glandular hairs ..... ***I. sessilifolium***

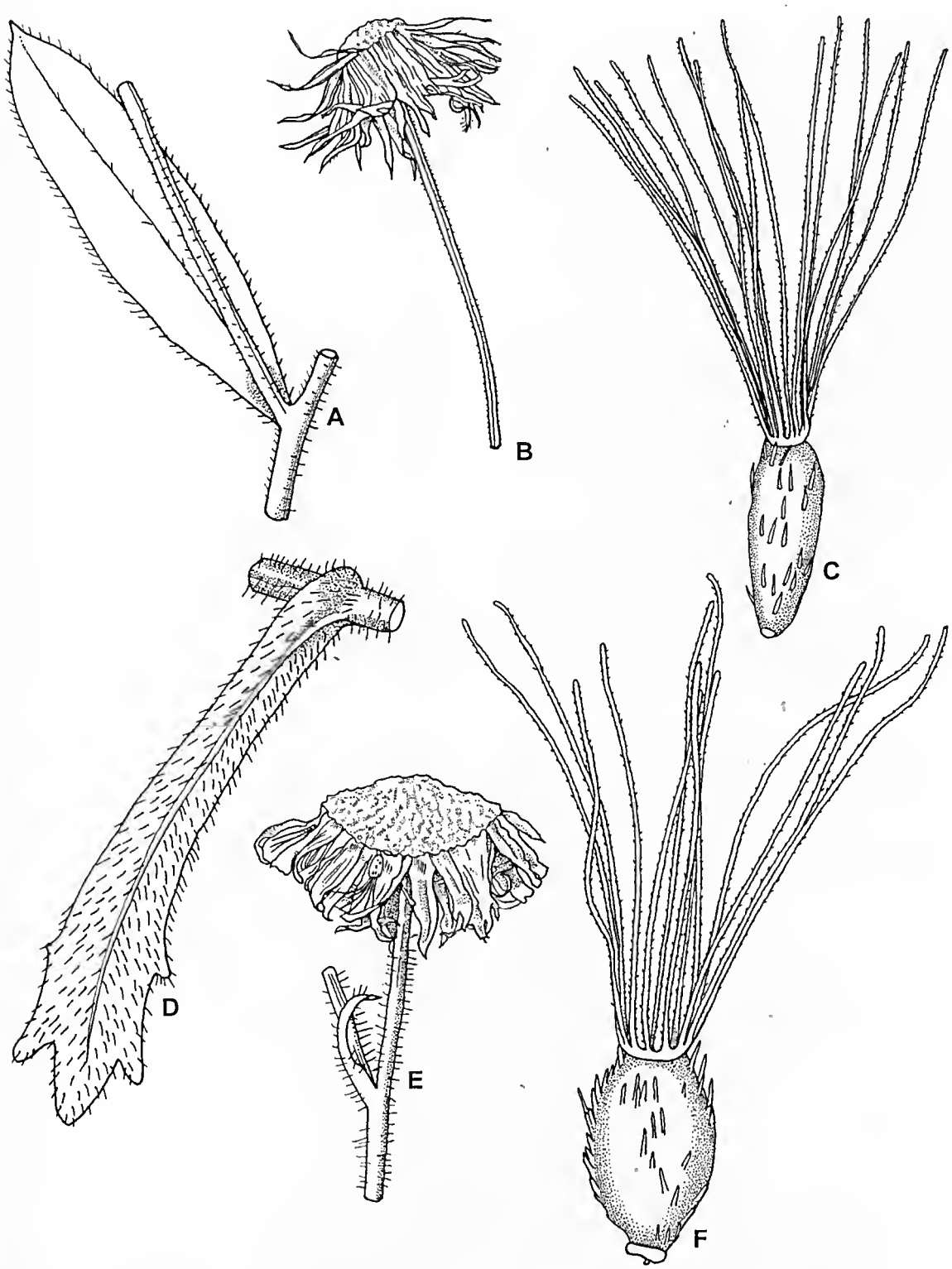

Figure 1. a-c. *Iotasperma australiense* (*Cumming 24470*, BRI AQ739926). a. leaf × 4; b. peduncle, receptacle and involucral bracts × 4; c. achene and pappus × 30. d-f. *Iotasperma sessilifolium* (*Latz 14697*, MEL0279545A). d. leaf × 4; e. peduncle, receptacle and involucral bracts × 4; f. achene and pappus × 30.

Grove, via Camooweal, 22.vi.1950, *A. de Lestong 481* (BRI); Bowthorn Station, 7.vi.2009, *R. Booth LH15-18 & D. Kelman* (BRI). Cook District: 28.9 km by road W of Wakooka Outstation, 27.x.2006, *K.R. McDonold 5932 et ol.* (BRI); Horseshoe Lagoon entrance road, Lakefield N.P., 24.vii.2010, *K.R. McDonald 9661 & J. Covacevich* (BRI); Kutchera Station, c. 70 km NE of Croydon, 21.ix.2006, *R. Cumming 24470* (BRI). North Kennedy District: Sawpit Creek, White Mountains N.P., 23.vii.1992, *A.R. Beon 4820* (BRI). South Kennedy District: c. 35 km E of Lake Buchanan, 17.vi.1998, *E.J. Thompson BUC2064 & G.P. Turpin* (BRI).

Distribution and habitat: Endemic to Australia. Occurring in the Kimberley region of Western Australia, the "Top End" of the Northern Territory, and northern Queensland, as far east as Lake Buchanan (Figure 2). It grows on sandy soils in open eucalypt woodland. Sites are typically seasonally damp, but not swampy.

Phenology: Flowering and fruiting specimens have been collected from May to September.

Conservation status: A very widespread species. A conservation coding of Least Concern is recommended (IUCN 2012).

Notes: Apart from the differences cited in the key below, *I. australiense* differs from *I. sessilifolium* by the inner involucral bracts 0.3–0.4 mm wide (0.6–0.9 mm wide for *I. sessilifolium*), the 7–10 disc florets (27–36 for *I. sessilifolium*), and the narrower achenes, 2.5–3 times longer than wide (c. 2 times longer than wide for *I. sessilifolium*).

This species is sometimes misidentified as *Blumea diffusa* R.Br. ex Benth. or *B. integrifolia* DC., as the plant size, capitulum size and involucral bracts are similar. However, the female florets of *Blumea* spp. are not ligulate.

2. *Iotasperma sessilifolium* (F.Muell.) G.L.Nesom, *Phytologia* 76: 146 (1994), as *'sessilifolia'*

Erigeron sessilifolius F.Muell., Fragm. 11: 100 (1880). **Type: NORTHERN TERRITORY.** Depot Pool [SW of Mataranka], 1879, *A. Forrest s.n.* (lecto, here chosen: MEL1553028; isolecto: MEL1553026, NSW569017).

[*Erigeron ambiguus*, Lawrence (1992, p. 945), misapplied]

Illustrations: Jessop 1981, *Flora of Central Australia*, p. 376, fig. 475, as *Erigeron sessilifolius*; Cooke 1986, *Flora of South Australia* Part 3, p. 1467, as *Erigeron sessilifolius*; Lawrence 1992, figs. 268, 288, as *Erigeron ambiguus*; Nesom 1994, p. 145, as *Iotasperma australiensis*.

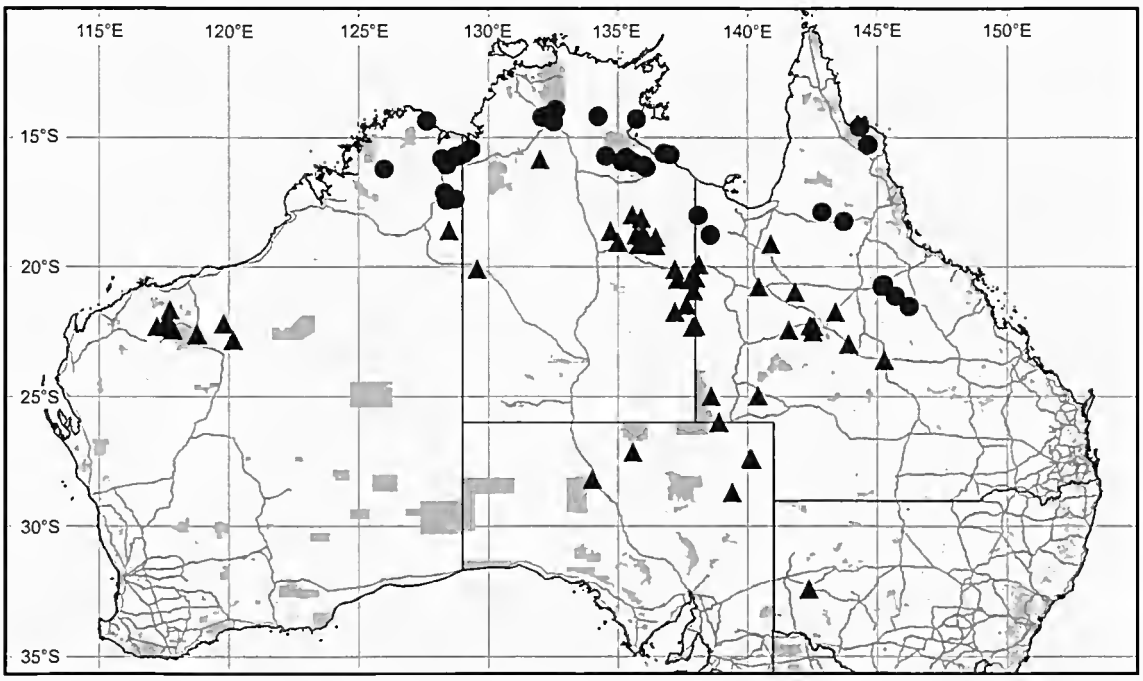

Figure 2. Distribution of *Iotospermo oustraliense* (circles) and *I. sessilifolium* (triangles).

Decumbent or erect herb to 30 cm high. *Stems* with dense indumentum of patent eglandular hairs 0.9–1.5 mm long, and a sparse covering of shorter gland-tipped hairs. *Leaves* oblanceolate, 14–61 mm long, 4–15 mm wide, oil glands absent; apex acute; base obtuse to amplexicaule; margins conspicuously dentate, with teeth 1–3 mm long; venation obscure; dense indumentum of antrorse eglandular hairs on both surfaces. *Capitula* 4.5–6.0 mm long, 8–9 mm diameter. Peduncles 8–30 mm long, with dense eglandular hairs 0.5–0.8 mm long and moderately dense glandular hairs 0.05–0.10 mm long. *Involucral bracts* 30–40, subequal in length, 2–4-seriate; outer bracts narrowly-elliptic, 2.5–3.6 × 0.5–0.7 mm, with short glandular hairs and longer eglandular hairs on outer surface, apex acuminate; inner bracts narrowly-elliptic, 2.9–4.1 × 0.6–0.9 mm, sparsely glandular on outer surface, apex acuminate, margins hyaline. *Receptacle* 4.5–7.0 mm across. *Ray florets* 60–100, corolla tube 1.5–2.1 mm long; ligules 1.3–2.0 mm long, lilac to blue or white, apex minutely retuse. *Disc florets* 27–36, corolla tube 2.4–2.7 mm long, corolla lobes 0.3–0.4 mm long, acute. *Achenes* elliptical in outline, 0.8–1.0 mm long, 0.4–0.5 mm wide. *Pappus* bristles 14–20, each 1.8–2.3 mm long; barbellae c. 0.05 mm long. (Figure 1d–f).

Selected specimens exomined: **WESTERN AUSTRALIA.** Munjina Claypan, Juna Downs station, 15.ix.1998, *S. van Leeuwen 3B8B* (DNA, PERTH); c. 17.8 km W of intersection of Nanutarra to Munjina road and Hamersley road, 12.viii.2011, *E. Ridley & B. Morgon BESER015* (BRI, PERTH); 0.9 km west from the Wittenoon to Nanutarra road on the track to Pindering Well, Hamersley Station, 2.ix.1991, *M.E. Trudgen MET10649 & S.M. Maley* (PERTH); Silvergrass Plain, 71 km NW of Tom Price, 11.ix.2007, *E. Thomo ET1377* (PERTH); c. 8 km N of Ethel Creek homestead, 28.viii.1995, *A.A. Mitchell PRP449* (PERTH); 18 km NE of Bonnie Creek homestead and 19 km SW of Nullagine, 22.viii.2008, *B. Morgon BMor13B5* (PERTH). **NORTHERN TERRITORY.** Sanctuary Swamp, 4.vii.1980, *J.R. Moconochie 2459* (BRI, DNA, NT); 26 mile waterhole, Austral Downs Station, 20.vii.1971, *N. Henry 271* (BRI, NSW, NT); Tobermory homestead, 21.v.1972, *C. Dunlop 2557* (BRI, NSW, NT); Brunette Downs homestead, 25.viii.198S, *P.K. Lotz 10093* (DNA, MEL, NT); Button Waterhole, Gordon Downs station, 20.vii.1973, *P.K. Latz 4015* (DNA, NSW, NT, PERTH); Connells Lagoon Reserve, 24 Aug 1989, *B.G. Thomson 3333* (DNA, NT); Shady camp stock yards, Burramurra, 20° 28'S 137° 18'E, 18.viii.1983, *B.G. Thomson 434* (NT); No. 21 Bore, Alroy Downs, 26.vi.197S, *J. Must 1436* (DNA); Lake Nash Waterhole, Lake Nash station, s.d., *B.W. Strong 437* (DNA, NT). QUEENSLAND. Burke District: turnoff to Toorak Research Station, c. 40 km S of Julia Creek, 10.x.2007, *J. Silcock 67* (BRI); bed of Flinders River crossing at Cleanskin Hut, 44.5 km N of Canobie HS, 6.viii.2004, *I.D. Fox IDF31B5 & G. Wilson* (BRI); Cloncurry, s.d., *E. Polmer 34* (BRI). Mitchell District: Barcaldine, vii.1978, *G. Warren s.n.* (BRI, AQ315437); Morella, Longreach Shire, 3.vi.1994, *B.A. Fronzmann BF32* (BRI). Gregory North District: Neuragully Waterhole, 'Monkira', c. 120 km SE of Bedourie, 7.v.2007, *A.R. Beon 26316* (BRI, CANB, NSW). **NEW SOUTH WALES.** Kinchega National Park, billabong of Darling River, 16.v.1979, *K. Poijmons 2754* (CANB).

Distribution and habitat: Endemic to Australia. Ranging from the Pilbara region of Western Australia, throughout the southern two-thirds of Northern Territory, northern South Australia, western New South Wales and the western half of Queensland, as far east as Barcaldine (Figure 2). It grows in depressions, in swamps, on floodplains or around bores, in grassland or herbland communities. Soils are clays or clay-loams.

Phenology: Flowering and fruiting specimens have been collected from May to October.

Conservation status: A very widespread species. A conservation coding of Least Concern is recommended (IUCN 2012).

Notes: Mueller (1880) did not cite any specimens in the protologue for *Erigeron sessilifolius*, but a gathering by Alexander Forrest (now mounted on two sheets at MEL) was available to him before the publication date, and one label bears the notation 'Erigeron sessilifolius n. sp.' in what appears to be Mueller's handwriting. This gathering matches the description in the protologue very well.

Nesom (1994) included an illustration of the pappus for *I. sessilifolium* (as *I. australiense*), where many bristles are less than 0.5 mm long, and some bristles almost completely lacking. These bristles have been damaged; undamaged pappus bristles are all equal in length, and 1.8–2.3 mm long. They are very fragile however, and broken bristles such as those illustrated by Nesom (1994) can often be found.

As the description and illustration of *Erigeron ambiguus* given in Lawrence (1992) are based on a specimen from Gordon Downs (*Latz 4015*, cited above), they are referable to *Iotasperma sessilifolium*.

Acknowledgements

I thank the Directors of MEL, DNA, NT and PERTH for specimen loans of *Iotasperma*, and the Director of NSW for access to the collection. Will Smith (BRI) provided the illustrations and edited the distribution map. Brendan Lepschi kindly sent high quality images of a specimen at CANB.

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Muelleria

37: 39–64

Published online in advance of the print edition, Tuesday 2 October

ROYAL
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Eucalyptus wimmerensis revisited and notes on the morphologies and taxonomies of five Victorian mallee-boxes

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Introduction

Taxa previously regarded as mallee-boxes were included in the Series *Subbuxeales* Blakely (1934). Various taxonomists and commentators, for example, Chippendale (1988), Brooker & Slee (1997), Nicolle (1997) and (2006) and Rule (2004) have maintained this classification. However, Brooker (2000), in his revision of the genus, discarded the series and assigned the mallee-boxes to the Supraspecies *Moluccanae* within the Series *Buxeales*. Rule (2012) noted that Brooker's construct was an aggregation of morphologically diverse taxa and opted to define a narrower, informal complex of species which possess specific, shared features. This informal collective, here referred to as the *Eucalyptus odorata* Complex, is further used to accommodate the new taxa described below. Such shared features include a mallee or a small, tree-like habit, adult leaves with mostly irregular island glands, inflorescences that are simple and axillary, buds with the outer operculum intact at anthesis and fruits that are 3 or 4-loculed. Species conforming to this prescription include *E. odorata* Behr, *E. polybractea* R.Baker, *E. viridis* R.Baker, *E. wimmerensis* Rule, *E. aenea* K.D.Hill, *E. castrensis* K.D.Hill, *E. walshii* Rule, *E. filiformis* Rule, *E. hawkeri* Rule, *E. yarriambiack* Rule and *E. cajuputea* F.Muell. ex Miq.

Eucalyptus silvestris Rule (1994), a species that has sometimes been confused with *E. wimmerensis* in the field, was erected to accommodate small, box-barked trees or robust mallees occurring in the Wimmera region

Abstract

Four new subspecies of *Eucalyptus wimmerensis* (subsp. *arapilensis*, subsp. *pallida*, subsp. *parvifarmis* and subsp. *grata*) and a new subspecies of *E. polybractea* (subsp. *subcerea*) are described. Their affinities, ecologies, distributions and conservation statuses are discussed. In all cases the new taxa are regarded as rare and threatened. In addition, notes are provided that clarify the morphologies and taxonomies of five Victorian mallee-boxes, namely *E. silvestris*, *E. hawkeri*, *E. yarriambiack*, *E. walshii* and *E. filiformis* which are related to or confused with *E. odorata*, *E. wimmerensis*, *E. polybractea* or *E. viridis*.

Keywords: Mallee-box, Series *Subbuxeales*, Series *Buxeales*, Supraspecies *Maluccanae*, pruinosity, whipstick, mallee.

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

of western Victoria. Originally it was regarded as having an affinity with *E. odorata* but subsequent research by this author indicates it is better placed with the grey boxes adjacent to *E. woollsiana* R.T.Baker and *E. microcarpa* Maiden. Further comments on the affinities of this species are provided in the attached notes.

Eucalyptus macmahonii Rule (1997) is a smooth-barked, green-leaved mallee that has also been associated with *E. wimmerensis*. It was interpreted as being a member of the series *Rufispermae* Maiden but was regarded as being an intersectional hybrid between *E. wimmerensis* and *E. phenax* subsp. *phenax* Brooker & Slee, for example, by Brooker and Kleinig (2001) and Nicolle (2006). In the field it is readily separable from *E. wimmerensis* by its adult leaves being densely reticulate with mostly intersectional glands, its maturing buds retaining fragments of the outer operculum, and its fruits being cupular, generally larger and smooth-walled (0.6–0.9 mm long, 0.5–0.8 mm diam.). In more recent times intermittent field observations by this author have found sporadic occurrences of the species throughout the Wimmera region and near Bordertown in South Australia. Nowhere is the species common, but it is best represented in the Mt Arapiles-Nurcoung area and in the Lawloit Range. More study is needed to clarify its origins.

Key to species of the *E. odorata* complex

1 Buds, branchlets and immature fruits copiously pruinose ..... ***E. polybractea***
1: Adult structures non-pruinose or, if so, growth tips and buds faintly pruinose at anthesis **2**
2 Juvenile leaves ovate, 1.5–4 cm wide ..... ***E. castrensis***
2: Juvenile leaves linear to ovate-lanceolate, 0.2–2.5 cm wide **3**
3 Growth tips and buds becoming faintly pruinose at anthesis **4**
3: Growth tips and buds not pruinose at any stage **6**
4 Slender-stemmed mallees ..... ***E. polybractea***
4: Spreading, robust, single or few-stemmed trees **5**
5 Juvenile leaves 1–2.5 cm wide; fruits 4–7 mm diam. ..... ***E. odorata***
5: Juvenile leaves 0.7–1.1 cm wide; fruits 3–4 mm diam. ..... ***E. yarriambiack***
6 Juvenile leaves 0.2–0.5 cm wide **7**
6: Juvenile leaves 0.4–2.5 cm wide **8**
7 Adult leaves lustrous, green ..... ***E. viridis***
7: Adult leaves dull to sub-lustrous, blue-green ..... ***E. filiformis***
8 Smooth bark throughout **9**
8: Rough bark present at least as a short basal stocking **12**
9 Slender trees; adult leaves 1.4–2.6 cm wide ..... ***E. walshii***
9: Mallees; adult leaves 0.6–1.8 cm wide **10**
10 Buds 3–5 mm diam.; fruits 4–7 mm diam. ..... ***E. wimmerensis***
10: Buds 2–3 mm diam.; fruits 3–5 mm diam. **11**
11 Adult leaves lettuce-green ..... ***E. aenea***
11: Adult leaves greenish with a bluish tinge ..... ***E. wimmerensis***
12 Basal box bark hard, compact, finely fissured; adult leaves linear, to 16 cm long ..... ***E. cajuputea***
12: Basal box bark thick, irregularly furrowed or thin and loosely held; adult leaves narrow-lanceolate or lanceolate, to 12 cm long **13**
13 Box bark restricted to a short basal stocking ..... ***E. wimmerensis***
13: Box bark persistent to mid-stem or higher **14**
14 Slender-stemmed trees to 20 m tall; canopy sparse; foliage pendulous ..... ***E. hawkeri***
14: Mallees or robust spreading trees to 12 m tall; canopy moderately dense; foliage erect **15**
15 Juvenile leaves 0.4–1 cm wide; fruits 4–5 mm diam. ..... ***E. wimmerensis***
15: Juvenile leaves 1–2.5 cm wide; fruits 4–7 mm diam. ..... ***E. odorata***

Within the Wimmera region of western Victoria, including the Little Desert, there are small islands of mallee-box communities which mostly occur on laterite rises both within the Little Desert and within adjoining areas predominantly used for agriculture. Through many years of investigation by this author it has been found that these communities, in addition to *E. wimmerensis*, contain a variety of mallee-box entities which, probably due to isolation, have taken different evolutionary paths. Field observations and progeny trials have shown that several are worthy of taxonomic recognition, with some having been described recently, others being described in this paper and a few still under investigation. This last group includes a whipstick mallee from Mt Jeffcott near Donald, a dwarf, glaucous, linear-leaved mallee from both Mt Elgin to the west of Nhill and Nurcoung near Mt Arapiles, a mallee scattered sparsely throughout the Wimmera and featuring linear, lustrous and green adult leaves and small, ovoid fruits and a weeping mallee, also from Nurcoung, which sheds its outer operculum prior to anthesis. Most of these unnamed entities, including some of those treated here, are regarded as existing in such meagre numbers that they are on the verge of extinction. Whether the circumstances of these rarities can be attributed to the clearing for farming or whether they are naturally in decline is a matter for speculation. It is a view taken here that, if investigations through progeny trials and field studies indicate that an entity meets the necessary criteria for taxonomic recognition, it should be treated as such.

These studies have indicated that *E. wimmerensis* sens. lat. contains a number of identifiable, divergent entities, each of which is considered worthy of taxonomic recognition. In addition to the typical form, which occurs in the north-western part of Wimmera and adjacent areas of South Australia, the LIttle Desert and in the southern Wimmera near Mt Arapiles at Cooack and Nurcoung, four new subspecies of *E. wimmerensis* are treated here. Two (subsp. *arapilensis* and subsp. *parviformis*) occur in the southern Wimmera and two (subsp. *pallida* subsp. *grata*) occur in the Lawloit Range in the north-western part of the region. In addition, a relatively common mallee-box, which occurs in the southern Wimmera and which has been regarded as a dull-leaved form of *E. wimmerensis,* is here recognised as having a closer affinity with *E. polybractea*. It is thus described as a new subspecies within *E. polybractea* (subsp. *subcerea*).

Terminology:

Glaucous and *pruinose* are regarded as synonymous. In this context, *glaucous* is considered to describe the whitish colour of leaves. It is not to be confused with the colours of blue-grey or grey-green. On the other hand, pruinose, is used to describe the waxy bloom occurring on stems, petioles, buds and immature fruits.

Sub-glaucous refers to a leaf colour that is intermediate between blue-green and glaucous.

Linear refers to the length to width ratios being > 12:1.

Lanceolate refers to length to width ratios < 8:1 and with the broadest point being relatively close to the base.

Linear-lanceolate and *narrow-lanceolate* refer to length to width ratios intermediate between linear and lanceolate.

Ovate refers to length to width ratios of < 4:1 and broadest close to the middle of the leaf blade.

Seedling trials

Seedling trials using seed-lots representative of forms of *E. wimmerensis* and related mallee-box taxa were conducted in the nursery of the Royal Botanic Gardens Victoria (RBGV) and in a private facility. The standard procedure was to select 5–7 seedlings representative of each seed-lot for study when they had reached about the 6th pair juvenile leaves. Data, which included leaf shape, length and width, petiole length, level of congestion along the stem (crowded to sparse) and leaf colour and lustre, were collected from perfectly formed leaves at between the 8th and 10th pairs, this being a stage of seedling development at which morphological divergence could be observed. These same seedlings were retained for observations of further developments that might occur as the seedlings matured, particularly with regard to changes in leaf sizes and colour and lustre. The seedling trials had two aims. Given that the seedlings of the identified variants of *E. wimmerensis* have not been previously studied, the trials were designed to determine whether any are sufficiently divergent from the species to warrant specific recognition. The trials were also considered important in providing clarifications of the relationships between *E. wimmerensis* and related taxa, namely *E. polybractea* and *E. viridis*.

A. Trials for presumed forms of *E. wimmerensis* (excluding *E. wimmerensis* subsp. *grata*)

Previous field observations of adult plants identified several forms or variants close to but differing from typical *E. wimmerensis*. As well as the typical form, other entities presumed to be forms of the species included the following: 1. Northern Blue-leaved Form (a rare, shrubby mallee with dull, bluish adult leaves from the Lawloit Range in the north-western part of the Wimmera). 2. Mt Arapiles Box-barked Form (a mallee with a variable stocking of rough bark from the Mt Arapiles area in the southern part of the Wimmera). 3. Nurcoung Green-leaved Form (a small-growing, smooth-barked mallee with greenish, lustrous adult leaves from the Mt Arapiles-Nurcoung area in the southern Wimmera). 4. Southern Dull-leaved Form (a relatively common mallee with dull, blue-green adult leaves and faintly pruinose mature buds from the southern Wimmera). 5. Nurrabiel Box-barked Form (a tallish, rough-barked, green-leaved form with a tree-like habit which is restricted to a single population in the Lower Norton-Nurrabiel area to the south-west of Horsham).

In the trials the following seed-lots of the forms of *E. wimmerensis* and related taxa (*E. viridis* and *E. polybractea*) were used: Typical form; north of Bordertown in South Australia, Diapur, Mt Elgin, Gerang Gerung, Little Desert, Kiata South and Cooack. Northern Blue-Leaved Form; 3 km west of Diapur. Mt Arapiles Box-barked Form; the north-east and south-west bases of the mountain and Jane Duff Reserve. Nurcoung Green-leaved Form; the Nurcoung Flora Reserve and the Mitre-Nurcoung Road. Southern Dull-leaved Form; c. 4 km south of Lower Norton, Mitre-Nurcoung Road and the north base of Mt Arapiles. Nurrabiel Box-barked Form; c. 7 km south of Lower Norton. *E. viridis;* south-east of Wedderburn. *E. polybractea;* north-west of Inglewood.

The results indicated that the seedlings across the provenances of typical *E. wimmerensis* exhibited little

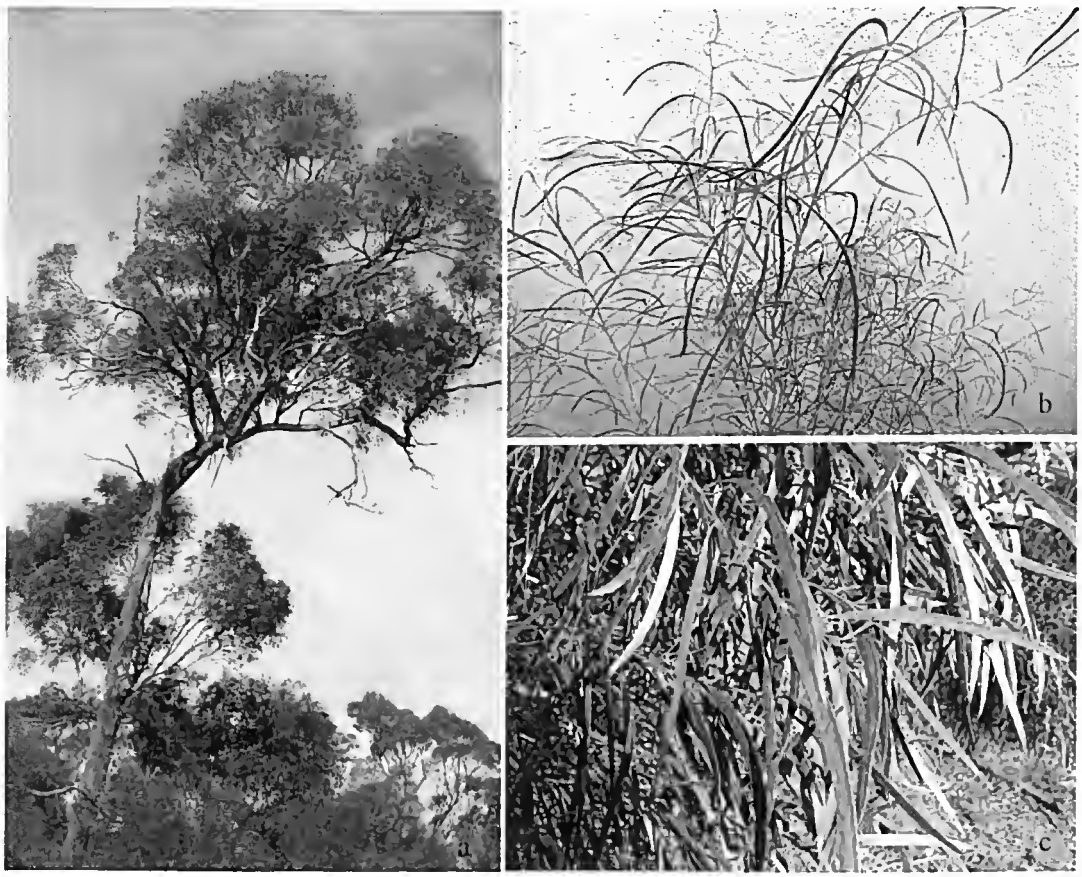

Figure 1: *Eucalyptus viridis*, SE of Wedderburn seed-lot. a. tree; b. juvenile leaves; c. foliage.

variation and featured juvenile leaves that were linear-lanceolate, narrow-lanceolate or lanceolate, dull, blue-green to sub-glaucous and petiolate with moderately crowded internodes. Seedlings of the Mt Arapiles box-barked form had slightly narrower juvenile leaves than other forms whilst those of the Nurcoung green-leaved form were generally shorter. Seedlings of the northern blue-leaved form were inseparable from those of the provenances of typical *E. wimmerensis*. Seedlings of *E. polybractea* initially were similar to those of the forms of *E. wimmerensis* but as they matured their new leaves became increasingly glaucous. Seedlings of the southern dull-leaved form, although similar to other forms of *E. wimmerensis* in early juvenile development, also produced glaucous new leaves as they matured. The seedlings of *E. viridis* featured juvenile leaves that were linear, falcate, sessile or sub-sessile with crowded internodes, blue-green then green and lustrous. Lastly, the Nurrabiel box-barked form featured juveniles that were lanceolate to ovate-lanceolate, sub-glaucous and distinctly petiolate with relatively sparse internodes.

The trials of the forms of *E. wimmerensis* and related taxa indicated that, whilst three forms of *E. wimmerensis* (northern dull-leaved, Mt Arapiles and Nurcoung) show an appreciable level of divergence from the typical form in adult morphology, none is considered as having significantly divergent seedlings (see Table 1). On this basis it is considered appropriate that each form be recognised as a subspecies of *E. wimmerensis*. Whilst the seedlings of the southern dull-leaved form were initially similar to those of other forms of *E. wimmerensis*, the expression of glaucousness in more advanced seedling development, as well light seasonal glaucousness in adult leaf growing tips, suggests closer links with *E. polybractea*. This indicates that it is appropriate to recognise the form as a subspecies of *E. polybractea*. The similarities between the seedlings of *E. wimmerensis* and *E. polybractea* in early seedling development suggest that they are closely related taxa which show divergence in adult morphology. In particular, the latter develops blue-grey or glaucous adult leaves and usually conspicuously pruinose branchlets, buds and immature fruits. Despite this apparent divergence future molecular studies appear necessary to clarify this relationship.

With regard to the Nurrabiel box-barked form, seedlings from these trials and additional trials, along with further field studies, indicate that it is closely related to *E. hawkeri* rather than to either *E. wimmerensis* or *E. polybractea* and best placed within that species. Additional seedling trials of seed-lots of similar plants occurring in the nearby Smith Reserve, which were previously recorded as *E. gracilis* F.Muell. (David Cameron, pers. Comm.), were also found to be close to *E. hawkeri*.

Lastly, these trials highlighted the differences between seedlings of *E. wimmerensis* (and its subspecies) and *E. viridis* and reinforces the case for regarding the two as separate species (Figures 1-6).

B. Trials of *E. wimmerensis* subsp. *grata*

Since the discovery of this taxon, approximately 20 years ago, six sets of trials have been conducted both in private facilities and the RBGV nursery. These trials have confirmed its capacity to produce uniform seedlings and alluded to its links with *E. wimmerensis*. Initially, it was thought to be related to *E. hawkeri*, mainly because of its weeping foliage and, to a lesser extent, its tallish habit and its short basal stocking of box bark. Recent comparative trials, which included seed-lots of four provenances of *E. hawkeri*, confirmed that the new taxon has a closer relationship with *E. wimmerensis*.

Taxonomy

1. *Eucalyptus wimmerensis* Rule, *Muelleria* 7(2): 193 (1990).

Type: VICTORIA. Lawloit Range on the Western Highway between Nhill and Kaniva, *J.H.Willis s.n.* 27 Dec. 1964 s.n. (holotype: MEL 1057352)

Rule (1990) described *Eucalyptus wimmerensis* to accommodate mallee-box populations in the western part of the Victorian Wimmera region and adjacent areas of South Australia. Previously, populations of *E. wimmerensis* occurring in the Lawloit Range to the west of Nhill had been considered by Willis (1973) as a large-fruited form of *E. viridis*. However, the species only superficially resembles *E. viridis*, particularly during summer when new adult leaves in most populations become more lustrous and greener than normal. *E. viridis* is distinguished by its variable habit (usually a mallee but less often a small, single-stemmed tree), its variable stocking of persistent compact, greyish box

bark, its linear, sessile or shortly petiolate, lustrous and green, crowded juvenile leaves, its linear, lustrous and green adult leaves, with indistinct lateral veins usually obscured by numerous, crowded island glands, its linear, lustrous and green coppice leaves, its simple, axillary, 7–11-flowered inflorescences and its distinctly pedicellate buds (pedicels usually being longer than the buds) and distinctly small, more or less cupular, thin-walled fruits (3–5 mm long, 2.5–5 mm diam.). In contrast, *E. wimmerenesis* differs from *E. viridis* primarily by its consistent mallee habit, its broader, blue-green, distinctly petiolate juvenile leaves, its broader, duller,

Table 1. Morphological comparisons of Mallee-box taxa.

Characters	*E. wimmerensis subsp. wimmerensis*	*E. wimmerensis subsp. arapilensis*	*E. wimmerensis subsp. parviformis*	*E. wimmerensis subsp. pallida*
Habit	mallee 4–10 m, foliage semi-erect	mallee 4–8 m, foliage semi-erect	shrub or mallee 2–5 m, foliage semi-erect	shrub or mallee 2–5 m, foliage semi-erect
Bark	smooth throughout or grey-brown box bark persistent at base	grey box bark to at least mid-stem	Smooth through-out	grey-brown box bark to about mid-stem
Juvenile leaves – shape	narrow-lanceolate to lanceolate	linear-lanceolate to narrow-lanceolate	narrow-lanceolate	narrow-lanceolate
– size (cm)	5–9 x 0.6–1.5	5–9 x 0.4–0.9	4–7 x 0.5–1	5–9 x 0.5–1
– colour/ lustre	blue-green, dull	blue-green, dull	blue-green, dull	blue-green, dull
– petiole length (cm)	0.6–1.2	0.7–1.6	0.6–1.1	0.6–1.4
Adult leaves – shape	narrow-lanceolate to lanceolate	narrow-lanceolate	narrow-lanceolate to lanceolate	narrow-lanceolate to lanceolate
– size (cm)	6–10 x 0.7–1.6	5–10 x 0.6–1	4–8 x 0.8–1.3	5–9 x 0.8–1.4
– colour/lustre	olive-green or green, with a faint bluish tinge, sub-lustrous or rarely lustrous	blue-green to green, sub-lustrous	green with a bluish tinge, sub-lustrous to lustrous	blue-green to sub-glaucous, dull
Petiole length (cm)	0.6–1.7	1–1.6	1–1.6	0.6–1.2
Peduncle length (cm)	0.7–1.2	0.4–1.1	0.3–0.7	0.6–1.1
Bud – Number	7–11	7–11	7–11	7–11
– shape	ovoid, fusiform or slightly clavate	ovoid to fusiform	ovoid	ovoid
– size (mm)	4–7 x 3–5	4–7 x 3–4	4–5 x 2–3	5–6 x 3–4
– pedicel length (mm)	2–4	4–7	1–3	2–3
Fruits – shape	cupular, sub-cylindrical or slightly barrel-shaped	cupular, sub-cylindrical or slightly barrel-shaped	hemi-spherical to cupular	hemi-spherical, cupular or globose-truncate
– size (mm)	4–7 x 4–6(–7)	5–6 x 4–5	4–5 x 3–4	4–6 x 4–5
– ribbing	rarely present	absent	absent	absent
– pedicel length (mm)	1–3	3–6	0–2	1–2
Pruinosity	absent	absent	absent	absent

moderately reticulate, adult leaves with larger, irregular, discrete (non-crowded) island glands and its larger buds and larger, thick-walled fruits (fruits 5–7 mm long, 3–6(–7) mm diam.).

Brooker and Slee (1996) formally revised *E. wimmerensis* to a subspecies of *E. viridis*. In this revision, to justify their assertion, they focussed on two characters, here regarded as of minor significance (the amount of box bark present as a basal stocking and the presence or absence of ribbing on the fruits), and ignored other, more important differences, such as in juvenile and adult leaves, buds and fruits, upon

Table 1. Morphological comparisons of Mallee-box taxa (continued)

Characters	*E. wimmerensis* *subsp. grata*	*E. polybractea* *subsp. polybractea*	*E. polybractea* *subsp. subcerea*	*E. viridis*
Habit	mallee or small tree 5–12 m, foliage weeping	mallee or slender tree 4–12 m, foliage semi-erect	mallee 4–8 m, foliage semi-erect	small tree or mallee 5–10 m, foliage semi-erect
Bark	stocking of light grey box bark on lower stem	dark grey-brown box bark persistent to various heights	dark grey-brown box bark persistent to various heights	dark grey compact bark on lower stem
Juvenile leaves – shape	narrow-lanceolate to lanceolate, often falcate	narrow-lanceolate to lanceolate	narrow-lanceolate	linear, often falcate
– size (cm)	7–12 x 0.7–1.8	4–10 x 0.8–1.5	5–9 x 0.6–1.2	5–10 x 0.2–0.5
– colour/ lustre	blue-green, dull	sub-glaucous to glaucous	initially sub-glaucous, eventually glaucous	blue-green, eventually green, lustrous
– petiole length (cm)	0.6–1.2	0.5–1.5	0.6–1.3	0–0.4
Adult leaves – shape	narrow-lanceolate to lanceolate, often falcate	narrow-lanceolate to lanceolate	narrow-lanceolate to lanceolate	linear to linear-lanceolate
– size (cm)	7–12 x 1–2	5–10 x 0.8–1.9	5–9 x 0.9–1.6	4–10 x 0.4–0.8
– colour/lustre	green, lustrous	sub-glaucous to glaucous	blue-green to sub-glaucous	green lustrous
Petiole length (cm)	0.6–1.5	1–1.6	1–1.8	0.6–1
Peduncle length (cm)	0.6–1.1	0.6–1.2	0.8–1.4	0.6–1.1
Bud – Number	7	7–11	7–11	7–11
– shape	clavate to sub-pyriform	ovoid to fusiform	ovoid	ovoid to fusiform
– size (mm)	6–8 x 3–4	4–7 x 3–5	5–6 x 3–4	4–6 x 2–3
– pedicel length (mm)	3–5	3–6	2–4	3–5
Fruits – shape	cupular, sub-pyriform or sub-cylindrical	cupular to sub-cylindrical	hemi-spherical to cupular	cupular to sub-cylindrical
– size (mm)	6–8 x 4–6	4–7 x 4–7	4–6 x 4–5	4–5 x 3–4
– ribbing	rarely basally ribbed	absent	absent	absent
– pedicel length (mm)	2–4	2–5	1–3	2–4
Pruinosity	absent	present on seedlings, copious on branchlets, buds and immature fruits	present on seedlings, faint on buds and growth tips at anthesis	absent

which the erection of *E. wimmerensis* had been based. Nicolle (1997) regarded *E. wimmerensis* as a subspecies of *E. viridis* and incorrectly gave its juvenile leaves as being glossy and green and the buds and fruits being almost identical to *E. viridis*. However, Nicolle (2006) adjusted his assessment of *E. wimmerensis* by regarding it as a species. In doing so he highlighted the differences between it and *E. viridis* in juvenile and adult leaves, buds and fruits. Also Nicolle (2006) suggested that *E. wimmerensis* is most closely related to *E. odorata*, a position that was given when the taxon was erected. A recent assessment of *E. wimmerensis* was made by Walsh and Stajsic (2008) who also accepted it as a species.

Eucalyptus cajuputea was recently resurrected by Nicolle (2013) to replace South Australian populations regarded as *E. viridis* by Boomsma (1981) and Brooker and Kleinig (1990). These latter authors noted that *E. viridis* is limited to a few restricted remnant populations in the Flinders Ranges and other populations attributed to the species are intergrades involving other box species of the region. Field observations and progeny trials conducted by this author, for the most part, support Nicolle's account of the species. Nicolle has also suggested that *E. cajuputea* may be conspecific with *E. wimmerensis*, a notion which is here rejected on the basis of differences between the two in several important characters. *E. cajuputea* differs from *E. wimmerensis* by being a tree at its optimum development (*E. wimmerensis* is consistently a mallee), having a substantial stocking of hard, dark, grey-brown, compact bark, (the rough bark of *E. wimmerensis*, when present, is thin and often loosely held), having longer, narrower juvenile leaves (linear to linear-lanceolate and to 13 cm long) and having longer, linear adult leaves (to 16 cm long). In the case of buds and fruits, there is overlap in sizes but generally those of *E. cajuputea* are smaller (buds 2–3 mm wide and fruits 4–6 mm long, 3–5 mm wide).

Five subspecies of *E. wimmerensis* are recognised here.

1a. *Eucalyptus wimmerensis* Rule subsp. *wimmerensis*, *Muelleria* 9: 82 (1996).

Syn: *E. viridis* subsp. *wimmerensis* (Rule) Brooker & Slee

Mallees 4–10 m tall. *Bark* smooth throughout or with a variable stocking of thin, often loosely-attached, box-like bark; old bark deciduous in short ribbons and plates; new upper bark off-white, light grey or light brown, becoming darker with age. *Seedling leaves* narrow-elliptical, decussate, sessile for a few pairs. *Juvenile leaves* narrow-lanceolate to lanceolate, becoming slightly elliptical, broadening as seedlings mature, semi-erect, petiolate, disjunct, moderately crowded, dull, blue-green, slightly discolorous, 5–9 cm long, 0.8–1.5 cm wide; petioles 0.6–1.2. *Intermediate leaves* lanceolate or ovate-lanceolate, disjunct, petiolate, dull, blue-green, slightly discolorous or concolorous. *Adult leaves* narrow-lanceolate to lanceolate, acuminate, uncinate, olive-green, green or green with a bluish tinge, concolorous, sub-lustrous, rarely lustrous, semi-erect, coriaceous, 6–10 cm long, 0.7–1.6 cm wide; petioles to 0.6–1.7 cm long; venation moderately sparse with lateral veins conspicuous and moderately acute; intramarginal vein c. 1 mm from margin; oil glands numerous, large, irregular, island; new season's growth tips light green, sub-lustrous or lustrous. *Coppice leaves* blue-green, dull or sub-lustrous, elliptical to ovate-lanceolate. *Inflorescences* simple, axillary, 7–11-flowered, along the main axis or along leafy terminal branchlets;

Key to the subspecies of *Eucalyptus wimmerensis*

1	Adult leaves dull, blue-green to sub-glaucous	subsp. ***pallida***
1:	Adult leaves sub-lustrous to lustrous, olive-green, green or green with a slight bluish tinge	2
2	Bark smooth throughout	3
2:	Box bark present at least on lower stem	4
3	Juvenile leaves 0.5–1 cm wide; fruits 3–4 mm diam.	subsp. ***parviformis***
3:	Juvenile leaves 0.6–1.5 cm wide; fruits 4–7 mm diam	subsp. ***wimmerensis***
4	Box bark persistent to at least mid-stem; juvenile leaves 0.4–1 cm wide	subsp. ***arapilensis***
4:	Box bark forming a short basal stocking; juvenile leaves 1–1.8 cm wide	5
5	Adult leaves erect, 6–10 cm long, 0.7–1.6 cm wide	subsp. ***wimmerensis***
5:	Adult leaves pendulous, 7–12 cm long, 1–2 cm wide	subsp. ***grata***

peduncles slightly angled, 0.7–1.4 cm long. *Floral buds* ovoid to fusiform or clavate, sometimes slightly ribbed, pedicellate, non-scarred (outer operculum intact), 4–7 mm long, 3–5 mm diam.; pedicels 2–4 mm long; operculum conical or slightly obtuse, shorter than the hypanthium; hypanthium basally tapered, faintly angled; filaments white; stamens irregularly flexed, all fertile; anthers adnate, basifixed, globoid, dehiscing through sub-terminal pores; locules 3–4; ovules in 4 vertical rows. *Flowering period* mid-summer to autumn. *Fruits* cupular, sub-cylindrical or slightly barrel-shaped, sub-sessile to distinctly pedicellate sometimes slightly angled, 4–7 mm long, 4–6(–7) mm diam.; pedicels 1–3 mm long; disc descending; valves enclosed. *Fertile seeds* mid to dark brown, ovoid to slightly cuboid; dorsal surface shallowly reticulate; hilum ventral (Figure 2 and Table 1).

Distribution and habitat: The typical subspecies occurs in the north-western part of the Wimmera region and adjacent areas of South Australia, the Little Desert and south of the Little Desert in the Nurcoung and Cooack areas. It is commonly associated with laterite rises and is often the dominant species in the mallee communities in which it grows.

Associated species: *Eucalyptus calycogona* subsp. *trachybasis* Nicolle, *E. dumosa*, *E. phenax* subsp. *phenax*, *E. froggattii* Blakely, *E. leptophylla* F.Muell. ex Miq. *E. costata* F.Muell., *E. macmahonii* and *E. wimmerensis* subsp. *grata* (described below) have been observed growing with the typical subspecies of *E. wimmerensis* whilst it may abut or occur adjacent to *E. leucoxylon* subsp. *stephaniae* Rule, *E. arenacea* Marginson and Ladiges, *E. silvestris* and *E. largiflorens* F.Muell. At Nurcoung there is also contact with *E. wimmerensis* subsp. *parviformis* and *E. polybractea* subsp. *subcerea* (described below).

Conservation status: Field observations suggest that there is in excess of 20,000 plants of *E. wimmerensis* subsp. *wimmerensis* mostly occurring on roadsides, but less frequent in a few protected reserves, including the Little Desert National Park, and on private land. In Victoria the largest numbers of plants occur in the

Figure 2: *Eucalyptus wimmerensis* subsp. *wimmerensis*. a. juvenile leaves (Diapur seed-lot); b. typical mallee form, Little Desert; c. typical branchlet, Little Desert; d. typical coppice leaves, Diapur.

northern Wimmera in the Lawloit Range between Nhill and Kaniva and on the northern fringe of the Little Desert N.P. to the south of Kiata. In other areas of the northern Wimmera, such as at Gerang Gerung, north of Nhill, the Telopea Downs area and to the west of the Lawloit Range it is less common. In the southern Wimmera it is common on the southern edge of the Little Desert in the Cooack-Nurcoung area to the north of Mt Arapiles, mostly confined to roadsides and private land. The taxon has also been observed in the Little Desert at a few sites along the McDonald Highway and along the Nhill-Harrow Road but because of the nature of the terrain, it is impossible to estimate both its occurrence and numbers. In South Australia it is sparsely scattered to the north, north-west, west and south of Bordertown. Given that the taxon occurs in districts suitable for agriculture and that there are extensive sites where roadside remnants occur adjacent to cleared paddocks, it appears that substantial numbers were lost when farms were first established. Whilst field observations over a period of more than 25 years suggest there has been little recent decline in numbers and that seedling recruitment in some areas has been continuing, it is reasonable to anticipate some future losses may occur due to changing climatic conditions and the need for more land for agriculture. Thus, in accordance with IUCN (2001) guidelines the taxon is considered endangered (EN A2bc + 4bc).

Notes: The typical subspecies of *E. wimmerensis* is distinguished by its mallee habit (4–10 m tall), its short stocking of thin, box bark or smooth bark throughout, its dull, blue-green, linear-lanceolate or narrow-lanceolate juvenile leaves, which broaden as the seedlings mature, its green, olive-green or slightly bluish, usually sub-lustrous adult leaves, its relatively large buds (5–7 mm long, 3–5 mm diam.) and its relatively large fruits (5–7 mm long, 4–6(–7) mm diam.).

Field observations indicate that the height of the basal stocking of box bark changes across the seasons. During the winter months the stocking reaches its optimum height but much of it is shed in summer. Whilst some populations may carry a winter stocking of a few metres in height, other populations, some of which occur in the Little Desert and its southern fringes, carry only a modest basal stocking, all or most of which is shed in summer. There is also seasonal change in the colour of the smooth upper bark of the typical subspecies. Initially, the fresh new bark, which appears in summer, is pale (off-white, light grey or light brown) but, as the year progresses, the bark becomes more colourful and sometimes slightly lustrous.

Field observations also indicate that the typical subspecies of *E. wimmerensis* undergoes changes in canopy colour and lustre. In summer the canopy is dominated by newly produced light green adult leaves following spring new growth that give the canopy an appreciably greener and more lustrous appearance than is seen in winter. This pattern of canopy change is similar in other subspecies of *E. wimmerensis*, particularly subsp. *arapilensis* and subsp. *parviformis,* but only slightly in subsp. *pallida* and subsp. *grata*. Observations further indicate that the colour and lustre of adult leaves of the typical subspecies varies within populations. Occurring in small numbers in some populations are variants that are more lustrous than normal. Despite changes in colour and lustre as the leaves mature, these variants tend to hold their lustre throughout the year. Whilst the significance of these individuals is not fully understood, it is suspected that they are intraspecific hybrids involving subsp. *grata*.

Within the typical subspecies, more than other subspecies, there is a wide range of fruit shapes which include cupular, sub-cylindrical and slightly barrel-shaped. With regard to ribbing, such is slight and infrequent and appears to be confined to the type subspecies. Recent surveys have also found individuals at Diapur and Nurcoung with fruits slightly wider than normal which extends the range of the subspecies to 4–6(–7) mm. diam.

1b. *Eucalyptus wimmerensis* subsp. *arapilensis* Rule sp. nov.

Type: Victoria. South-west side of Mt Arapiles, adjacent to the intersection of McClures Road and the southern access track, 36° 45′ 50″ S., 141° 48′ 24″ E. *K.Rule 5410,* 13 v 2010 (holotype: MEL 2419929; isotypes: AD, CANB, NSW).

Distinguished within *Eucalyptus wimmerensis* by the combination of its stocking of persistent box bark, which may extend to the upper stem, its variable mallee habit (erect and slender to modestly robust and spreading), its linear-lanceolate to narrow-lanceolate juvenile leaves, its relatively small, blue-green adult leaves, its

buds being borne on long pedicels and its relatively small fruits.

Mallees 4–8 m tall, habit variable, ranging from erect and slender to modestly robust and spreading. *Bark* grey, box type, as a variable stocking extending to upper stem on larger mallees or confined to about mid-stem on smaller mallees; upper smooth bark light brown; old bark decorticating in short strips and small plates. *Juvenile leaves* linear to linear-lanceolate, disjunct, petiolate, moderately crowded, dull, blue-green, slightly discolorous, 5–9 cm long, 0.4–0.9 cm wide; petioles 0.6–1 cm long. *Adult leaves* narrow-lanceolate, semi-erect, concolorous, sub-lustrous, blue-green, 5–10 cm long, 0.6–1 cm wide; petioles 0.7–1.6 cm long. *Inflorescences* 7–11-flowered; peduncles 0.4–1.1 cm long. *Floral buds* ovoid or fusiform, 4–7 mm long, 3–4 mm wide; operculum conical, c. half the length of the hypanthium; pedicels, 4–7 mm long. *Flowering period* autumn. *Fruits* cupular, sub-cylindrical or slightly barrel-shaped, basally tapered, 5–6 mm long, 4–5 mm diam.; pedicels, 3–6 mm long; disc descending; valves enclosed. (Figure 3 and Table 1)

Distribution and habitat: The new taxon is known from two locations; in the mallee communities which occur around northern and western bases of Mt Arapiles and in Jane Duff Reserve which is located about 7 km to the west of Mt Arapiles. Its preferred soils are shallow, well-drained gravels and sands.

Additional specimens examined: Victoria: Mt Arapiles, between access track and north-east base, c. 800 m south of McClures Road entrance, 36° 45′ 00″ S. 141° 50′ 20″ E., *K. Rule 2910*, 11 iv 2010 (MEL); Jane Duff Reserve 36° 43′ 50″ S., 141° 43′ 18″ E. *K. Rule 5610*, 13 v 2010 (MEL)

Etymology: The epithet refers to type locality of the new subspecies.

Associated species: *Eucalyptus hawkeri, E. leptophylla, E. macmahonii, E. costata* and *E. dumosa* occur as associates of the new taxon whilst *E. microcarpa, E. leucoxylon* subsp. *stephaniae* and *E. largiflorens* often abut the mallee communities in which the new subspecies occurs. At Mt Arapiles it occurs close to *E. wimmerensis* subsp. *parviformis* and *E. polybractea* subsp. *subcerea* (described below) and at Jane Duff Reserve it occurs with the former. Hybrids between the new subspecies and *E. hawker*, which display slightly larger leaves than typical, have been confirmed through recent progeny trials. These occur both near the north-east base of Mt Arapiles and at two sites on its south-western side.

Conservation status: Whilst the new taxon is common where it occurs, field surveys suggest that it may be represented by between 400 and 600 plants, all of which occur within the complex of protected reserves of the Mt Arapiles-Tooan State Park. Whilst these numbers are low by national standards their continued protection indicates a secure future. In accordance with ICUN (2001) guidelines a status of vulnerable is recommended (VU D 1+2).

Notes: *Eucalyptus wimmerensis* subsp. *arapilensis* differs from the typical subspecies by its substantial stocking of persistent box-like bark, its narrower juvenile

Figure 3: *Eucalyptus wimmerensis* subsp. *arapilensis*, NE of Mt Arapiles. a. mallee form; b. foliage.

leaves, its narrower, blue-green adult leaves and its relatively small buds and fruits borne on relatively long pedicels

Eucalyptus wimmerensis subsp. *arapilensis* differs from *E. polybractea* subsp. *subcerea* primarily by its lighter coloured persistent box bark, its narrower juvenile leaves, its greener adult leaves, its non-pruinose buds and growth tips and its distinctly pedicellate buds and fruits. From *E. wimmerensis* subsp. *parviformis* the new subspecies differs by its larger habit, its persistent box bark, its narrower juvenile leaves, its duller adult leaves and its fruits borne on longer pedicels (Table 1).

1c. *Eucalyptus wimmerensis* subsp. *parviformis* subsp. nov. Rule

Type: Victoria. Nurcoung Flora Reserve, along north-south boundary track, c. 800 m S of the east-west access track, 36° 41' 10" S., 141° 43' 20" E., *K.Rule 14006*, 3 x 2010 (holotype: MEL 2419926; isotypes: AD, CANB, NSW).

Distinguished within *Eucalyptus wimmerensis* by the combination of its relatively small habit, its smooth bark throughout, its generally smaller, greener and more lustrous adult leaves, and its small buds and fruits.

Shrubby, slender-stemmed *mallees* 2–5 m tall, *Bark* smooth throughout off-white, becoming light grey or brown with age; old bark decorticating in short strips and plates, loosely held on lower stem. *Juvenile leaves* narrow-lanceolate, disjunct, petiolate, moderately crowded, dull, blue-green, slightly discolorous, 4–7 cm long, 0.5–1 cm wide; petioles 0.6–1.1 cm long. *Adult leaves* narrow-lanceolate or lanceolate, semi-erect, concolorous, sub-lustrous to lustrous, green with a bluish tinge, 4–8 cm long, 0.6–1.1 cm wide; petioles 0.6–1.2 cm long. *Inflorescences* 7–11-flowered; peduncles slender, terete, 0.3–0.7 cm long. *Floral buds* ovoid, shortly pedicellate, 4–5 mm long, 2–3 mm diam.; opercula conical, c. half the length of the hypanthium; pedicels 1–3 mm long. *Flowering period* summer. *Fruits* hemispherical to cupular, basally tapered, thick-walled, 4–5 mm long, 3–4 mm diam.; pedicels 0–2 mm long; disc descending; valves enclosed (Figure 4 and Table 1).

Distribution and habitat: *Eucalyptus wimmerensis* subsp. *parviformis* known from the Nurcoung area where it exists in moderate numbers and nearby from small stands at Jane Duff Reserve and on the southern and northern edges of the Mt Arapiles section of the Mt Arapiles-Tooan S.P. It is highly likely that other remnants exist in the district. It occurs in shallow sands or gravels on laterite rises.

Additional specimens examined: Victoria: Jane Duff Reserve 36° 43' 50" S., 141° 43' 18" E. *K. Rule 2112* and *L. Rule*, 24 iii 2012 (MEL); Nurcoung F.R., north-south boundary track , c. 200 m S from east-west access track 36° 40' 45" S. 141° 43' 22" E. *K. Rule 2512* and *L. Rule*, 24 iii 2012 (MEL); Mitre-Nurcoung Road, c. 700 m from Fullers Road towards Mitre, 36° 41' 20" S. 141° 44' 30" E. *K. Rule 2612* and *L. Rule*, 24 iii 2012 (MEL); Start of access track to Nurcoung F.R., 36° 40' 50" S., 141° 44' 15" *K. Rule 11112* and *L. Rule*, 18 xi 2012 (MEL); Golf Course Road, on boundary of the Mt Arapiles section of the Mt Arapiles-Tooan S.P., 36° 46' 25"S., 141° 48' 30" E., *K. Rule 4913* and *J. Dowling*, 13 xi 2013 (MEL); Adjacent to Nurcoung F.R. on private land, 36° 41' 00 S., 141° 43' 40" E., *K. Rule 99103*, 11 xi 1999 (MEL); Access track on northern side of Mt Arapiles, 36° 44' 30" S.' 141° 50' 00" E., *K. Rule 5305*, 24 ix 2005 (MEL).

Figure 4: *Eucalyptus wimmerensis* subsp. *parviformis*. a. mallee form, Nurcoung F.R.; b. fruits, Nurcoung F.R.

Etymology: The specific epithet is derived from the Latin *parvius* 'small' and *formosus* 'form' which alludes to the many relatively small features of the subspecies.

Associated species: *Eucalyptus dumosa, E. leptophylla, E. phenax* subsp. *phenax, E. costata, E. calycogona* subsp. *calycogona* Turcz., *E. froggattii, E. macmahonii, E. wimmerensis* subsp. *wimmerensis, E. wimmerensis* subsp. *arapilensis, E. hawkeri* and the newly described *E. polybractea* susbp. *subcerea* have been observed as associated taxa. Along the Mitre-Nurcoung Road, to the west of the access track to the Nurcoung Flora Reserve, is a thicket of a large-fruited mallee-box which is morphologically consistent with the typical subspecies. On private land adjacent to the flora reserve small clumps of an unnamed mallee-box with glaucous, linear leaves occurs. Similar mallees are known from Mt Elgin. Also, in the Nurcoung Flora Reserve and in adjacent private land numerous apparent hybrids are present and appear to involve white mallees (*E. dumosa* or *E. phenax* subsp. *phenax*) and at least one of the associated subspecies of *E. wimmerensis*, *E. goniocalyx* subsp. *goniocalyx* F.Muell. ex Miq. and *E. leucoxylon* subsp. *stephaniae* also occur in close proximity to the new taxon. At Duff Reserve it occurs with *E. wimmerensis* subsp. *arapilensis, E. hawkeri* and *E. leptophylla* whilst at Mt Arapiles it occurs close to *E. arenacea, E. leucoxylon* subsp. *stephaniae, E. largiflorens, E. hawkeri* and *E. microcarpa*.

Conservation status: The new taxon occurs in small clumps or as individuals in the Nurcoung Flora Reserve and on adjoining private land, as well as along the adjacent Mitre-Nurcoung Road. Outliers occur at Jane Duff Reserve and Mt Arapiles. In the Nurcoung area the taxon is moderately abundant and estimated numbers are as high as 400 plants. Elsewhere its numbers are meagre but some unobserved plants may occur on adjacent private land that has not been accessed. Field observations suggest that within the area encompassed by Nurcoung, Mt Arapiles Jane Duff Reserve considerable habitat favoured by the taxon appears to have been lost to agriculture. Despite most of its numbers occurring within protected reserve, in accordance with IUCN (2001) guidelines, a status of endangered is recommended (EN A 2bc).

Notes: *Eucalyptus wimmerensis* subsp. *parviformis* is distinguished from the typical subspecies by its small, shrubby or whipstick habit, its smooth white to light grey bark, its smaller, more lustrous adult leaves and its smaller buds and fruits.

Eucalyptus wimmerensis subsp. *parviformis* closely resembles the associated, unrelated *E. leptophylla*, particularly as they are similar in habit, bark and adult leaves, as well as bud and fruit sizes. A close examination of their juvenile leaves, buds and fruits permits the two to be distinguished from each other. *Eucalyptus leptophylla* is distinctive in the field by its ovate, glaucous juvenile leaves, its reddish mature buds and its fruits featuring a descending whitish disc.

Eucalyptus wimmerensis subsp. *parviformis* could also be mistaken for a shrubby form of *E. viridis*, particularly because of its small, seasonally lustrous and greenish adult leaves and its small fruits. However, the two are separable at the seedling stage as *E. viridis* features narrower, greener more lustrous juvenile leaves and at the adult stage by *E. viridis* having a compact stocking of box-like bark, a generally taller habit, buds borne on longer pedicels and thinner-walled fruits. There are also similarities between the new subspecies and *E. aenea*, which occurs in the Goulburn River National Park of central New South Wales. However they differ by *E. aenea* having bark that is more colourful (copper-coloured), broader leaves at all stages, the adult leaves being lettuce-green, and fruits that are as wide as long (see Table 1).

1d. *Eucalyptus wimmerensis* subsp. *pallida* subsp. nov. Rule

Type: Victoria. c. 3.1 km west of Diapur on Nhill-Miram Road, 36° 19' 00" S. 141° 25' 05" E. *K.Rule 1012* and *L.Rule*, 24 iii 2012 (holotype: MEL 2419931; isotypes: AD, CANB, NSW).

Distinguished within *Eucalyptus wimmerensis* by the combination of its small, shrubby habit, its persistent, brownish box bark, which extends to mid-stem, its dull, bluish adult leaves and its generally smaller buds and fruits.

Small, shrubby, spreading *Mallees* 2–5 m tall, *Bark* grey- brown, box-like, flaky, persistent on the lower stem; smooth bark off-white, light grey or light brown, decorticating in short strips and plates. *Juvenile leaves* narrow-lanceolate, disjunct, petiolate, moderately crowded, dull, blue-green, slightly discolorous, 5–9 cm

long, 0.5–1 cm wide; petioles 0.5–1 cm long. *Adult leaves* narrow-lanceolate to lanceolate, slightly falcate, semi-erect, concolorous, dull, blue-green to sub-glaucous, slightly lustrous and greenish when new, 5–9 cm long, 0.9–1.4 cm wide; petioles terete, 0.6–1.2 cm long. *Inflorescences* 7–11-flowered; peduncles slender, 0.6–1.1 cm long. *Floral buds* ovoid, non-pruinose, 5–6 mm long, 3–4 mm wide; operculum conical, c. half the length of the hypanthium; pedicels short, slender, 2–3 mm long; filaments white. *Flowering period* autumn. *Fruits* hemispherical, cupular or slightly globular-truncate, thin-walled, 4–6 mm long, 4–5 mm diam.; pedicels slender, 1–2 mm long; disc descending; valves enclosed (Figure 5 and Table 1).

Distribution and habitat: *Eucalyptus wimmerensis* subsp. *pallida* is known from the Lawloit Range between Nhill and Kaniva in the north-western part of the Victorian Wimmera region where it grows on the slopes of laterite rises. A small number of shrubby mallee-boxes with sub-lustrous, bluish adult leaves has been observed in the Nurcoung area. Further investigation is required to determine whether these represent a southern disjunction of this taxon.

Additional specimen examined: Victoria: Diapur, Nhill-Miram Road, c. 50 m west of Diapur-Lawloit Road intersection, *K. Rule 0913* and *L. Rule*, 22 iii 2013, 36° 19′ 13″ S., 141° 27′ 00″ E (MEL)

Etymology: The subspecific epithet is derived from the Latin *pallidus* 'pale' and refers to the colour of the taxon's adult leaves.

Associated species: *Eucalyptus wimmerensis* subsp. *wimmerensis* and subsp. *grata*, E. *leptophylla*, *E. costata*, *E. dumosa* and *E. macmahonii*, have been observed as associated taxa. *E. arenacea*, *E. leucoxylon* subsp. *stephaniae*, *E. largiflorens* and *E. silvestris* also occur in the vicinity of the new taxon. Mallees believed to be intergrades between this new taxon and the typical subspecies have been observed at Mt Elgin, about 2 km to the south of Diapur.

Conservation status: *Eucalyptus wimmerensis* subsp. *pallida* is known only from two small occurrences in the Lawloit Range; about 3 km to the west of Diapur and at Diapur, with the total number of plants observed being approximately 40. It is highly likely that the taxon occurs on private land between Diapur and Mt Elgin where extensive areas of mallee-box exist. In accordance with IUCN (2001) guidelines, given the taxon's small numbers and restricted distribution, a status of critically endangered is recommended (CR B1ab (I, ii, iii, iv, v) + 2ab (I, ii, iii, iv, v) C2a(i): D).

Notes: *Eucalyptus wimmerensis* subsp. *pallida* could be mistaken for a form of *E. odorata*, given its persistent box bark and its dull, bluish foliage. However, it is considered here as closer to *E. wimmerensis* mainly on the basis of its smaller mallee habit (*E. odorata* usually being a tree or large mallee), its narrower juvenile leaves, which are inseparable from those of typical *E. wimmerensis*, and its smaller adult leaves, buds and fruits (fruits of *E. odorata* to 8 mm long, 7 mm diam.).

Eucalyptus wimmerensis subsp. *pallida* differs from the typical subspecies primarily by its smaller, more shrubby habit, its substantial stocking of brownish box bark, its duller, bluish adult leaves and generally smaller fruits.

Figure 5: *Eucalyptus wimmerensis* subsp. *pallida*. a. mallee, W of Diapur; b. branchlet, Diapur.

Initially, the new taxon was considered an outlier of *E. polybractea* subsp. *subcerea*, particularly as its canopy consists of dull, bluish leaves. However, its buds and growth tips are never pruinose. It further differs from that taxon which has more colourful bark, the stocking of persistent box bark being greyish and the smooth bark becoming coppery and lustrous (see Table 1).

Eucalyptus wimmerensis subsp. *grata* subsp. nov. Rule

Type: Victoria: 3.2 km west of Diapur on Nhill-Miram Road, 36° 19'01"S., 141° 25'02"E., *K. Rule 2508*, 15 viii 2008 (holotype: MEL 2419936; isotypes: AD, CANB, NSW).

Distinguished within *Eucalyptus wimmerensis* by its tallish habit, its short stocking of box bark, its relatively large, often falcate, juvenile leaves, its relatively long, lustrous and green, pendulous adult leaves, its consistently 7-flowered inflorescences and its elongated fruits.

Habit mallee or rarely a single-stemmed slender tree, 5–12 m tall. *Bark* dark smooth light brown, darkening with age; persistent light, grey-brown, flaky, box-type bark forming a short basal stocking or rarely smooth throughout; old smooth bark decorticating in dark brown strips. *Juvenile leaves* narrow-lanceolate to lanceolate, falcate, disjunct, petiolate, discolorous, dull blue-green, 7–12 cm long, 0.7–1.8 cm wide; nodes moderately crowded; petioles 0.6–1.2 cm long. *Adult leaves* narrow-lanceolate to lanceolate, often falcate, pendulous, acuminate, uncinate, lustrous, green, coriaceous, 7–12 cm long, 1–2 cm wide; petioles terete, 0.6–1.5 cm long; new season's growth tips lustrous and green. *Inflorescences* 7-flowered; peduncles angular or terete, slender, 0.6–1.1 cm long. *Floral buds* clavate to sub-pyriform, basally ribbed and tapered, often lustrous, red-brown at maturity, 6–8 mm long, 3–4 mm wide; operculum conical, c. half the length of the hypanthium; pedicels angular, 3–5 mm long. *Flowering period* autumn. *Fruits* cupular, sub-pyriform, sub-cylindrical, tapering into the pedicel, basally ribbed, 6–8 mm long, 4–6 mm diam.; pedicels angular, 2–4 mm long; disc descending; valves enclosed (Figure 6 and Table 1).

Distribution and habitat: *Eucalyptus wimmerensis* subsp. *grata* is known from a few locations in the north-western Wimmera in the Lawloit Range, namely west of

Figure 6: *Eucalyptus wimmerensis* subsp. *grata*, W of Diapur. a. tree; b. branchlet; c. basal bark.

Diapur and from Diapur and Mt Elgin, where it grows on shallow sandy soils over a laterite substrate.

***Additional specimens examined*:** Victoria: Diapur, near the intersection of the Nhill-Miram Road and the Diapur-Lawloit, 36° 19' 14" S., 141° 27' 07" E, *K.Rule 5413*, 14 xi 2013 (MEL); Mt Elgin, west of Nhill, on the southern side of the Western Highway, 36° 24'00"S., 141° 29'30"E., *K.Rule 5813* and *J. Dowling*, 14 xi 2013 (MEL); Diapur-Lawloit Road, south of Rogers Road, 36° 21'S., 141° 26'E, *K.Rule 0216*, 17 iii 2002 (MEL)

***Associated species*:** At the type locality for *E. wimmerensis* subsp. *grata* and at Diapur it grows with *E. dumosa*, *E. costata*, *E. wimmerensis* subsp. *wimmerensis* and subsp. *pallida*, *E. macmahonii*, and *E. leptophylla*. A suspected hybrid with *E. wimmerensis* subsp. *pallida* was detected in one of the early seedling trials. Other species including *E. arenacea*, *E. leucoxylon* subsp. *stephaniae*, *E. silvestris*, *E. calycogona* subsp. *trachybasis* and *E. goniocalyx* subsp. *goniocalyx* also occur in the immediate area. At Diapur it is associated with *E. wimmerensis* subsp. *wimmerensis* and subsp. *pallida* and *E. leptophylla*. At Mt Elgin *E. wimmerensis* subsp. *wimmerensis*, *E. costata*, *E. dumosa*, *E. phenax* subsp. *phenax* and an unnamed, low-growing, glaucous mallee-box, which is currently under study, are associates.

***Etymology*:** The subspecific epithet is derived from the Latin gratis 'pleasing' which alludes to elegant appearance of the taxon.

***Conservation status*:** The type population occurs to the west of Diapur, both at the edge of the Nhill-Miram Road and on private property in a block about 2 hectares of a well-preserved natural, mallee-dominated community. Whilst only about 35 plants have been observed at the type locality, it is possible that other occurrences exist on private property in the area. From Diapur and Mt Elgin its numbers are also meagre and not fully known. In accordance with IUCN(2001) guidelines a status of critically endangered is recommended (CR A2ce; B1 (i,ii,iii.iv,v) + C2a (I,ii):D)

***Notes*:** *Eucalyptus wimmerensis* subsp. *grata* is distinguished in the field from the type subspecies of *E. wimmerensis* mostly by its tallish habit and its relatively broad, falcate, green, coarse, lustrous, pendulous adult leaves. Also, whilst its juvenile leaves are larger than those of other subspecies, they are considered not fundamentally divergent from the species. Thus, the new taxon is here assigned the rank of subspecies.

Similarities between *E. wimmerensis* subsp. grata and *E. hawkeri*, particularly in the pendulous nature of their adult foliage, necessitated a re-examination of the latter. Whilst there is some overlap in juvenile leaf morphology, with those of the latter being broader, sub-glaucous and rarely falcate, the two differ appreciably in habit, bark, adult leaves, buds and fruits. *E. hawkeri* is taller and usually a tree (some recently located trees grow up to 20 tall) with substantially more rough bark, adult leaves that have a bluish tinge and become duller in winter and slightly smaller buds and fruits (fruits of *E. hawkeri* 5–7 mm long, 3–5 mm diam.).

Initially, because of its lustrous and green adult leaves *E. wimmerensis* subsp. grata was considered to be an aberrant broad-leaved, large-fruited form of *E. viridis*. However, close examinations both in the field and of nursery-grown seedlings discounted that connection. *Eucalyptus viridis* differs from *E. wimmerensis* subsp. *grata* by its stocking of thin, dark grey, compact, box-type bark, its narrower, more lustrous juvenile leaves, its smaller, semi-erect adult leaves and its smaller buds and fruits.

2. *Eucalyptus polybractea* R.T. Baker, *Proc. Lin. Soc. New South Wales* 25, 692 (1901)

Type: New South Wales. West Wyalong, Dec. 1900 R.H. Cambage s.n. (holotype: NSW 333432 isotypes: K).

Syn. *E. fruticetorum* auct. non F.Muell. ex Miq W.F. Blakely, Key *Eucalyptus* 228 (1934).

Populations of the species occur in three markedly disjunct regions; in New South Wales in the West Wyalong area, Victoria in the North-central, West-central and Wimmera regions and South Australia in the Northern Flinders Ranges. Various authorities including Brooker and Kleinig (1990) and Nicole (1997) regarded the South Australian populations as a separate species but Nicolle (2013) reassessed them as *E. polybractea*.

Eucalyptus polybractea is distinguished within the mallee-boxes by its often few-stemmed mallee habit, its

Key to the subspecies of *Eucalyptus polybractea*

1 Adult parts conspicuously pruinose ..... subsp. ***polybractea***

1: Growth tips and buds faintly pruinose at anthesis ..... subsp. ***subcerea***

variable stocking of grey to brown persistent box bark and off-white to copper-coloured upper smooth bark, its linear-lanceolate to narrow-lanceolate, moderately crowded, glaucous juvenile leaves, its narrow-lanceolate to lanceolate, blue-grey or glaucous adult leaves, its pedicellate, ovoid or fusiform buds and its cupular, sub-cylindrical or barrel-shaped fruits (4–7 mm long, 4–7 mm diam.). Above all, the species is distinguished by its glaucous juvenile leaves, its copiously pruinose branchlets, petioles, buds and immature fruits and its dull, blue-grey to glaucous adult leaves.

Eucalyptus polybractea is closely related to *E. odorata* which is mostly a spreading, rough-barked, dull-leaved tree confined to South Australia. As well as habit, bark and leaf morphology, *E. odorata* differs from *E. polybractea* by rarely having lightly pruinose buds and having generally larger buds and fruit. Further, on the basis of seedling morphology, it is my view that *E. polybractea* is also a close relative of *E. wimmerensis*.

Rule (2011) alluded to a form of mallee-box occurring in the southern Wimmera, which has been regarded as a form of *E. wimmerensis*, as having links with *E. polybractea*. Further research, as described above, has confirmed this and it is here described as a subspecies of *E. polybractea*. The rationale for this decision rests with its development of glaucous pre-adult leaves and it showing faint pruinosity in its buds and growth tips during the flowering period. Its taxonomic treatment as a form of *E. polybractea* further facilitates the clarification of the *E. wimmerensis* complex.

2a. *Eucalyptus polybractea* subsp. *polybractea*

Few-stemmed *Mallees*, occasionally dense and shrubby, or rarely slender trees 4–15 m tall. *Bark* variable, usually persistent dark, grey-brown, box-type present on lower stem, rarely higher, or rarely smooth throughout; smooth bark light grey or brown, seasonally lustrous, grey to pink or copper-coloured; old bark deciduous in short ribbons and plates. *Seedling leaves* narrow-elliptical, decussate, sessile for a few pairs. *Juvenile leaves* narrow-lanceolate to lanceolate, semi-erect, petiolate, disjunct, moderately crowded, dull, sub-glaucous to glaucous, 4–10 cm long, 0.8–1.5 cm wide; petiole length 0.5–1.5. *Intermediate leaves* usually broader than juvenile leaves, sub-glaucous to glaucous. *Adult leaves* narrow-lanceolate or lanceolate, acuminate, uncinate, concolorous, dull, blue-grey or glaucous, semi-erect, coriaceous, 5–10 cm long, 0.8–1.8 cm wide, petioles to 0.9–1.6 cm long; venation moderately sparse with conspicuous lateral veins; intramarginal vein c. 1 mm from margin; oil glands irregular, island. *Inflorescences* simple, axillary, 7–11-flowered, along the main axis or along leafy terminal branchlets; peduncles slightly angled, 0.6–1.2 cm long. *Floral buds* ovoid to fusiform, shortly pedicellate, non-scarred (petaline and sepaline opercula intact), conspicuously pruinose at maturity, 4–7 mm long, 3–4 mm diam.; pedicels 3–6 mm long; operculum conical or slightly obtuse, shorter than the hypanthium; hypanthium basally tapered, faintly angled; filaments white, irregularly flexed, all fertile;

Figure 7: *Eucalyptus polybractea* subsp. *polybractea*, Inglewood. a. adult foliage; b. seedling, Inglewood.

anthers adnate, basifixed, globoid, dehiscing through sub-terminal pores; locules 3–4; ovules in 4 vertical rows. *Flowering period* early autumn. *Fruits* cupular or sub-cylindrical, shortly pedicellate, round in cross-section, 4–7 mm long, 4–7 mm diam.; walls moderately thick; immature fruits pruinose; mature fruits often burgundy-coloured; pedicels 2–5 mm long; disc descending; valves enclosed. *Fertile seeds* mid to dark brown, ovoid to slightly cuboid; dorsal surface shallowly reticulate; hilum ventral (Figure 7, Table 1).

Distribution and habitat: The typical subspecies occurs in New South Wales in the West Wyalong area, in Victoria it is widespread in the North-central and West-central regions, where it is usually a common species on dry, stony rises, and in South Australia it is restricted to similar sites in the northern Flinders Ranges.

Associated species: In New South Wales the species is often associated with other mallee species including *E. viridis, E. behriana* F. Muell., *E. dumosa* and *E. dwyeri* Maiden & Blakely and the species occurs close to *E. dealbata* Cunn. ex Schauer and *E. sideroxylon* Cunn. ex Woolls subsp. *sideroxylon.* In Victoria, where it is much more widespread it has contact with *E. viridis, E. froggattii, E. behriana , E. leptophylla, E. calycogona* subsp. *trachybasis, E. porosa* F.Muell. ex Miq., *E. tricarpa* subsp. *tricarpa* (L.A.S. Johnson) L.A.S. Johnson and K.D. Hill, *E. microcarpa, E. macrorhyncha* F.Muell. ex Bentham *and E. polyanthemos* subsp. *marginalis* K.Rule. In South Australia its associates include *E. odorata, E. socialis* subsp. *socialis* F.Muell. ex Miq., *E. flindersii* Boomsma, *E. percostata* Brooker and Lang, *E. dumosa, E. porosa* and *E. cajuputea.*

Conservation status: In South Australia Nicolle (2013) indicates that *E. polybractea* subsp. *polybractea* is rare and in New South Wales it is reported as rare but in abundance where it occurs. In Victoria the taxon is both the dominant species and in abundance in areas such as Bendigo, Inglewood, Wedderburn and St Arnaud, its numbers being estimated as in excess of 50,000 plants. Elsewhere it exists in small fragments. Few data are available regarding the reduction of its range since European settlement but in Victoria, at least, significant losses to farming are apparent. At this stage there are no indications that its numbers will decline in the immediate future. However, should any catastrophic events occur, such as regular wildfires or habitat degradation due to climatic change or changed conservation policies in the face of a demand for more farming land, its numbers may come under threat. In accordance with IUCN (2001) guidelines a status of vulnerable is recommended (VU A2bc+4bc).

Notes: Victorian populations of typical *E. polybractea* occurring in the Bendigo, Kamarooka and Inglewood areas, as well as parts of Wedderburn, are morphologically consistent with those of the type locality. However, at the western fringes of this distribution at locations such as at St Arnaud, Tottington, Bolangum, Boort and the Jeffcott Range are several forms showing varying levels of divergence in habit, bark and fruit size. Some tallish forms, such as at Bolangum and Tottington have been erroneously regarded as *E. odorata.* Others, such as near Boort, to the south-east of Wedderburn and at St Arnaud, have substantial stockings of box bark. Also at Boort are some mallees with greenish adult leaves which are suspected as being intergrades involving *E. viridis.* In the St Arnaud area there a few stand with relatively large fruits (to 7 mm diam.). A form occurring at Moorl Moorl is almost smooth-barked and has broader juvenile leaves than typical, whilst a remnant stand of mallees on the ridge of the Jeffcott Range is substantially box-barked and dwarf and shrubby in habit, together with relatively small adult leaves, buds and fruits. All of these forms exhibit conspicuous pruinosity in seedlings and adult structures consistent with the typical form and are currently considered a part of that taxon. None of these forms should be confused with *E. yarriambiack* which is a spreading, thick-stemmed tree with faintly pruinose buds and growth tips at anthesis and normally a canopy dominated by lustrous and green adult leaves. Nor should they be confused with *E. filiformis* which, although being box-barked and having bluish adult leaves, has linear, blue-green juvenile leaves and non-pruinose adult structures.

2b. *Eucalyptus polybractea* subsp. *subcerea* subsp. nov. Rule

Type: Victoria. Lower Norton-Nurrabiel Road, 3.7 km S of Lower Norton, 36° 49′ 07″ S., 142° 04′ 21″ E., *K.Rule 0231*, 5 iv 2002 (holotype: MEL 2419944; isotypes: AD, CANB, NSW).

Distinguished from the type of *Eucalyptus polybractea* by its dull, blue-green adult leaves, its faintly pruinose

growth tips and mature buds at anthesis, and its generally smaller more compact buds and fruits.

Mallees slender-stemmed, occasionally dense and shrubby, 4–8 m tall. *Bark* box-like, thin, dark grey-brown, often crusty, usually persistent to at least mid-stem; shrubby forms almost smooth-barked; smooth bark light brown to copper-coloured and lustrous; old bark deciduous in short ribbons and plates. *Juvenile leaves* linear-lanceolate to narrow-lanceolate, semi-erect, petiolate, disjunct, moderately crowded, discolorous, initially sub-glaucous; becoming increasingly glaucous as the seedlings develop, 5–9 cm long, 0.6–1.3 cm wide; petioles 0.6–1.3. *Adult leaves* narrow-lanceolate or lanceolate, acuminate, uncinate, concolorous, dull, blue-green, new spring growth slightly lustrous and green but becoming dull and blue-green by anthesis, semi-erect, coriaceous, 5–9 cm long, 0.9–1.6 cm wide, petioles 1–1.6 cm long. *Inflorescences* 7–11-flowered; peduncles slightly angled, to 0.8–1.4 cm long. *Floral buds* ovoid, shortly pedicellate, faintly pruinose at maturity, 5–6 mm long, 3–4 mm diam.; pedicels 2–4 mm long; operculum conical or slightly obtuse, shorter than the hypanthium; hypanthium basally tapered, faintly angled; filaments white. *Flowering period* early autumn. *Fruits* hemispherical to cupular, shortly pedicellate, 4–6 mm long, 4–5 mm diam.; walls moderately thick; mature fruits often burgundy-coloured; pedicels 1–2 mm long; disc descending; valves enclosed (Figure 8 and Table 1).

Distribution and habitat: *Eucalyptus polybractea* subsp. *subcerea* occurs in the Wimmera region of Victoria on laterite rises in most mallee communities to the south of the Little Desert. Its numbers far exceed those of other mallee-boxes in the areas where it occurs.

Additional specimens examined: **Victoria.** Smith Reserve, SW of Horsham, 36° 50' 13" S., 142° 05' 30" E., *K.Rule 0234*, 5 iv 2002 (MEL); Lower Norton-Nurrabiel Road, 6.8 km S of Lower Norton, 36° 50'41"S., 142° 03'47"E., *K.Rule 0230*, S iv 2002 (MEL); Tooan Scrub, 36° 47' 05" S. 141° 43' 15" E. *K.Rule 9445*, 8 iv 1994 (MEL) west base of Mt Arapiles, 36° 42' 00" S., 141° 53' 00" E. *K. Rule 0221* and *V. Stajsic* (MEL); Mitre-Nurcoung Road 36° 41' 14" S. 141° 44' 32" E. *K.Rule 2412* 24 iii 2012 (MEL); Blake's Road, SW of Tooan, 4.2 km E of Womimera Hwy, 36° 50' 55" S., 141° 46' 05" E. *K.Rule 13706* 3 x 2006 (MEL).

Figure 8: *Eucalyptus polybractea* subsp. *subcerea*. a. mallee, Nurcoung F.R.; b. coppice leaves, Nurcoung F.R.; c. buds, Lower Norton.

Etymology: The epithet is derived from the Latin *sub* 'less than' and *cereus* 'waxy' which alludes to faint level of glaucousness which develops during the flowering season.

Associated species: *Eucalyptus wimmerensis* subspp. *wimmerensis, arapilensis* and *parviformis, E. hawkeri, E. behriana , E calycogona* subspp. *calycogona* and *trachybasis, E dumosa, E. macmahonii, E. phenax* subsp. *phenax, E. leptophylla, E. costata, E. goniocalyx* subsp. *goniocalyx* and *E. leucoxylon* subsp. *stephaniae* are associates whilst *E. microcarpa, E. arenacea* and *E. largiflorens* often occur nearby. In the Nurcoung area, in the Nurcoung Flora Reserve and in adjacent private land, as confirmed by progeny trials, numerous hybrids involving *E. dumosa* and/or *E. phenax* subsp. *phenax* and constituent mallee-boxes occur, as do two other unnamed entities with mallee habits that are currently being investigated.

Conservation status: Where *E. polybractea* subsp. *subcerea* occurs it is usually the dominant mallee species. Despite this, its numbers appear to have been drastically reduced by clearing for agriculture to the extent it is now confined to remnants along roadsides, on farms and in a few protected reserves such as the Mt Arapiles-Tooan State Park, Nurcoung Flora Reserve and Smith's Reserve. The exact numbers are not known but it is estimated that as many as 4500 plants exist. In accordance with IUCN (2001) guidelines, on the basis its numbers having been severely depleted by clearing for agriculture, the taxon is considered endangered (EN A2ce)

Notes: The morphology of the new subspecies might suggest it occupies a position that is intermediate between *E. wimmerensis* and *E. polybractea.* There is a reasonable case on historical grounds for recognising it as a subspecies of the former as it has been regarded as a southern extension of that species from the time of its erection. Without knowledge of the light pruinosity of its growth tips and buds at anthesis and its seedlings, this new taxon could be mistaken for a dull-leaved form of *E. wimmerensis.* Further, the examination of dried herbarium materials may be of little use, particularly if the collections were made at a times other than when flowering occurred. Despite this, the glaucous seedlings and the display of light seasonal pruinosity of the adult plants indicate a link with *E. polybractea.* Thus, the taxon is more appropriately recognised as a subspecies of that species.

As stated above, the seedlings of the new taxon raised in seedling trials are not morphologically separable from those of forms of *E. wimmerensis* in early seedling development. However, as the seedlings mature they follow similar patterns of typical *E. polybractea* by producing glaucous new leaves. In the field, where its seedlings are subjected to more rigorous environmental pressures, the display of glaucousness is more apparent (see Figure2).

Where *E. polybractea* subsp. *subcerea* coexists with subspecies of *E. wimmerensis* (subsp. *wimmerensis* and subsp. *parviformis*), it is usually distinguished from those mallee-boxes by its duller adult leaves and substantial stocking of grey, box bark and lustrous, copper-coloured upper bark, which contrasts appreciably from their smooth or mostly smooth off-white or light grey bark.

Notes on the taxonomies of Victorian Mallee-boxes

There has been a reluctance in some quarters outside Victoria not to accept any of the recently described Victorian rare and threatened mallee-box entities, namely *E. wimmerensis, E. silvestris, E. hawkeri, E. walshii, E. filiformis* and *E. yarriambiack,* despite there being sufficient evidence to support their erections. In many cases assessments have been published without adequate comment, particularly with reference to whether they are underpinned by rigorous field studies and progeny trials. Although these taxa have been widely accepted in Victoria, their legitimacies have been brought into question in texts published for popular consumption. This situation has the potential for confusion, particularly for those who work with eucalypts in areas of conservation, vegetation survey and revegetation. Thus, notes clarifying the morphologies and taxonomies of these contentious taxa are provided below. These notes are also considered relevant to the study reported here as all are related to or associated with *E. wimmerensis.* As the integrity of *E. wimmerensis* and its relationship with *E. viridis* have been discussed above, the notes focus on *E. silvestris, E. hawkeri, E. walshii, E. filiformis* and *E. yarriambiack.*

Eucalyptus silvestris

Eucalyptus silvestris was erected to accommodate box-barked, small trees and robust mallees occurring in the north-western Wimmera and adjacent areas of South Australia in the vicinity of Bordertown. In the initial description comparisons were made with *E. odorata* on the basis of these populations having been regarded as eastern outliers of that species. In its treatment *E. silvestris* was given as being related to *E. odorata,* not only because of similarities in habit and bark, but because of its simple, axillary inflorescences, and was given as differing from *E. odorata* primarily by its greener adult leaves and its generally smaller buds and fruits. Brooker and Slee (1997) regarded *E. silvestris* as a depauperate, narrow-leaved form of *E. microcarpa* and merged it with that species, despite differences in inflorescence structure, those of *E. microcarpa* being terminal panicles. It should be noted that Brooker and Slee (1997) in their account of *E. microcarpa* did not acknowledge the distinctiveness of *E. silvestris* by making reference to *E. microcarpa* only having compound, terminal panicles. Their interpretation was adopted by EUCLID (2006). Subsequent investigations by this author found that the adult leaf venation patterns and oil glands of *E. silvestris* are similar to those of *E. microcarpa,* being densely reticulate with scattered intersectional glands, and differing from the moderately sparse reticulation with numerous island glands present in the adult leaves of *E. odorata,* as given by Brooker and Kleinig (1990). Although *E. silvestris* appears to be related to *E. microcarpa* on the basis of leaf morphology, it is regarded as being different, not only in its inflorescence structure but in its smaller, sometimes mallee-like habit, its narrower juvenile leaves (1.5–3 cm wide compared with 3–6 cm wide) and its narrower, greener, more lustrous adult leaves (to 2 cm wide compared with to 3 cm wide).

Nicolle (1997), (2006) (2013) and (2015) regarded *E. silvestris* as conspecific with *E. odorata* without addressing any of the differences between the two given in the original description by Rule (1994 and 2012), particularly with regard to adult leaves and fruits. Nor did he address the assessment of *E. silvestris* being a form of *E. microcarpa* given by Brooker and Slee (1997).

More recent investigations have shown a further difference between *E. silvestris* and *E. odorata* in their adult leaves with regard to the colour and lustre of new leaves produced in growing periods. Nicolle (2006) and (2013) and Brooker and Kleinig (1990) noted that the new adult leaves of *E. odorata* are dull and bluish and in time age to become sub-lustrous and green. In contrast, the new leaves of *E. silvestris*, being similar to those of *E. microcarpa*, are lustrous and green and become duller and slightly bluish as they age. This dullness is particularly apparent in winter. These differences in leaf morphology, along with differences in bud and fruit sizes, are considered sufficient to continue to regard *E. silvestris* as separate from and distantly related to *E. odorata.* At the same time, for the reasons given above, it is seen as being related to but separate from *E. microcarpa.*

Within western Victoria, in the Inglewood area, at Mt Jeffcott and in the southern part of the Wimmera, there are small populations of a grey box with narrow, seasonally glossy adult leaves and minute buds and fruits which might be interpreted as *E. silvestris,* or even *E. odorata.* These, however, have paniculate inflorescences and, although more or less consistent with the recently resurrected *E. woollsiana,* require more study to determine their identity.

Eucalyptus hawkeri

Eucalyptus hawkeri Rule (2004) was erected to accommodate populations of box-barked trees occurring at Mt Arapiles and in the nearby Jane Duff Reserve. More recently, however, it has been located in many mallee communities in the southern Wimmera. The combination of features which distinguish *E. hawkeri* from other box species in the region include its slender, erect, tree-like habit, its substantial stocking of rough bark, its narrow-lanceolate to ovate-lanceolate, blue-green or sub-glaucous juvenile leaves, its narrow-lanceolate to lanceolate, pendulous adult leaves, which when new are lustrous and green with a bluish tinge, its simple, axillary inflorescences and its relatively small buds and fruits. In the field the species is distinguished from related mallee-box taxa by its habit, bark and foliage.

EUCLID (2006) listed *E. hawkeri* as conspecific with *E. viridis.* This assessment was confusing as the two do not even remotely resemble each other in seedling and adult characters. Perhaps the authors have confused

one of the segregates of *E. wimmerensis* occurring at Mt Arapiles with *E. viridis*.

Nicolle (2006) assessed *E. hawkeri* as being a hybrid between *E. microcarpa* and *E. wimmerensis* and supported his assessment by referring to trees along the access road to the summit of Mt Arapiles as hybrids and representative of *E. hawkeri*. It must pointed out that, prior to the species being published, those same trees were examined, along with countless others in and adjacent to the Mt Arapiles reserve, and were regarded as being *E. microcarpa*. Further, no reference to those particular trees was made in the manuscript for the treatment of the species.

Recently, Nicolle (2015) adjusted the status of *E. hawkeri* to that of being an intergrade between *E. wimmerensis* and *E. microcarpa*. This implies that the many small occurrences that occur both at Mt Arapiles and adjacent sites should exhibit a range of forms that do not diverge beyond the morphological boundaries set by the two reputed parents. None of this fits *E. hawkeri* which has a combination of distinctive features, as described above, is uniform both within and between its populations. As well, repeated progeny trials of seed-lots from its well dispersed populations have overwhelmingly indicated that it is true-breeding. Furthermore, *E. wimmerensis* and *E. microcarpa* are not only distantly related box species but have markedly contrasting morphologies; one being a medium-sized tree with broad leaves at all stages and paniculate inflorescences and the other a mallee with narrow leaves at all stages and simple, axillary inflorescences. It is highly likely that any population derived from these taxa would consist of an assortment of individuals and stands exhibiting a diverse range of features.

However, since the discovery of *E. hawkeri*, small occurrences of hybrids with *E. wimmerensis* subsp. *arapilensis* have been identified through field observations and seedling trials at Mt Arapiles near its north-eastern base and on the south-west side of the mountain and with *E. microcarpa* to the north-east of the mountain, including the Mitre Rock area. Also a small stand of suspected hybrids with *E. microcarpa*, which feature paniculate inflorescences, has been observed at Lower Norton. A seedling trial indicated that a single spreading mallee occurring in Jane Duff Reserve is a hybrid with *E. wimmerensis* subsp. *arapilensis*. No hybrids have been observed at other sites where the species occurs.

Recent surveys have located populations of *E. hawkeri* in mallee-box dominated communities in the southern Wimmera in addition to Mt Arapiles and Jane Duff Reserve, where the species was originally observed. Such locations include Nurcoung, Lower Norton, Smith's Reserve, the Tooan Mallee and south-east of Tooan along Blakes Road. As well, additional stands have been located at Mt Arapiles where the species was reported as occurring in relative abundance in 2004. These include a small stand of trees growing on the south-western side of the mountain, where some individuals are up to 20 m tall, and a large stand of scores of spindly trees less than 10 m tall growing on a rocky rise on its northern side. The estimated number of plants of *E. hawkeri* now exceeds 1000.

Eucalyptus yarriambiack

Eucalyptus yarriambiack Rule (2012) was described as occurring on well-drained loams adjacent to the Yarriambiack Creek to the north of Brim. Its morphology is generally consistent with the mallee-boxes of the *E. odorata* complex and includes the following distinguishing features; its small, robust, single or few-stemmed, spreading tree with a substantial stocking of box bark, its narrow-lanceolate to elliptical, dull, blue-green juvenile leaves, its small, seasonally lustrous, green adult leaves with a moderately sparse reticulation and island glands, its simple, axillary inflorescences, its small, unscarred buds, which become faintly pruinose at anthesis, and its small, thick-walled fruits. Largely, on the basis of its juvenile leaves, it was regarded as being closest to *E. wimmerensis*. However, with a more recent evaluation of its morphology, it appears to have a closer affinity with *E. polybractea*. The species, which consists only of about 150 plants, is relatively isolated from other so-called mallee-box taxa, with populations of *E. wimmerensis*, the contentious *E. silvestris* and *E. polybractea* being absent from the area where it occurs. *E. odorata*, with which has been associated is not considered to occur in Victoria (Rule 1994).

The distribution of *E. yarriambiack* is more or less parallel to stands of *E. largiflorens* which grow exclusively in heavy soils along the Yarriambiack Creek. However, scattered occurrences along minor roads off the

Henty Highway, including Wardles Road East, Wardles Road West and Starrocks Road, suggest that the pre-settlement range was more extensive.

As was given in its treatment, *E. yarriambiack*, is superficially similar to *E. largiflorens* in habit and bark, as well as adult leaf, bud and fruit sizes. In other characters, however, the two are readily separable with *E. largiflorens* having seedlings with longer, linear juvenile leaves, duller, bluish rather than green adult leaves, which are densely reticulate with small intersectional glands, compound inflorescences, buds with an operculum scar and thin-walled fruits.

Nicolle (2015) listed *E. yarriambiack* as a hybrid between *E. largiflorens* (black box) and *E. odorata* (peppermint box) with the footnote, 'based on the type plant'. The statement is ambiguous. If, as was claimed, he conducted field studies and seedling trials, it is puzzling as to why he did not make an assessment based on the entire population whose plants are located in close proximity to the type plant and easily accessible?

Whilst it is unclear, from Nicolle's assessment, whether *E. yarriambiack* is meant to be a hybrid swarm of recent origin or a long-established, stabilised hybrid, it is maintained here, on the basis of progeny testing, that the designated type plant of *E. yarriambiack* is typical of the population and does not reflect hybridism. If the taxon is a recent hybrid it would be expected that the population would be highly variable with an assortment of forms whose morphologies reflect both mallee-box and black box influences both in its seedlings and adult plants. The decisions regarding the taxonomy of *E. yarriamblack* were based on observations gathered from comprehensive field work and progeny trials, all of which indicated that it is a morphologically uniform and true-breeding entity with only mallee-box features. Within the entire population no individual has been observed that could be construed as a hybrid, despite the close proximity of *E. largiflorens*.

Eucalyptus yarriambiack as a stabilised hybrid has slightly more credence, given its uniformity, morphological distinctiveness and its capacity to replicate itself. However, even this line of speculation is questionable. To achieve its current mallee-box state, it would have needed a lengthy period of selection and divergence, whereby many traces of *E. largiflorens* were eradicated and its current morphological state and its capacity to breed true were achieved. As well, during this period, breeding barriers must have been established, given there is no evidence of recent, chance hybridisation.

The involvement of *E. odorata* as the other reputed parent presumably refers to *E. silvestris* which, as stated elsewhere, Nicolle claims is conspecific with *E. odorata*. The closest population of *E. silvestris* occurs about 70 km to the west, between Nhill and Yanac but it is conceivable that it may have been present in the Yarriambiack area at a time when different environmental conditions prevailed. However, to consider that *E. silvestris* is one of the reputed parents of a presumed hybrid is inappropriate as its adult leaves, like those of *E. largiflorens*, are densely reticulate with intersectional glands and not consistent with those of the mallee-boxes of the *E. odorata* complex. Thus, it seems unlikely that *E. yarriambiack* could have inherited an adult leaf morphology which would have been absent in both the reputed parents at the time of the hybridisation event.

Eucalyptus walshii

Eucalyptus walshii Rule (2004) is regarded as a relictual species being represented by about 30 plants which occur in two small stands near Broughton's Waterhole in the central section of the Little Desert National Park. It is distinguished by its habit of a small, slender, single-stemmed tree with no apparent lignotuber to about 10 m tall, its sparse crown, its smooth bark throughout, the bark being off-white to slightly yellow, its relatively broad, dull, blue-green juvenile leaves (to 2.3 cm wide), its lanceolate or ovate-lanceolate, blue-green, dull to sub-lustrous adult leaves (to 2.6 cm wide), the adult leaves also having a venation pattern with faint areoles and small, mostly island glands, and its relatively small, clavate buds and cupular fruits with a relatively broad orifice. Differences between *E. walshii* and typical *E. wimmerensis* are most apparent in a range of vegetative structures, the latter being a true mallee, not tree-like, having a dense rather than an open canopy, usually having some basal box-type bark with the upper smooth bark being grey or brown and darker, having narrower juvenile leaves (to 1.5 cm wide) and narrower, greener, adult leaves (to 1.6 cm wide) with a moderately sparse venation pattern and relatively large island glands.

Initially, the habit of *E. walshii* was problematical, as to whether it is a tree or a mallee. Field observations indicated that the population contains a few seedlings and saplings, several immature trees and a few apparently mature trees to about 10 m tall, all of which are haphazardly distributed with some plants occurring close to each other and others being well segregated individuals. This is not consistent with a typical mallee pattern where several, usually symmetrically distributed stems arise from a large underground lignotuber. All the naturally occurring plants of *E. walshii* appear to be single-stemmed and despite the conditions in which they grow, are not dependent on lignotubers for regeneration.

It has been considered that *E. walshii* might be a hybrid between *E. wimmerensis* and another box species occurring in the Wimmera region, possibly *E. microcarpa*, *E. silvestris* or *E. porosa*. None of these are known to occur in the Little Desert proper and all have attributes not found in *E. walshii*, for example, substantial stockings of box bark and, as with *E. wimmerensis*, the ability to develop lignotubers. If the hybrid scenario were correct, it would be expected that *E. walshii* would be variable across a range of characters in both seedlings and adult plants and reflect influences derived from its antecedents. Of course, it might be argued that to achieve its current disposition it would have had to undergone a lengthy period of selection and divergence. Whatever, its origins, the fact remains that *E. walshii* is a distinctive entity that is capable of replicating itself.

Nicolle (2006), in claiming that *E. walshii* is a minor variant of *E. wimmerensis* noted, 'A few abnormally broad-leaved individuals of *E. wimmerensis* from Broughton's Waterhole in the Central Block of the Little Desert have been recently named as *E. walshii* (Rule 2005), but it is not considered distinct here. The slight differences from *E. wimmerensis* may be related to environmental factors'. This assertion is flawed as both *E. wimmerensis* and *E. walshii* grow adjacent to each other in the same soil on the same sandy rise. In this context *E. walshii* is clearly distinctive by its habit, crown density, bark and leaves. In contrast, the adjacent plants of *E. wimmerensis* are true mallees with the morphology that characterises that species. Furthermore, differences between the two, particularly in juvenile leaf width, have been confirmed by progeny trials and in cultivated plants, one which is displayed in Melbourne Gardens, Royal Botanic Gardens Victoria. Lastly, Nicolle (2015) is inconsistent in not accepting *E. walshii* as being separate from *E. wimmerensis* on the basis of differences in habit and other characters when he accepts the segregation of other taxa; *E. dendromorpha* (Blakely) L.A.S. Johnson & Blaxell from *E. obstans* L.A.S. Johnson & K.D. Hill (previously incorrectly known as *E. obtusiflora* DC.) on the basis of being a tree rather than a mallee, *E. gregsoniana* L.A.S. Johnson & Blaxell from *E. pauciflora* Sieber ex Sprengel on the basis of being a mallee rather than a tree, and *E. prolixa* D.Nicolle (2000) from *E. calycogona* on the basis of it being a mallet rather than a mallee.

EUCLID (2006) also placed *E. walshii* under *E. viridis*, presumably on the basis that it regarded the taxon as synonymous with *E. wimmerensis* which it recognised at a subspecific level. On the basis of the evidence presented in this paper, *E. viridis*, *E. wimmerenesis* and *E. walshii* are here regarded as separate species.

Eucalyptus filiformis

Eucalyptus filiformis Rule (2004) is also a relictual species which consists of a stand of only seven plants. It occurs on the southern slope of Mt Jeffcott in a largely cleared remnant of a rare and unique habitat, described as metamorphic slopes scrubby woodland. Whether its current numbers are due to clearing or genetic decline is unknown. It is distinguished within the mallee-boxes by its small, few-stemmed mallee habit, its thin, light grey box bark, which covers most of the stem, and whitish smooth branches, its linear (or filiform), crowded, rigidly-erect, bluish juvenile leaves, its relatively small, bluish adult leaves, that are sub-lustrous when new but become duller with age, its relatively small buds and fruits, the fruits being sub-cylindrical to slightly barrel-shaped. Cultivated plants grown in RBGV have developed distinctive intermediate leaves that are bluish, coarse and rigidly erect.

EUCLID (2006) included *E. filiformis* with *E. viridis* which lacks merit as the two only resemble each other in some aspects of their seedling morphology, that is, their juvenile leaves are linear and crowded along the stem. However, *E. viridis* differs from *E. filiformis* by its dark greyish, compact bark that rarely extends above mid-stem, its greener and more lustrous leaves at all stages and its generally smaller buds and fruits.

Nicolle (2006) claimed that *E. filiformis* is synonymous with *E. polybractea* by noting that, 'These mallees are generally characteristic in adult morphology of *E. polybractea* occurring elsewhere and not considered sufficiently distinct nor forming a sufficiently large or uniform population to be regarded as a distinct species here'. This claim that the adult morphologies of *E. filiformis* and *E. polybractea* are inseparable is inaccurate. The barks of the two differ with the latter having a dark, grey-brown box bark with seasonally more colourful smooth bark above (coppery, brown or dark grey prior to shedding). Further, whilst it can construed that the adult leaves of both species are similar, both being dull and bluish, in other adult structures, namely buds, branchlets and immature fruits, *E. polybractea* is copiously pruinose whereas *E. filiformis* is non-pruinose. It is only the coppice leaves that are sub-glaucous, a condition that also occurs elsewhere in forms of both *E. odorata* and *E. wimmerensis*, neither of which Nicolle (2006) regards as synonymous with *E. polybractea*. In delivering his assessment of *E. filiformis* Nicolle makes no mention of the differences between *E. filiformis* and *E. polybractea* in seedling morphology. *Eucalyptus filiformis* was regarded as being closest to *E. viridis* on the basis of similarities in their juvenile leaves, despite those of *E. viridis* eventually becoming lustrous and green. Nicolle's reference to the species lacking uniformity is also inaccurate as the plants within the stand are markedly similar and, without slight differences in leaf widths between plants shown in seedling trials, they would be regarded as being vegetative clones derived from a common parent. Lastly, with regard to the number of plants of *E. filiformis* being too few to warrant it being a species, it is contended here that an entity meets important criteria for being a species if there is morphological uniformity across its range, regardless of its numbers or extent, it differs significantly from its relatives in both its seedling and adult forms and, through progeny trials, it is found to be true-breeding. To use the small size of the population of *E. filiformis* to support an assessment of its status is a questionable strategy as it implies knowledge of its evolutionary history and ignores the possibility that its numbers may have been significantly reduced by the extensive clearing of natural vegetation for the grazing of sheep that has occurred at Mt Jeffcott and similar sites in the region.

Acknowledgements

Neville Walsh of MEL is thanked for his support and advice during this project, as are other personnel of MEL, namely Frank Udovicic for his valuable assistance with the preparation of this manuscript, Val Stajsic for his assistance in the field over many years and Catherine Gallagher for facilitating access to the MEL collections. Thanks are given to Chris Jenek of the RBGV nursery for his invaluable assistance with the mallee-box seedling trials, and to Peter Hawker of Parks Victoria, my wife, Lesley Rule, and Jeff Dowling of Mt Waverley for their assistance in the field. David Cameron of the Arthur Rylah Institute is also thanked for his advice with aspects of the manuscript and invaluable assistance regarding the conservation statuses recommended for the new taxa. Lastly, and most importantly, it is appropriate to acknowledge the Bjarne K. Dahl Trust, which is dedicated to the conservation of eucalypts, for providing financial assistance for the conduct of important aspects of the study, particularly the field studies and seedling trials for the *E. wimmerensis* segregates.

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Muelleria

37: 65–75

Published online in advance of the print edition, Tuesday 2 October

ROYAL BOTANIC GARDENS VICTORIA

Lachnagrostis (Poaceae) in the Highlands of New Guinea

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Introduction

Botanical exploration of the Highlands of New Guinea began in the early part of the 20th century. Among the many plants collected from this region were numerous specimens of the C3 grasses, *Lachnagrostis* Trin. and *Agrostis* L. A cursory examination of the *Lachnagrostis* collections suggest that more than one taxon is present. This paper investigates these specimens in more detail and considers their relationship to Australian *Lachnagrostis* taxa in terms of morphology and habitat.

Physiography and vegetation of the New Guinea highlands

The Island of New Guinea (NG) comprises of the nation of Papua New Guinea (PNG) on the eastern half (formerly British New Guinea in the south and German New Guinea in the north) and the Indonesian provinces of West Papua and Papua which make up Western New Guinea (WNG) or Irian Jaya (formerly Dutch or Netherlands New Guinea) on the western half. The NG Highlands are a central chain of mountains running the whole length of the island from west to east, of which the highest peaks are Puncak Jaya (Carstensz Pyramid, Mt Carstensz, Mt Jayawijaya), WNG (4884 m alt.); Puncak Madala (Juliana-top, Juliana Peak), WNG (4760 m alt.); Puncak Trikora (Wilhelmina-top, Mt Wilhelmina), WNG (4750 m alt.); Mount Wilhelm, PNG (4509 m alt.), Mt Giluwe, PNG (4368 m alt.) and Mt Victoria, PNG (4038 m alt.). The tree line occurs at about 4000 m and the highest peaks contain permanent glaciers. Montane forests (*Castanopsis*, *Nothofagus*, Coniferous), lower montane grasslands and

Abstract

The Australian grass, *Lachnagrostis aemula* (R.Br.) Trin. is identified among numerous collections of *L. filiformis* (G.Forst.) Trin. from Papua New Guinea and Western New Guinea. Both species are confined to sub-alpine grasslands at elevations of 1700–3700 m, where rainfall and humidity are high and temperatures are relatively low and uniform throughout the year. While *L. filiformis* is most commonly found on human-disturbed sites, *L. aemula* appears to be associated with more natural sites: a similar habitat preference to that found in Australia.

Keywords: Blown-grass, Papua, Irian Jaya, Biogeography

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

swamps (*Miscanthus–Imperata, Phragmites, Machaerina*) and Tree-fern savanna (*Cyathea*) occupy much of the Lower Montane Zone with altitudes from 1000–3000 m on long slopes, spurs and ridges (Paijmans 1976). Most of the lower montane grasslands and sedge swamps are likely the result of land clearing and deliberate firing for agricultural purposes. Above 3000 m, the Upper Montane Zone is comprised of discontinuous ridges, peaks and plateaus with plant communities of forests (Myrsinaceae, Ericaceae, Myrtaceae, Rubiaceae, Conifers), sub-alpine grasslands (incl. *Deschampsia* P.Beauv., *Monostachya* Merr., *Poa* L., *Festuca* L. and *Danthonia* DC spp.) and herbaceous swamps (incl. *Anthoxanthum* L., *Agrostis* L., *Carpha* Banks & Sol. ex R.Br., *Gleichenia* Sm., *Astelia* Banks & Sol. ex R.Br., *Leucopogon* R.Br. and *Drapetes* Banks ex Lam. spp.) (Paijmans 1976).

Climate of the New Guinea highlands

Day-time temperatures in the Highlands show little variation throughout the year but decrease as altitude increases. Mean annual temperature across the Highlands is 19°C at 1500 m, 17°C at 2000 m, 14°C at 2500 m, 12°C at 3000 m and 10°C at 3500 m (McAlpine et al. 1983). Night temperatures are usually about 10°C lower than day temperatures. Rainfall, although relatively high across the island, tends to decrease from the west to the east. At Puncak Jaya, annual rainfall is 5500 mm, while at Mt Hagen in the Western Highlands Division of PNG, annual rainfall is 2577 mm with a range from 129 mm in June and 294 mm in March. In contrast, the Lowlands of NG have a maximum temperature of 30–32°C and minimum of 23–24°C (diurnal and seasonal variation being similar). The tropical Lowlands experience a more pronounced monsoonal season than the Highlands, with a definite dry season. The direction of trade winds and the influence of mountain ranges in producing rain shadows, result in widely ranging annual rainfall from less than 1000 mm to 2200 mm. Humidity in the Lowlands is uniformly high at 80%, while it varies from 65% to 80% in the Highlands.

Plant collecting in the New Guinea highlands

Although a few exploratory treks to the highest peaks in both PNG and WNG were made from 1906, it wasn't until the 1920's that a few European gold seekers started pushing into the interior, following rivers from the coast. The Morobe gold field near Wau (1100 m alt.) was the site of limited gold mining during 1924–1926 but it was at the Upper Edie Creek, 5 km away, that a gold rush began in 1926 (Waiko 1993). The earliest European contact with the people of the Highlands was in the 1930's, by the Queenslander Mike Leahy and his brothers in search of gold. The Highlands were found to be densely populated, and its peoples engaged in complex systems of agriculture (e.g. clearing, burning, fallow, crop rotation), landscape gardening (e.g. drainage, mounding, terracing, irrigation, fencing) and silviculture (Bourke 2009). Most people live and farm in broad valleys between 1500 m and 2000 m (Brown 1978, McAlpine et al. 1983), where high plant productivity is ideal due to rainfall being adequate but not excessive, soil moisture is abundant, soils are fertile, diurnal temperature changes are relatively large and frosts are rare (Bourke 2017). Food production altitudinal zones for NG have been defined as lowlands: sea level to 600 m; intermediate: 600–1200 m; highlands: 1200–1800 m; high altitude 1800–2400 m; very high altitude: 2400–2800 m; uninhabited: > 2800 m (Bourke 2017).

The earliest biological collections from the mountains of WNG were those of the first Dutch South New Guinea Expedition of 1907–1908, led by Hendrikus Albertus Lorentz, which reached the Hellwig Mountains (2320 m alt.) (Marshall & Beehler 2011). The second Expedition of 1909–1910, again led by Lorentz, and the third of 1912–1913, led by Franssen Herderschee, made their way into the Snow Mountains and eventually to Puncak Trikora. Also in 1912–1913, F.R. Wolleston leading a British Expedition, with the assistance of C. Boden Kloss (Kuala Lumpur), to the WNG Highlands, reached Puncak Jaya. The Central New Guinea Dutch Expedition of 1921–1922 and 1922–1923, led by A.J.A. Overeem and J.H.G. Kremer, respectively, explored the Swart (Toli) Valley and Doorman Mountains (2750–3500 m alt.).

Botanical exploration of the PNG Highlands began in earnest with the Archbold Expeditions from 1833 to 1839 and again from 1853 to 1964. Richard Archbold was a self-funded, private explorer who financed seven expeditions to PNG and WNG, with Queenslander, Leonard John Brass as the principal botanist. Of these, the first (1933–1934), third (1938–1939) and seventh (1964–1965) included exploration of montane forests, subalpine and alpine environments. Since the 1950's,

continuous plant collecting from the Highlands has occurred, particularly in association with agricultural and forestry development, administrative postings and general plant surveys by botanists, both from within PNG and without (particularly Australia) (Frodin 1990).

Materials and Methods

A review of *Lachnagrostis* and *Agrostis* collections made in NG (WNG & PNG) was made through the Netherlands Biodiversity API (BioPortal 2018) of the Naturalis Biodiversity Center (NHN: L, U, WAG), the Australasian Virtual Herbarium (AVH 2018) (Australia and New Zealand herbaria) and the Plants of Papua New Guinea (PNGplants 2018) (LAE, BRI, CANB, NSW, MEL) websites.

Collections of *Lachnagrostis* from NG, lodged at L, BRI and CANB, were examined and morphological measurements made for various vegetative, inflorescence and spikelet characters (Table 1) on a range (29) of specimens (App. 1). The characters measured represent those often used in descriptions and diagnostic keys used for these grasses (Jacobs & Brown 2009; VicFlora 2018) and the specimens examined were assessed in accordance with those descriptions. Specimens with purplish panicles, lower glumes 4.5 mm or more and anthers 0.6 mm long or more were designated as *L. aemula* NG (1g–8g) and compared to a selection (10) of *L. aemula* (R.Br.) Trin. specimens from the Great Dividing Range in New South Wales and Victoria (1a–10a). Specimens with green panicles, lower glumes 4.0 mm or less and anthers less than 0.6 mm were designated as *L. filiformis* (1f–21f). Specimens that didn't meet these character sets in all details, were included within *L. filiformis*. Character measurements for one specimen of *Agrostis hirta* Veldkamp (1h) and three specimens of *A. infirma* var. *remota* (Buse) Veldkamp (1i–3i) were also included in the following analysis to serve as related outgroups.

Multivariate analysis was performed on the dataset using the PATN package (Belbin 2013). Because the data consisted of both continuous and discrete variables, it was transformed by the function (Value – Minimum Value)/Range of Value. The analysis used the Gower Metric association measure and classification was by agglomerative hierarchical clustering using the Flexible Unweighted Pair Group Method with Arithmetic mean (UWGMA) with a beta value of -0.1 (displayed as a row

Table 1. Morphological characters measured or scored on herbarium specimens of *Lachnagrostis* and *Agrostis* (characters in italics not used in multivariate analysis).

Measurements	Code	Measurements	Code
Vegetative Characters		**Spikelet Characters**	
Leaf roll [1]	Lr	Lower glume total length, mm	Glt
Maximum leaf width, mm [a]	*Lw*	*Upper glume total length, mm*	*Gut*
Flattened leaf width, mm [2]	Lwf	Lower glume:Upper glume length	Gtr
Mid-culm leaf length, cm	Llh	Lemma total length, mm	Lt
Maximum ligule length, mm [a]	Lig	Lemma apex setae, mm	Ls
Inflorescence Characters		Lemma back hairiness [7]	B
Inflorescence habit [3]	Ia	Lemma laterals hairiness [7]	S
Inflorescence height, cm [4]	Ih	Lemma awn attachment, % [8]	Aap
Inflorescence colour [5]	Ic	Awn total length	At
Minimum pedicel length, mm [a]	Pds	Awn column as % of total length	Acp
Maximum pedicel length, mm [a]	*Pdl*	Palea total length, mm	Pt
Median pedicel length [6]	Pdm	Rachilla extension length, mm	Re
		Anther length, mm	A

[1] flat = 1, flat & conduplicate (due to drying) = 2, involute = 3
[2] maximum leaf width*leaf roll
[3] very stiff and erect = 1, rather stiff and more or less erect = 2, not stiff but erect to slightly drooping = 3, lax and weeping = 4
[4] measured from point of emergence from sheath or from lowest whorl if fully emerged
[5] rachis & pedicel colour + spikelet colour/2: light green = 1, mid-green = 2, greyish green (green with minute purple mottling) = 3, mid-purple = 4, dark to reddish purple = 5
[6] (min + max pedicel length)/2
[7] glabrous = 0, occasional hairs only = 1, scattered hairs = 2, covered in hairs but surface still discernible = 3, covered in hairs and surface obscured = 4.
[8] attachment point measured from lemma base
[a] measured to the nearest 0.5 mm

fusion dendrogram). Ordination was made by Semi-Strong Hybrid (SSH) multidimensional scaling (set at 100 random starts and 500 iterations) and displayed as a 3D ordination plot. Analysis evaluation was made by the calculation of Kruskal-Wallis (KW) values for each resultant group, and Principle Component Correlations (PCC) for each variable.

Testing for significant difference for individual characters between dendrogram subgroups was performed using Excel Data Analysis t-test: Two Sample Assuming Unequal Variances.

A close linear relationship between temperate and altitude exists in NG, which defines a 5.2°C decline in mean maximum (c = 32.67), mean minimum (c = 22.08) and mean annual (c = 27.32) temperatures for every altitudinal increase of 1000 m (Bourke 2017) (e.g. Y_{max} = 32.67 – (0.0052 * a) where Y_{max} = maximum temperature and a = altitude in meters). This relationship was used in an assessment of the climatic ranges for *Lachnagrostis* and *Agrostis*.

Results and Discussion

Between L, BRI and CANB, 54 collections of *Lachnagrostis* were found from PNG and WNG, plus 45 duplicates. Three extra collections (one each) were found at DNA, NSW and MEL and an additional duplicate was found at MEL. All of these specimens had been previously included in *Agrostis avenacea* Gmel. (syn. *Lachnagrostis filiformis* (G.Forst.) Trin.) (Van Royen 1979; Veldkamp 1982; Johns et al. 2006): a grass with widespread natural distribution through Australasia and Malesia but an invasive species in the Americas, parts of Asia, Europe and elsewhere. Apart from *L. filiformis*, collections of *A. infirma* Buse var. *infirma* (syn. *A. rigidula* Steud. var. *rigidula*, *A. sozanensis* var. *exaristata* Hand.–Mazz.), *A. infirma* var. *remota* (Buse) Veldkamp (syn. *A. stricta* (Roem. & Schult.) Buse non J.F.Gmel. var. *remota* Buse, *A. reinwardtii* H.C.Hall ex. Miq., *A. rigidula* var. *remota* (Buse) Hoynck & J.M.Linden), *A. hirta* Veldkamp, *A. clavata* Trin. and *A. gigantea* Roth have been made from NG. The last three taxa were represented by one

Table 2. Means and ranges for measured and scored characters for *Lachnagrostis* and *Agrostis* specimens.

Character	*L. aemula* NG	*L. aemula* Aust	*L. filiformis* NG	*A. hirta* NG	*A. infirma*[1] NG
Lr	1.1 (1–2)	1	1.1 (1–2)	3	1.7 (1–2)
Lw, mm	3.1 (1.5–4)	4.3 (3–6.5)	3.2 (1–5.5)	1.5	2.0 (1–3.5)
Lwf, mm	3.3 (2–4)	4.3 (3–6.5)	3.3 (1.5–5.5)	4.5	2.8 (2.0–3.5)
Llh, cm	18 (10–28)	15 (8–22)	15 (7–26)	13	10 (6–12)
Lig, mm	5.8 (3–10)	6.0 (3.5–11)	5.6 (2–9)	9	3.7 (3–4)
la	2.1 (1–3)	2.0 (1–3)	3.3 (2–4)	4	2
lh, cm	22 (15–29)	27 (19–24)	28 (113–42)	30	18 (15–22)
lc	6.0 (5–7.5)	5.5 (4.5–6)	4.2 (1.5–6)	8	5.0 (3–7.5)
Pds, mm	1.8 (1–3)	3.3 (1.5–5)	1.1 (0.5–3)	1.5	1.5 (1–2)
Pdl, mm	8.6 (7–13)	13.5 (7.5–13)	5.7 (3–10)	5.5	5.2 (5–5.5)
Pdm, mm	5.2 (4.0–7.3)	8.4 (4.5–11.5)	3.4 (2–5.5)	3.5	3.3 (3.3–3.5)
Glt, mm	4.7 (4.4–5.1)	4.8 (4.0–5.5)	3.5 (3.0–4.5)	3.7	3.6 (2.7–4.3)
Gut, mm	4.1 (3.8–4.6)	4.2 (3.3–5.0)	3.1 (2.6–3.8)	3.7	3.3 (2.5–4.0)
Gtr	1.1 (1.1–1.2)	1.1 (1.1–1.2)	1.1 (1.1–1.2)	1.0	1.1
Lt, mm	2.2 (2.0–2.5)	2.2 (1.7–2.6)	1.7 (1.5–2.0)	2.4	2.4 (2.0–2.7)
Ls, mm	0.2 (0.1–0.5)	0.2 (0.0–0.5)	0.1 (0.0–0.2)	0.1	0.0
B	3.3 (1–4)	4	2.3 (0–4)	0	0
S	3.8 (3–4)	4	3.0 (1–4)	1	0
Aap, %	56 (48–64)	50 (38–62)	52 (41–67)	42	52 (40–60)
At, mm	5.3 (4.4–6.5)	7.0 (5.8–8.1)	4.3 (3.0–5.7)	4.7	3.4 (2.0–4.2)
Acp, %	30 (27–34)	32 (27–34)	31 (24–43)	32	37 (35–39)
Pt, mm	1.9 (1.7–2.2)	1.8 (1.4–2.3)	1.4 (1.2–1.8)	1.3	0.0
Re, mm	1.6 (1.2–1.9)	1.9 (1.5–2.3)	1.0 (0.6–1.5)	0.0	0.0
A, mm	0.7 (0.6–0.8)	0.7 (0.4–0.9)	0.4 (0.3–0.6)	1.0	0.9 (0.7–1.0)

[1] var. *remota*

collection each: *A. hirta* assumed to be an endemic and the other two as introductions. Relatively few collections were identified as *A. infirma* var. *infirma* (spikelets usually 1.9–2.8 mm, awnless: Veldkamp 1982 as *A. rigidula* var. *rigidula*), as the majority were determined as var. *remota* (spikelets usually 3–4.5 mm, awns 2–5.5 mm: Veldkamp 1982 as *A. rigidula* var. *remota*). This more common variety of *A. infirma* in NG is also found in Sumatra and Java, while the typical variety is common to Taiwan, Timor, Java, Celebes, and the Philippines (Veldkamp 1982). The numbers of *A. infirma* var. *remota* collections from NG were approximately twice as many as those of *L. filiformis*.

Morphology

Most character states were variable between specimens of the same taxon, displaying a range of measurements or scores (Table 2). Mean Coefficients of Variation (CV) across all characters (original measures, not derived) were 20% for *L. aemula* from NG, 19% for *L. aemula* from Australia and 27% for *L. filiformis*. The highest variations were for leaf length (Llh), ligule length (Lig), lemma back hairiness (B), lemma setae length (Ls) and minimum pedicel length (Pds). Some of this variation, and particularly that associated with vegetative characters, may be attributable to plasticity in phenotype response to climatic variation (Brown 2012), but whether such plasticity is sufficient to bridge the gap between currently circumscribed taxa within *Lachnagrostis* is untested to date. Definitive differentiation between the two species is not always clear (VicFlora 2018), though they can be easily separated at the extremes of their character ranges.

Multivariate analysis (ordination stress value 0.1259) resulted in a clear separation of NG *Agrostis* from *Lachnagrostis* and of *L. aemula* from *L. filiformis* in both the dendrogram (Figure 1) and for coordinates 1 and 2 of the ordination plot (Figure 2). A clear separation of *A. hirta* from *A. infirma* was also found for coordinate 3 (not shown). All of the Australian *L. aemula* were grouped with the collections from NG, with most separated into a subgroup (Figure 1). The two methods of analysis (i.e. hierarchical clustering and ordination) ranked characters differently in separating taxa (Table 3). For hierarchical clustering, the first eight ranked characters (i.e. those with the highest KW values) were rachilla extension length, anther length, median pedicel length, lower glume (i.e. spikelet), lemma (i.e. floret) and palea lengths, lemma awn length and minimum pedicel length. The first eight ranked characters for ordination analysis (i.e. those with r^2 values > 75%) were rachilla extension, lemma, lower glume and awn lengths, hairiness of the lemma back and laterals, inflorescence habit and median pedicel length. The high ranking of rachilla extension length (Re) in multivariate analysis was unexpected, as it is rarely used as a diagnostic character.

Panicle colouration was not a major character in the differentiation of the hierarchical clusters or in the ordination analysis (Table 3). Although *L. aemula* can have distinctly purple and stiffly divergent inflorescences (Jacobs & Brown 2009), these characters are not always discernible on pressed specimens where colours can be faded and the stage of emergence and age, as well as the style of mounting, can mask the true inflorescence habit. Purpling of the inflorescence was generally stronger in the NG *L. aemula*, compared to *L. filiformis*, but about a third of the latter also displayed strong colouration (Table 2). The greater purpling of both *L. aemula* and *L. filiformis* in the NG specimens may be a response to lower temperatures and higher light intensities or duration (Chalker-Scott 1999), particularly at the higher altitudinal end of their habitats.

Character measurements of NG *L. filiformis* were largely consistent for the taxon as described for Australia (Jacobs & Brown 2009). However, two specimens (19f,

Table 3. Kruskal-Wallis (KW) scores and r-squared values for Principle Coordinate Correlations (PCC) from PATN multivariate analysis of *Lachnagrostis* and *Agrostis* morphological character assessment.

UWGMA KW scores				PCC r-squared values			
Re	34.31	la	21.52	Re	0.850	Gtr	0.457
A	32.18	lc	18.59	B	0.848	lh	0.417
Pdm	29.37	Lr	16.07	S	0.833	Ls	0.376
Glt	29.07	Lig	12.39	Lt	0.828	Lr	0.343
Lt	27.39	Llh	8.31	Glt	0.822	Lwf	0.274
Pt	26.48	Aap	7.89	la	0.816	lc	0.273
At	26.15	Acp	7.75	At	0.803	Llh	0.253
Pds	25.95	lh	7.64	Pdm	0.758	Acp	0.179
S	24.12	Gtr	7.19	Pds	0.683	Aap	0.109
B	23.32	Lwf	6.65	Pt	0.600	Lig	0.093
Ls	22.39			A	0.544		

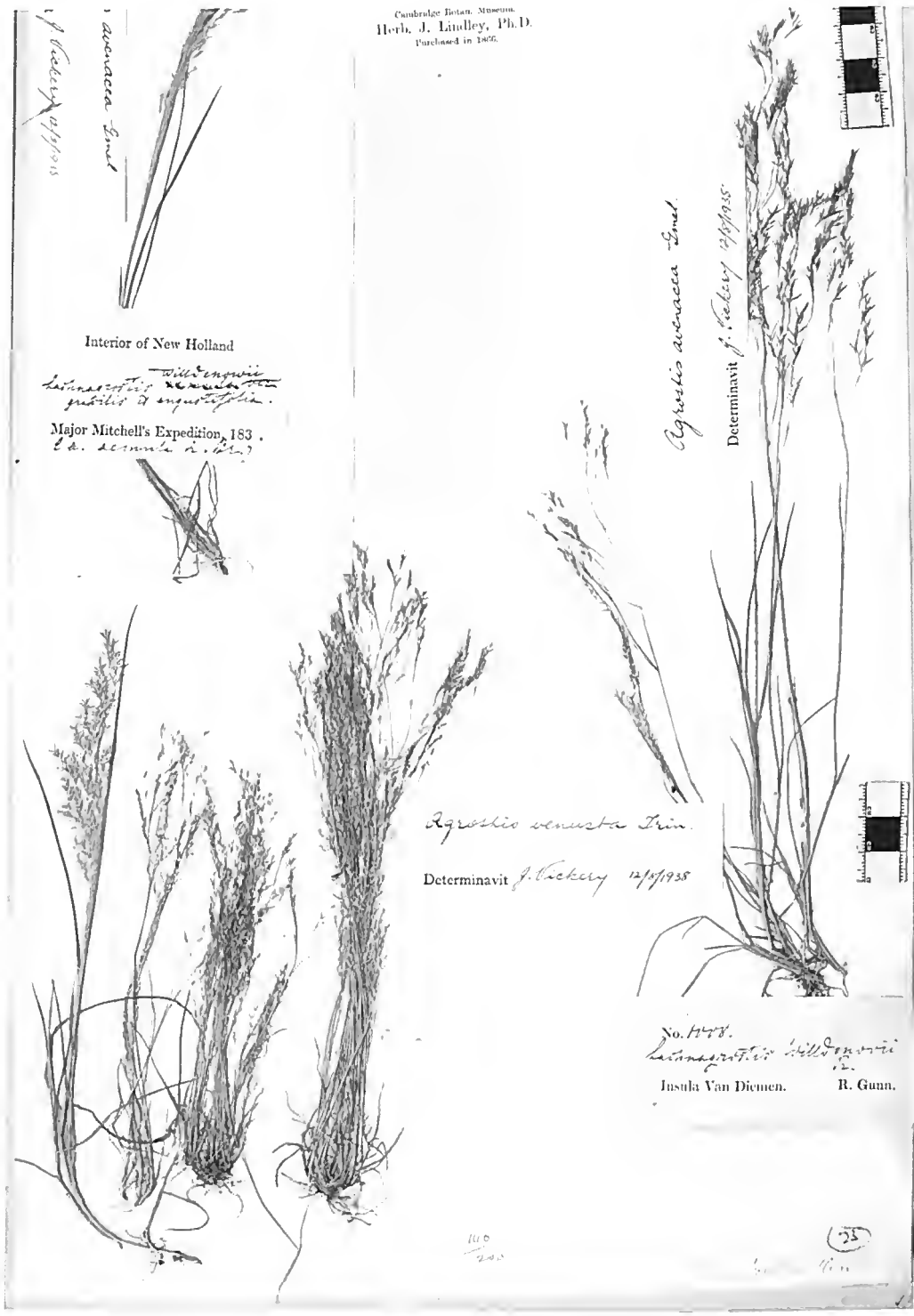

Figure 1. PATN Row Fusion Dendrogram from Unweighted Pair Group Method with Arithmetic Mean (UWGMA) Hierarchical Clustering analysis of *Lachnagrostis* and *Agrostis* morphological character assessment.

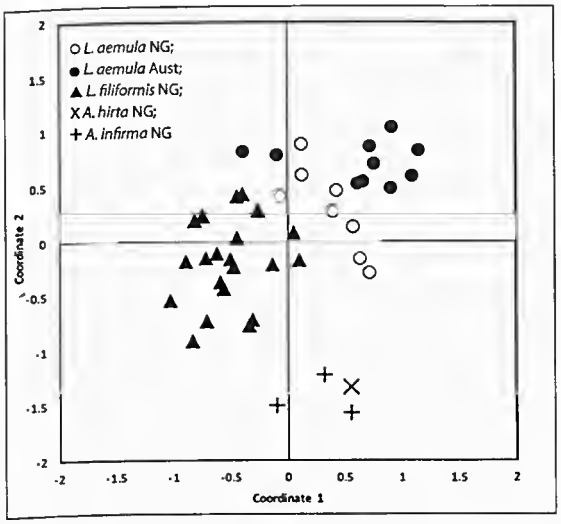

Figure 2. Coordinates 1 and 2 graph of *Lachnagrostis* and *Agrostis* morphological character assessment using PATN 5emi-strong Hybrid (5SH) multidimensional scaling ordination: NG = New Guinea, Aust = Australia.

20f) were found to have larger anthers (0.6 mm) than typical and one of these (19f) also had larger than normal spikelets (4.5 mm). Ordination plotting placed these specimens closer to *L. aemula* than the other *L. filiformis*, but the dendrogram had them well embedded within *L. filiformis* (Figure 1). Although the dendrogram split *L. filiformis* into two subgroups, and t-testing (detailed results not given) showed significantly longer spikelets, rachilla extensions, lemma awns and hairier lemmas for the second subgroup compared to the first, the ranges in values showed large overlaps (e.g. spikelet lengths of 3.0–3.7 mm for subgroup 1 and 3.0–4.5 mm for subgroup 2).

The NG specimens of *L. aemula* had significantly shorter rachilla extensions, lemma awns and pedicels (both shortest and median) compared to the Australian specimens. Two Australian specimens of *L. aemula* (7a and 8a) were grouped with the NG specimens in the dendrogram (Figure 1), based on their relatively small spikelets (4.0–4.2 mm). These two collections were made from East Gippsland and may represent a local variant. Two NG *L. aemula* (2g and 6g) were grouped with the Australian specimens (Figure 1), seemingly based on their relatively longer pedicels (6.3–7.3 mm median). Whereas all the Australian and PNG *L. aemula* specimens had densely hairy (score 4) lemmas, two of the four WNG *L. aemula* had lemma backs with near glabrous (score 1) to scattered hairs (score 2) (Table 2). These specimens also had a slightly higher mean spikelet length (4.9 mm compared to 4.5 mm) and stronger purpling than the rest of the NG specimens. As for *L. filiformis*, despite some t-test statistically significant morphological differences among *L. aemula* collections, the ranges in the characters usually overlapped (e.g. total awn length ranged from 4.4–6.5 mm for specimens from NG compared to 5.8–8.1 mm from Australia) (Table 2). Without field observation, a broader base of collections, common nursery trials or supportive DNA evidence, it seems best not to separate any of these *L. aemula* collections into subspecific taxa, at this time.

Habitat

In NG, the *Lachnagrostis* and indigenous *Agrostis* collections have been made between 1700 and 3700 m alt. (mean of 2397 m) (calc.: high altitudinal at 23.8°C mean max to 13.2°C mean min to uninhabited zones at 13.5°C mean max, 2.9°C mean min). While *L. filiformis* and *A. infirma* var. *remota* have been collected across this range (with the single collection of *A. hirta* being from 2286 m alt.), *L. aemula* collections have only been made from 2800 m alt. and above (mean of 3366 m) (calc.: from 18.1°C mean max and 7.5°C mean min and

Key to *Lachnagrostis* and *Agrostis* species of New Guinea used in this paper.

1 Palea absent or less than ½ as long as the lemma; rachilla extension absent or minute and glabrous 2

1: Palea at least ¾ as long as the lemma; rachilla extension well developed and hairy 3

2 Palea more than 1 mm long; spikelets strongly purple ..... ***Agrostis hirta***

2: Palea absent or minute; spikelets green to purplish ..... ***Agrostis infirma****

3 Anthers (0.6–) 0.7–0.8 mm long; spikelets (4.2–)4.5–5.2 mm long; rachilla extension (including hairs) 1.4 mm or longer; longest pedicels at least 7 mm long ..... ***Lachnagrostis aemula***

3: Anthers 0.3–0.4 (–0.6) mm long; spikelets 3.0–4.0(–4.5) mm long; rachilla extension (including hairs) less than 1.4 mm long; longest pedicels usually less than 8 mm long ..... ***Lachnagrostis filiformis***

* includes both New Guinea varieties

colder). None of these species have been collected from the year-round hot, humid Lowlands (calc.: lowlands to intermediate altitudinal zones at 29.6°C mean max, 15.8°C mean min).

Although, *L. filiformis* in Australia is typically a species of temperate grasslands, swamps, stream and lake edges and woodlands, it will grow in arid environments around bores and along creeklines in wet seasons. Despite a flowering season over summer, the species appears to withstand hot daytime temperatures, provided its roots are kept cool (e.g. edge of creeks and waterholes) and winters are mild during its growing season. It also grows in subtropical Queensland, and occasionally in tropical north Queensland (AVH 2018), but at higher altitudes and particularly where permanent water is available (e.g. spring-fed soaks).

The typical form of *L. aemula* is largely confined to wet temperate forests and some dry sclerophyll forests of the Great Dividing Range of Eastern Australia and Tasmania. The wet forests receive more than 889 mm annual rainfall with at least 51 mm per month (Paton & Hosking 1975). Those of Victoria and Tasmania and at higher altitudes (above 700 m) in New South Wales typically have mild to warm summers (18–21°C Jan max, 8–13°C Jan min) and mild to cold winters (9–13°C July max, 2–5°C July min). These temperatures are only slightly higher than those found at the lower end of the altitude range for *L. aemula* in NG. At lower altitudes in New South Wales, summers are hot to very hot (26–27°C Jan max, 12–16 °C Jan min) and not supportive of *L. aemula*. Dry forests typically have 605–867 mm annual rainfall, January temperatures from 22–33°C Jan max and 11–19°C min and July temperatures of 9–16°C max and -0.5–4.5°C min (Newman 1970) and therefore, it is only in the wetter and cooler examples of these, that typical *L. aemula* will grow. Other more robust forms of *L. aemula* can withstand higher temperature regimes in western Victoria and South Australia (Brown in preparation).

Because the majority of *L. filiformis* collections in NG have come from anthropological sites (e.g. roadsides, clearings, gardens), it has been suspected to be an introduced species (Veldkamp 1982). However, as the species only occurs in the Highlands, where it was found growing in the early years of European exploration, it could hardly have been introduced by the same. Although the people of the Highlands are somewhat isolated from those of the Lowlands and often from those in adjacent valleys, goods were traded throughout NG, long before European encroachment (Brown 1978). Apart from a few isolated collections from near Cairns in North Queensland, the nearest common source of *L. filiformis* to NG is south-east Queensland. The species does not appear to be indigenous to western Malesia, with only two small collections from Mt Tatamailau, East Timor in 1954 and two collections from Mt Kinabalu, Borneo in 2001 (BioPortal 2018). The species is native to New Zealand and has been collected from a few Australasian Pacific islands (e.g. Mount Koghi, New Caledonia, 1061 m alt.; Mount Gower, Lord Howe Island, 875 m alt.; Norfolk Island; Kermadec Islands; Chatham Islands), and even as far as Easter Island in the south-east Pacific (AVH 2018), so it possible that the prehistory origins of *L. filiformis* in NG came by way of accidental seed introduction via seafaring traders. However, given the barrier of the humid Lowlands, this does seem improbable. It is more likely that if the species was introduced to the Highlands, it would be by migratory wetland birds.

NG Highlanders practice shifting cultivation, which means that land is cleared for a garden for only one or two harvests before leaving it to bush regrowth for the next 20 to 50 years (Paijmans 1976, Brown 1978). As a result, and although *L. filiformis* is primarily a pioneer species of bared ground, it likely has only a short-term existence on sporadic pockets of cleared land and on the edges of existing gardens, before these sites are taken over again by regrowth. However, with enough interconnected gardens throughout the Highlands and perhaps more permanent sites to supply seed. (e.g. edges of streams and lake beds, roadside verges and ditches), it has managed to persist for at least 100 years, if not thousands of years. The species does not commonly grow at very high altitudes, with only four collections (less than 10%) from above 3000 m alt. In Australia, *L. filiformis* does not grow above the snowline, which at about 1000 m alt., is well below the same in NG.

The *L. aemula* sites in NG are at altitudes higher than that suitable for agriculture. Therefore, this species is even more likely than *L. filiformis* to be indigenous. It is mainly found in wet ground (e.g. stream edges, boggy ground) in grasslands and forest glades. Two collections

were made from "dry ashy soils of a native rock shelter" on Puncak Trikora but this may just reflect conditions at the time of observation. These rock shelters are largely used by hunters and collectors, rather than being permanently occupied (Brown 1978). With relatively few collections made, *L. aemula* is likely to be an uncommon species in NG and whether it represents an example of relictualism, is unknown. Like all *Lachnagrostis* species, *L. aemula* is not a competitive grass and in Australia, it does not survive well in improved and grazed pastures. However, unlike *L. filiformis*, it is not usually a coloniser of bared agricultural ground and has not achieved the 'weedy' status of the former (Warnock et al. 2008). The species is largely confined to relatively undisturbed sites, although it can be occasionally found on the verges of mountain roadsides and probably responds favourably to bushfire events (Kitchin et al. 2013).

Acknowledgements

Thanks are due to the Directors and staff of L, CANB, BRI and MEL for loans of herbarium collections.

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Appendix 1: Collections of ***Lachnagrostis*** and ***Agrostis*** assessed for morphological characters.

Taxon	Collections assessed [1]
Lachnagrostis aemula	***New Guinea***: **1g** – Sugarloaf complex along the Wapu River, PNG, 2896 m, 13.vii.1960, *Hoogland & Schodde 7052* (L0837046); **2g** – Wilhelmina-top, WNG, 3560 m, ix.1938, *Brass & Meyer-Drees 9821* (L0837063); **3g** – Wilhelmina-top, WNG, 3700 m, ix.1938, *Brass & Meyer-Drees 10116* (L0837061); **4g** – Wilhelmina-top, WNG, 3650 m, ix.1938, *Brass & Meyer-Drees 9969* (L0837062); **5g** – Mt Trikora, WNG, 3450 m, 17.viii.1984, *Mangen 1107* (L0837059); **6g** – Mt Albert Edward, PNG, 3680 m, v.1938, *Brass 4400* (AQ226576); **7g** – McNicoll–Andabare Plateau, PNG, [2600 m], 22.viii.1960, *Robbins 3336* (CANB87706a); **8g** – Mt Sugarloaf grasslands, PNG, 2896 m, 29.vi.1960, *Robbins 2761* (CANB87781). ***Australia:*** **1a** – Namadgi Nat. Park, NSW, 1175 m, 13.xii.2013, *Walsh 8119* (MEL2378431); **2a** – Nundle to Crawney Pass, NSW, 720 m, 6.xii.1996, *Hosking 1377* (MEL303346); **3a** – Queanbeyan to Williamsdale railway easement, ACT, 745 m, 13.xi.1996, *Crawford 4006* (MEL2212073); **4a** – Sheba Dam, NSW, 1153 m, 5.xii.2009, *Hosking 3287 & Brown* (MEL2366247); **5a** – Mt Gingera, ACT, 1855 m, 17.i.1958, *Burbridge 5611* (MEL1576691); **6a** – Dandenong Ranges, Vic, 305 m, 30.xi.1957, *Muir 274* (MEL1055530); **7a** – Metung Rd, Lakes Entrance, Vic, [62 m], 27.xi.1960, *Muir 1975* (MEL1055531); **8a** – Newry Hill Climb, Vic, [78 m], 21.x.1984, *Beauglehole ACB78705* (MEL1533249); **9a** – Langwarrin Railway Station, Vic, [78 m], 28.xi.1978, *Corrick 6206* (MEL1509861); **10a** – Mt Buffalo [2], Vic [671 m], 19.xi.1987, *Beauglehole ACB92328* (MEL1590071).
Lachnagrostis filiformis	***New Guinea:*** **1f** – Sirunki, Putidi Hill, PNG, 2591 m, viii.1962, *Walker ANU456* (L0837609); **2f** – Gembogi, Chimbu Valley, PNG, 2134 m, 13.ix.1971, *Wace ANU13020* (L0837065); **3f** – Mt Kaindi summit, PNG, 2250 m, 16.i.1993, *Hoft 3281* (L0393732); **4f** – Edie Creek, PNG, 1981 m, 7.xi.1966, *Ridsdale s.n.* (L0837044); **5f** – NE of Lake Habbema, WPG, 2800 m, x.1938, *Brass 10726* (L0837065); **6f** – Lake Myola, PNG, 1921 m, 5.xi.1964, *Gillison 409* (L0837060); **7f** – Yobobos grassland area, PNG, 2591 m, 24.viii.1960, *Hoogland & Schodde 7579* (L0837057); **8f** – Lake Myola, PNG, 2000 m, 22.vii.1974, *Croft et al. LAE61936* (L0837052); **9f** – Mt Kenive, PNG, 2400 m, 2.viii.1974, *Croft et al. LAE65225* (L0837051); **10f** – Alipe, Kepaka, Upper Kaugel Valley, PNG, 2134 m, 25.i.1973, *Bowers 847* (L0837067); **11f** – Urunu, Vanapa Valley, PNG, 1900 m, vii.1933, *Brass 4783* (L0837066); **12f** – Mt Wilhelm, PNG, 2600 m, x.1938, *Brass 30777* (L087064); **13f** – Kombugomambuno, Mt Wilhelm, PNG, 3330 m, 2.viii.1984, *Kerenga & Garki 56864* (L0837058); **14f** – Pass between Mt Nee and Mt Kerewa, PNG, 2890 m, 13.vii.1966, *Kalkman 4875* (L087056); **15f** – Quinane Nursery, Aiyura, PNG, 1829 m, ii.1953, *Womersley 5121*, (AQ226400); **16f** – Daulo Road Camp, Chimbu Pass, PNG, 2438 m, *Womersley et al. 6090* (AQ226399); **17f** – Kergsugl to Mt Wilhelm, PNG, 2591 m, 2.vii.1970, *Willis s.n.* (MEL572651); **18f** – Tomba, PNG, 2438 m, 29.vi.1957, *Saunders 639* (MEL571234); **19f** – Kumbapuku, Kepake, PNG, 2225 m, 8.xi.1968, *Bowers 309* (CANB199808); **20f** – Kambia Village, Kandep Valley, PNG, 2256 m, 12.viii.1960, *Robbins 3271* (CANB87740); **21g** – Mt Gilwe, PNG, 3658 m, 17.vii.1967, *Coode NGF32545* (L0837043).
Agrostis hirta	**1h** – Sugarloaf complex along the Wapu River, PNG, 2286 m, 13.vii.1960, *Hoogland & Shodde 7046* (CANB83908).
Agrostis infirma var. *remota*	**1i** – McNicoll–Andabare Plateau, PNG, [2600 m], 22.viii.1960, *Robbins 3336* (CANB87706a); **2i** – Pinaunde River, PNG, 3505 m, 17.vi.1968, *Vandenberg NGF39564* (AQ226404); **3i** – Mt Gilwe, PNG, 3200 m, 25.xii.1973, *Croft et al. LAE60689* (AQ353578).

[1] Altitude in feet converted to metres with missing data in brackets estimated from location description and Google Earth.

[2] No definite location or habitat details provided – alt. of collection is therefore taken to be half way up the mountain.

Appendix 1: Collections of *Lachnagrostis* and *Agrostis* assessed for morphological characters (continued).

Taxon	Collections assessed [1]
Lachnagrostis aemula	***New Guinea*: 1g** – Sugarloaf complex along the Wapu River, PNG, 2896 m, 13.vii.1960, *Hoogland & Schodde 7052* (L0837046); **2g** – Wilhelmina-top, WNG, 3560 m, ix.1938, *Brass & Meyer-Drees 9821* (L0837063); **3g** – Wilhelmina-top, WNG, 3700 m, ix.1938, *Brass & Meyer-Drees 10116* (L0837061); **4g** – Wilhelmina-top, WNG, 3650 m, ix.1938, *Brass & Meyer-Drees 9969* (L0837062); **5g** – Mt Trikora, WNG, 3450 m, 17.viii.1984, *Mangen 1107* (L0837059); **6g** – Mt Albert Edward, PNG, 3680 m, v.1938, *Brass 4400* (AQ226576); **7g** – McNicoll–Andabare Plateau, PNG, [2600 m], 22.viii.1960, *Robbins 3336* (CANB87706a); **8g** – Mt Sugarloaf grasslands, PNG, 2896 m, 29.vi.1960, *Robbins 2761* (CANB87781). ***Australia:* 1a** – Namadgi Nat. Park, NSW, 1175 m, 13.xii.2013, *Walsh 8119* (MEL2378431); **2a** – Nundle to Crawney Pass, NSW, 720 m, 6.xii.1996, *Hosking 1377* (MEL303346); **3a** – Queanbeyan to Williamsdale railway easement, ACT, 745 m, 13.xi.1996, *Crawford 4006* (MEL2212073); **4a** – Sheba Dam, NSW, 1153 m, 5.xii.2009, *Hosking 3287 & Brown* (MEL2366247); **5a** – Mt Gingera, ACT, 1855 m, 17.i.1958, *Burbridge 5611* (MEL1576691); **6a** – Dandenong Ranges, Vic, 305 m, 30.xi.1957, *Muir 274* (MEL1055530); **7a** – Metung Rd, Lakes Entrance, Vic, [62 m], 27.xi.1960, *Muir 1975* (MEL1055531); **8a** – Newry Hill Climb, Vic, [78 m], 21.x.1984, *Beauglehole ACB78705* (MEL1533249); **9a** – Langwarrin Railway Station, Vic, [78 m], 28.xi.1978, *Corrick 6206* (MEL1509861); **10a** – Mt Buffalo [2], Vic [671 m], 19.xi.1987, *Beauglehole ACB92328* (MEL1590071).
Lachnagrostis filiformis	***New Guinea:* 1f** – Sirunki, Putidi Hill, PNG, 2591 m, viii.1962, *Walker ANU456* (L0837609); **2f** – Gembogi, Chimbu Valley, PNG, 2134 m, 13.ix.1971, *Wace ANU13020* (L0837065); **3f** – Mt Kaindi summit, PNG, 2250 m, 16.i.1993, *Hoft 3281* (L0393732); **4f** – Edie Creek, PNG, 1981 m, 7.xi.1966, *Ridsdale s.n.* (L0837044); **5f** – NE of Lake Habbema, WPG, 2800 m, x.1938, *Brass 10726* (L0837065); **6f** – Lake Myola, PNG, 1921 m, 5.xi.1964, *Gillison 409* (L0837060); **7f** – Yobobos grassland area, PNG, 2591 m, 24.viii.1960, *Hoogland & Schodde 7579* (L0837057); **8f** – Lake Myola, PNG, 2000 m, 22.vii.1974, *Croft et al. LAE61936* (L0837052); **9f** – Mt Kenive, PNG, 2400 m, 2.viii.1974, *Croft et al. LAE65225* (L0837051); **10f** – Alipe, Kepaka, Upper Kaugel Valley, PNG, 2134 m, 25.i.1973, *Bowers 847* (L0837067); **11f** – Urunu, Vanapa Valley, PNG, 1900 m, vii.1933, *Brass 4783* (L0837066); **12f** – Mt Wilhelm, PNG, 2600 m, x.1938, *Brass 30777* (L087064); **13f** – Kombugomambuno, Mt Wilhelm, PNG, 3330 m, 2.viii.1984, *Kerenga & Garki 56864* (L0837058); **14f** – Pass between Mt Nee and Mt Kerewa, PNG, 2890 m, 13.vii.1966, *Kalkman 4875* (L087056); **15f** – Quinane Nursery, Aiyura, PNG, 1829 m, ii.1953, *Womersley 5121*, (AQ226400); **16f** – Daulo Road Camp, Chimbu Pass, PNG, 2438 m, *Womersley et al. 6090* (AQ226399); **17f** – Kergsugl to Mt Wilhelm, PNG, 2591 m, 2.vii.1970, *Willis s.n.* (MEL572651); **18f** – Tomba, PNG, 2438 m, 29.vi.1957, *Saunders 639* (MEL571234); **19f** – Kumbapuku, Kepake, PNG, 2225 m, 8.xi.1968, *Bowers 309* (CANB199808); **20f** – Kambia Village, Kandep Valley, PNG, 2256 m, 12.viii.1960, *Robbins 3271* (CANB87740); **21g** – Mt Gilwe, PNG, 3658 m, 17.vii.1967, *Coode NGF32545* (L0837043).
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Agrostis infirma var. *remota*	**1i** – McNicoll–Andabare Plateau, PNG, [2600 m], 22.viii.1960, *Robbins 3336* (CANB87706a); **2i** – Pinaunde River, PNG, 3505 m, 17.vi.1968, *Vandenberg NGF39564* (AQ226404); **3i** – Mt Gilwe, PNG, 3200 m, 25.xii.1973, *Croft et al. LAE60689* (AQ353578).

[1] Altitude in feet converted to metres with missing data in brackets estimated from location description and Google Earth.

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Muelleria

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Published online in advance of the print edition, Tuesday 2 October

Correction to 'Two new subspecific taxa within the *Eucalyptus* Series *Argyrophyllae* for Victoria' (Rule & Walsh (2018), *Muelleria* 36, pp. 81-91

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The new subspecies of *Eucalyptus conspicua* described in the above paper was given as subsp. *dispara*. It has been pointed out to us that the latin adjective 'dispar' (different) does not alter form with gender of the noun. Therefore, the correct epithet for the new subspecies should be:

Eucalyptus conspicua subsp. *dispar* Rule & N.G.Walsh

Eucalyptus conspicua subsp. *dispara* is an orthographic error to be corrected in accordance with Article 60.1 of the International Code of Nomenclature for algae, fungi, and plants (McNeill et al. 2012).

Acknowledgements

We are grateful to Alex George for bringing this oversight to our attention.

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ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

Muelleria

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Lachnagrostis willdenowii Nees (Poaceae) – the name that never was

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Introduction

Examination of the presumed type material for *Lachnagrostis willdenowii* Nees. nom. illeg. raised taxonomic and nomenclatural questions concerning the difference between this taxon, treated as a synonym of *Agrostis venusta* Trin. by Hooker (1860) and Vickery (1941), and *L. willdenowii* Trin., nom. illeg., nom. superfl., treated as a synonym of *A. avenacea* J.F.Gmel. by Vickery (1941).

Methods

Scans of the relevant taxonomic publications and herbarium collections from CGE, K and MEL were examined.

Results and Discussion

Joseph Dalton Hooker (1860) cited *Lachnagrostis willdenowii* Nees, based on *Gunn 1008*, as a synonym of *Agrostis venusta* Trin., or at least he considered *L. willdenowii*, in the sense of Nees, to be the same taxon as *A. venusta*. Nees von Esenbeck (1843) noted *L. willdenowii* twice in his listing of grass taxa for his "*Gramina Novae Hollandiae*" paper in Sir William Jackson Hooker's, *The London Journal of Botany*. Neither listing notes authorship for the name. However, it could be argued that Nees meant Trinius as author for both, as they follow the first species dealt with under *Lachnagrostis*, being '*Lachnagrostis billardieri*. Tr.' and are separated by *L. aemula* as '*Lachnagrostis aemula*. R. Br.', which in modern

Abstract

Hooker (1860) recorded *Lachnagrostis willdenowii* Nees nom. illeg. non Trin. as a synonym of *Agrostis venusta* Trin., but *L. willdenowii* Nees is not considered to have been published as it is shown that Nees von Esenbeck (1843) was not raising a new name but referring to *L. willdenowii* Trin. nom. illeg., nom. supfl.

Keywords: Hooker, Trinius, *Lachnagrostis venusta*, *Lachnagrostis filiformis*

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

nomenclature is *L. aemula* (R.Br.) Trin. (based on *Agrostis aemula* R.Br.). Elsewhere in his paper, Nees applied his own name to taxa, where he obviously intended them to be accepted as new (e.g., p. 412: '*Agrostis aequata* N. ab. E.'; p. 413: '*Echinopogon Gunnianus* N. ab. E.'; and p. 414: '*Mühlenbergia mollicoma* N. ab. E.'). In each case, the taxon is accompanied by a reasonably full morphological description. Although Nees provided a short distinguishing description of *L. willdenowii* (*Gunn 1008*), he does not claim authorship. The name, '*Lachnagrostis willdenowii* Nees' has been written on at least two labels accompanying collections of *A. venusta Gunn 1008* at Kew (K000607840, K000838272–73) and indicates that this name, even if informally so, was used for the taxon for a time. Regardless of how Hooker interpreted Nees's (1843) listing of *L. willdenowii* (i.e. as *sensu* Nees or Nees nom. nov.), Vickery (1941) obviously treated it as the publication of a homonym, for she lists '*Lachnagrostis Willdenowii* Nees in Hook. *Lond. Journ. Bot.*, ii. (1843) p. 412. non Trin. (1824)' as a synonym of *A. venusta*.

Some 20 years before Nees (1843), Trinius (1824) published *Lachnagrostis willdenowii* Trin. as a new name for his earlier *L. retrofracta* (Willd.) Trin. Which, according to Willdenow (1809), derived from New Holland [Australia] and was cultivated in the Royal Berlin Botanical Gardens. Vickery (1941) and Jacobs and Brown (2009) considered *L. willdenowii* Trin. to be synonymous with *L. filiformis* (G.Forst.) Trin. (based on *Avena filiformis* G.Forst.), along with *Agrostis avenacea* J.F.Gmel. and *Agrostis forsteri* Roem. & Schult. nom. illeg., nom. superfl. However, early treatments, such as Roemer and Schultes (1817), Kunth (1829) (as *Deyeuxia forsteri* (Roem. & Schult.) Kunth.) and Steudel (1840) (as *Calamagrostis forsteri* (Roem. & Schult.) Steud.) considered *L. filiformis/A. forsteri* to be confined to New Zealand and Easter Island, and *L. willdenowii/L. retrofracta* to be a separate Australian taxon. Edgar (1995) designated the lectotype for *Avena filiformis* to be a specimen from New Zealand.

The collections Nees used in reference to *Lachnagrostis willdenowii* are most likely to be those combined on a sheet at the University of Cambridge herbarium (CGE34005) ex the herbarium of John Lindley (Fig. 1). The sheet contains two Lindley labels with Nees's annotations. The first is associated with a small plant having a single, partially enclosed and non-spreading inflorescence, collected as part of Major Mitchell's Expedition from the Interior of New Holland. Nees annotated this collection as '*Lachnagrostis ~~aemula~~ willdenowii* var. *gracilis* & *angustifolia* [i.e. thin and narrow-leaved] (*A. aemula* R.Br.).' In his paper, however, Nees (1843) recorded the Mitchell collection as *L. willdenowii* var. *angustifolia* and *humilis* (rather than *gracilis*, as noted on the CGE specimen) and equated it to Sieber's collection of *A. aemula*, in *Agrostoth. n.81*, rather than to *A. aemula* R.Br. which he considered similar to *L. billardierei* (R.Br.) Trin. (i.e. 'Adnot. *Agrostis aemula* Sieb. *Agrostoth. n. 81*. Ad *Lasiagrostin Willdenowii*, neque ad *Agrostin aemulum* R. Br. pertinent, quae *Lasiagrostis Billardieri* simillima est.'). Examination of a duplicate of *Sieber 81* (MEL 2123333A) shows it to conform to *L. filiformis*.

The second Lindley label on the CGE34005 sheet is an 'Ins. Van Diemen [i.e. Tasmania], R. Gunn' collection annotated by Nees as '*1008*' and '*Lachnagrostis willdenowii* Tr.' This collection is a mixture of *Agrostis venusta* and *L. filiformis* but the label is attached to the base of what is largely *L. filiformis* with a fragment of *A. venusta*. There is no additional Lindley/Nees label for the bulk of the collection. Nees (1843) described *Gunn 1008* as 'Valvula inferior biseta setulis bipartitis brevibus.' [i.e. lemma with a bisecting awn, short hairs and shortly cleft apex] which cannot relate to *A. venusta* with its glabrous and entire lemma, but does partially describe the lemma of *L. filiformis*. It seems that Nees did not closely examine the *A. venusta* on the sheet but assumed it to be either a variant of *L. filiformis* and not worthy of description, or he simply overlooked it altogether. Hooker (1860) gives no evidence of having consulted Steudel (1855) who included Nees' Latin description of *Gunn 1008* and cited Sieber's *A. aemula* as part of *Calamagrostis willdenowii* (Trin.) Steud. In doing so, Steudel (1855) combined Nees two listings of *L. willdenowii* as referring to the same taxon, with Trinius as the sole authority.

Ronald Gunn's 1837 Tasmanian collection of *Agrostis venusta* bore his taxon number of *1008*, against which Gunn (ca. 1830–1850), in his journal, wrote the name *L. willdenowii* (without authorship). Burns and Skemp (1961) indicate that Gunn relied on William Hooker, father of Joseph, and for whom he made his collections, to provide botanical names for his specimens. The list

Figure 1. CGE34005 displaying a collection *of Lachnagrostis filiformis* (G.Forst.) Trin. (syn. *Agrostis avenacea* J.F.Gmel.) ex Major Mitchell Expedition and a mixed collection of *L. filiformis* and *A. venusta* Trin. – the latter presumably cited by Vickery (1941) as the type of *L. willdenowii* Nees. Image kindly provided by Cambridge University Herbarium

of grass taxon numbers in Gunn (ca. 1830–1850) does not include any from consignments sent to Hooker after 1838, which suggests that, as Trinius (1841) had not yet published *A. venusta* and Nees's (1843) paper was still five years away, the most recent names that William Hooker had available for the taxonomic determination of *Gunn 1008* were either *L. willdenowii* Trin. or *L. aemula* (R.Br.) Trin.

The superficial resemblance of *Agrostis venusta* to *Lachnagrostis filiformis* (syn. *L. willdenowii* Trin.) with its fine leaves, open inflorescence, relatively small spikelets and long-awned lemmas, lends itself to cursory misidentification. The 1837 *Gunn 1008* collection of *A. venusta* at Kew (K000838272–73), ex Hooker's herbarium, has *'Lachnagrostis willdenowii'* overwritten on Gunn's original label, presumably meaning *L. willdenowii* Trin. However, 'Nees' is added to the name in a different pen and, therefore, after 1843. William Hooker could have provided Gunn with the name *L. aemula* (R.Br.) Trin. for *1008*, but he obviously recognised that *Gunn 1006* (K000607849), also sent in Gunn's 1837 consignment, was something different, and better represented *L. aemula* (the name written on Gunn's label and in his journal, against *1006*). By the time Gunn sent his 1840 collection of *A. venusta* (K000607840) to Hooker in his 1846 consignment, Nees (1843) had published his *"Gramina Novae Hollandiae"* and the name *'Lachnagrostis willdenowii* Nees' was subsequently written with the one pen on Gunn's label, in what appears to be Joseph Hooker's handwriting. The name *Agrostis venusta* Trin. has also been written on the sheet in the same hand and, as the ink is of the same intensity, maybe written with the same pen at the same time.

An additional name written on the K000607840 and K000838272–73 sheets is *'Agrostis gunnii* H.f.' which has been crossed out and replaced with *'Agrostis venusta* Tr.'. At Cambridge, an ex-Lindley sheet (CGE34007) has a *593* label with both *'Agrostis (Trichod:) venusta* Trin.' and *'Trichodium gunnii* Hook.Fil.'. The proposed naming of this grass after Gunn was never executed, as the name of *A. venusta* Trin. took precedence.

When Joseph Hooker published his New Zealand and Tasmanian Floras (Hooker 1853, 1860), he did not distinguish *Lachnagrostis filiformis* from *L. aemula*. In the earlier Flora, he synonymised both under *Deyeuxia forsteri*, while in the later Flora, he synonymised both under *Agrostis aemula*. Surprisingly, in neither Flora is *L. retrofracta* (Willd.) Trin. or *L. willdenowii* Trin. listed in synonymy, although *'A. retrofracta Schrad. in Herb. Hook.'* is (in reference to a Schrader herbarium collection: K000838257). Also in synonymy with *A. aemula* R.Br., Hooker (1860) included *'L. aemula, Nees, in Hook. Lond. Journ. Bot. ii. 412'*. This is a reference to Nees's (1843) listing of *L. aemula* R. Br.' (based on *George Everett Esq.* – CGE34010 and *Gunn 1006* – CGE34011), but again, as for *L. willdenowii*, Hooker gives no credit to Trinius for the combination. In this case, however, unlike for *L. willdenowii* Nees, the name *L. aemula* Nees has not been written on the Kew sheet of *Gunn 1006* (K000607849), nor perpetuated in later treatments, except that Vickery (1941) listed in synonymy for *A. aemula*, *"Lachnagrostis aemula* Trin. *Fund. Agrost.* (1820) p. 138; Nees ex Hook. f., *Handb. New Zeal. Fl.* (1864) p. 329.".

On 12.viii.1938, J. Vickery attached three labels to the CGE34005 sheet: an *'Agrostis avenacea* Gmel.' (syn. *L. filiformis*) label to the Mitchell collection, the same to the specimen Nees separated out as *L. willdenowii* Tr. from the *Gunn 1008* collection, and a third, *'Agrostis venusta* Trin.' to the previously unlabelled bulk of the *Gunn 1008* collection. Vickery (1941) designated *Gunn 1008* at C (in reference to Cambridge University Herbarium before CGE became the standard code in 1953) as the type of *L. willdenowii* Nees. As there appears to be no other candidate sheets at CGE, it is presumed that she was referring the type to the bulk of the *Gunn 1008* collection on CGE34005.

This study demonstrates that Nees (1843) did not consider specimens of *Agrostis venusta* (*Gunn 1008* ex parte) in his publication of Australian grasses, but did regard a specimen of *Lachnagrostis filiformis* (*Gunn 1008* ex parte) to be *L. willdenowii* (without author but assumed to be Trinius). Hooker (1860) misinterpreted Nees's account to place *L. willdenowii* sensu Nees in synonymy with *A. venusta* Trin., a mistake that was perpetuated by Vickery (1941), Morris (1994), Quattrocchi (2006) and Jacobs (2009). The confused history of these names demonstrates the need to examine, wherever possible, the original collections and associated publications before uncritically accepting current names and asserted synonyms.

Taxonomy

To clarify the taxonomic names discussed in this paper, the following partial synonymies are provided.

Agrostis venusta Trin. *Mém. Acad. Imp. Sci. Saint-Petersburg. Sér. 6, Sci. Math., Seconde Pt. Sci. Nat.* 6, 340 (1841)

Type: 'Van. Diem. Land.'; holo: V.D.L. (LE–TRIN–1666.01 (& fig.))

Lachnagrostis filiformis (G.Forst.) Trin. *Fund. Agrost.* 128 (1820)

Avena filiformis G.Forst. *Fl. Ins. Austr.* 9 (1786); *Agrostis avenacea* J.F.Gmel., *Syst. Nat.* 171 (1791) nom. nov. non *Agrostis filiformis* Vill. (1787); *Agrostis filiformis* (G.Forst.) Spreng., *Mont. Prom. Fl. Hol.* 32 (1807), nom. illeg., non Vill. (1787); *Agrostis forsteri* Roem. & Schult., *Syst. Veg.* 2: 359 (1817), nom. illeg., nom. superfl.; *Lachnagrostis forsteri* (Roem. & Schult.) Trin., *Gram. Unifl. Sesquifl.* 217 (1824), nom. illeg.; *Deyeuxia forsteri* (Roem. & Schult.) Kunth., *Révis. Gramin.* 1, 77 (1829), nom. illeg.; *Calamagrostis forsteri* (Roem. & Schult.) Steud., *Nomencl. Bot.* 2nd edn. 1, 250 (1840), nom. illeg.; *Calamagrostis filiformis* (G.Forst.) Cockayne, *Rep. Tongariro Natl. Park* 35 (1908), nom. illeg. non Griseb. (1868); *Deyeuxia filiformis* (G.Forst.) Petrie in C. Chilton (ed.), *Subantarctic Is. New Zealand* 2, 474 (1909), nom. illeg. non (Griseb.) Hook.f.; *Calamagrostis avenacea* (J.F.Gmel.) W.R.B.Oliv., Trans. & Proc. N. Zealand Inst. 49, 127 (1917), non *Calamagrostis filiformis* Griseb. (1868); *Lachnagrostis avenacea* (J.F.Gmel.) Veldkamp, *Blumea* 37, 230 (1992), nom. illeg., nom. superfl.

Type: 'Habitat in Nova Zeelandia et insula Paschatis'; lecto: *Forster s.n.* ex herb. *Sprengel* (B herb. *Willdenow 02208*) *fide* E.Edgar, *N. Zealand J. Bot.* 33, 19–20.

Agrostis retrofracta Willd., *Enum. Pl.* 94 (1809); *Lachnagrostis retrofracta* (Willd.) Trin., *Fund. Agrost.* 128 (1820); *Lachangrostis willdenowii* Trin. *Gram. Unifl. Sesquifl.* 217 (1824), nom. illeg.; *Deyeuxia retrofracta* (Willd.) Kunth. *Révis. Gramin.* 1, 77 (1829); *Calamagrostis retrofracta* (Willd.) Link, *Hort. Berol.* 2, 247 (1833); *Calamagrostis willdenowii* (Trin.) Steud., *Syn. Pl. Glumac.* 1, 192 (1854), nom. illeg.

Type: 'Habitat in Nova Hollandia'; holo: Anon. *s.n.*, Cultivated in hort. Bot. Berol. from material collected in Australia (B herb. *Willdenow 01692*).

Lachnagrostis aemula (R.Br.) Trin. *Fund. Agrost.* 128 (1820)

Agrostis aemula R.Br. *Prodr.* 172 (1810); *Deyeuxia aemula* (R.Br.) Kunth, *Révis. Gramin.* 1, 77 (1829); *Calamagrostis aemula* (R.Br.) Steud., *Nomencl. Bot.* 2nd edn. 1, 249 (1840).

Type: 'Port Jackson and Port Dalrymple'; lecto: *Brown 6219 p.p.* (BM *n.v. fide* J.W.Vickery, *Contr. New South Wales Natl. Herb.* 1, 115 (1941).

Acknowledgements

Thanks to the staff of K (particularly Maria Alvarez), CGE (particularly Christine Bartram) and MEL for access to, or images of, herbarium sheets in their collections, and to Neville Walsh and Tom May of MEL and Brendan Lepschi and Anna Monro of NRCA, Black Mountain for helpful discussions and advice regarding Latin interpretations and nomenclatural issues.

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The journeys and botanical collections of Edward Macarthur Bowman (1826–1872)

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Introduction

Edward Macarthur Bowman (1826–1872) was an important and talented Australian plant collector, yet very little has been written about him. His plant collections, particularly those from central-eastern Queensland, were made very soon after the first European settlement, and hence many of the species he gathered were new to science.

Bowman was one of the many plant collectors who regularly sent specimens to Ferdinand Mueller in Melbourne. Mueller considered Bowman to be "one of my most generous and observant amateur collectors" (Bean 2018).

The only published data about Bowman's collecting activities was provided by Blake (1955), who gave a useful summary of his collecting region in Queensland and mentioned many of his collecting localities. This paper documents his collecting activities in central and western N.S.W., and gives details of his travels and plant collecting in Queensland. Maps are provided showing the routes taken on his 1863 expedition to Burdekin River, the 1864 expedition to Cape River and Flinders River, and his journey to Clermont and Broadsound in 1871; other maps show the locations visited when he was based at Neerkol Creek in 1866–67 and Gainsford/Herberts Creek in 1869–71. Images of his handwriting and specimen labels are provided, his specimen labelling peculiarities are discussed, and his plant collection activities are analysed. A gazetteer of his Queensland collecting localities (Appendix 1) includes the estimated

Abstract

A detailed study of the plant specimens of Edward Macarthur Bowman is presented, including notes on their quality, numbering and labelling. This is followed by a chronology of Bowman's collecting activities, including maps depicting the routes he took on his major journeys. Samples of his handwriting and specimen labels are included, and a discussion of the importance of his specimen collections is given. An annotated list of his Queensland collecting localities is included.

Keywords: National Herbarium of Victoria, maps, handwriting, specimen collections

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

latitude and longitude and precision level for each locality, the number of gatherings made there, the year(s) and sometimes the month that the locality was visited, and miscellaneous notes.

No correspondence between Mueller and Bowman can now be found, and it was very likely destroyed in the 1930s (Short 1990). This reconstruction of Bowman's journeys and botanical itinerary is based largely on a painstaking process of sorting and resorting of digital specimen records provided by the National Herbarium of Victoria (MEL). Hypotheses were formed and sometimes later dashed by new external pieces of evidence, until finally a viable chronology was established. The search for E.M. Bowman specimens in the world's herbaria was assisted by Australia's Virtual Herbarium (AVH 2018) and several online herbarium catalogues. E-mail correspondence with the curators of several herbaria was also undertaken.

The present author has recently published a biographical paper on Edward Bowman (Bean 2018).

Herbaria holding Bowman specimens

MEL – this is the primary location, with 2510 separately catalogued specimens, but these comprising about 2000 gatherings

K – unknown number, probably more than 100. For many of the Bowman citations in *Flora Australiensis*, there is no specimen known from MEL; for Volume 3 alone, there are at least 12 citations of his specimens that do not have a corresponding MEL specimen.

BRI – 37 specimens

NSW – 26 specimens

P – 7 specimens; 4 *Acacia* (sent to P by Thozet, 2 are not at MEL), 1 *Pluchea*, 1 *Solanum*, 1 *Cyathea*.

CANB – 4 specimens

L – 3 specimens (*Cassia brewsteri* from Clermont; *Tragus australianus* from Neerkol Ck; *Ancistrachne uncinulata* from Herberts Ck)

US – 3 specimens known; 2 grass types (*Digitaria orbata* and *Panicum inaequale*) and *Acacia excelsa*.

DNA – 2 specimens

PERTH – 2 specimens

G – 1 specimen (type of *Neoroepera buxifolia*)

W – 1 specimen (type of *Setaria inaequalis*).

MO – 1 specimen (*Tapeinosperma pseudojambosa*).

General comments on E.M. Bowman specimens

a) Size and quality

Bowman's collections are always fertile and without mould. His collections from New South Wales and the early ones from Queensland (1859 to 1865), typically comprise small branchlets or seed heads, without roots, rarely more than 15 cm long, but often with several pieces attached to a sheet. From 1865 to 1870 (when his collections were made as day trips or on relatively short excursions), his specimens are more substantial, and the grasses and sedges often include the whole plant including roots and rhizomes. His specimens from 1871–72 revert to being often quite small, rarely more than 15 cm (Fig 3e).

b) Numbering

It is evident from examining the specimen records from Bowman's Burdekin River trip and Flinders River trip, that he assigned his numbers chronologically. This is because the numbers increase according to the sequence of localities along his route. However, it is equally evident that he did not assign the numbers as he collected each specimen, as there are numerous specimens that appear to be out of sequence. He probably assigned numbers when time allowed, for instance when he was encamped for a few days, or even (in a few instances) after the journey was over. It seems that when he was collecting around Rockhampton, he often did not number his collections at all.

Chronological numbering was not universally adopted by plant collectors of the time. For example, James Drummond of Western Australia would make a large collection set of hundreds of specimens, then arrange them by family and genus, and then assign numbers accordingly (Bean 1997). But in the case of both Bowman and Drummond, a new trip meant a new set of numbers, which, over the years, resulted in any given number being re-used several times. Bowman's collecting activities have here been divided into nine time periods, and within some of these time periods, two (or three) 'collection sets' are assumed, because Bowman has duplicated his specimen numbers. This suggests that two (or three) separate numbered sets of plant specimens were assembled. Applying this

logic, 13 collection sets (one from N.S.W. and 12 from Queensland) are enumerated here.

c) Labelling

Bowman's field labels varied over time, and it is sometimes possible to determine the year of collection from the type of label he used. I believe that Bowman placed a label with every gathering he sent to Mueller, except for the period 1868 to 1870. In many cases, Bowman's original label has been lost, either because it fell out in transit or after arrival in Melbourne, or was not retained by Mueller. The small size of Bowman's labels meant that they were much more likely to go astray than those used by (for example) Dallachy or O'Shanesy. The tiny labels he used in 1862 did not include a locality, but he must have told Mueller where the collections were made in the accompanying letters. In subsequent years, his labels usually included a traceable locality, often the name of a creek or river.

Bowman sometimes wrote notes about the specimens he collected, especially flower colour. Other notes were often about its horticultural potential or the use or potential use for that species. For example, a specimen of the Burdekin plum (*Pleiogynium timorense*) included the note "This is a large and handsome tree. The fruit is eatable and by no means bad"; for *Schefflera actinophylla* he commented: "One of the handsomest trees in the district well worthy of a place in every garden". Bowman never invented names for species he thought were new, but he did sometimes point out to Mueller differences that he observed; for *Solanum erianthum*, he wrote "This *Solanum* has white flowers and in that seems to differ from *S. verbascifolium* [now *S. mauritianum*] which I have always seen with blue fls [flowers] the leaves have the same scent E.M.B.".

Often a gathering would include several duplicates. The label for these duplicates was provided by Mueller, but only very rarely was Bowman's original label data transferred to the label for the duplicates. Bowman has been criticised for his many specimens where the label locality is merely "Queensland" or "Capricornia". Such criticism is unwarranted, as Bowman never wrote a label with either of these terms. These generalised localities were used solely by Mueller on his herbarium labels, and he sometimes used one of these terms even when Bowman's original label was present.

It is extremely rare that Bowman included the exact date of collection on his labels; only three such labels have been located. Sometimes he wrote the month and year, and sometimes the year only, but the great majority of his labels are undated.

d) Handwriting

Bowman's handwriting is quite distinctive, with the cursive script steeply forward sloping, and with complete but narrow loops for his y, g, f, and a long horizontal crossing of the t's. The letters are evenly spaced, and the lines of script are parallel (Fig. 1). As a result, his writing is readily legible and easily deciphered, in contrast to that of many of his correspondents. His initial loop of the upper case M and N is much higher than the subsequent loops, so that for plant labels where he wrote, for example, "No 47" (Fig. 2a), this is easily misinterpreted as "2047". His formation of the number "8" is very distinctive, with the final stroke downwards on the right, often closing the loop (Fig. 2b); the number "3" is similarly distinctive, as it often lacks the middle stroke (Fig. 2b).

Chronology of Bowman's collections

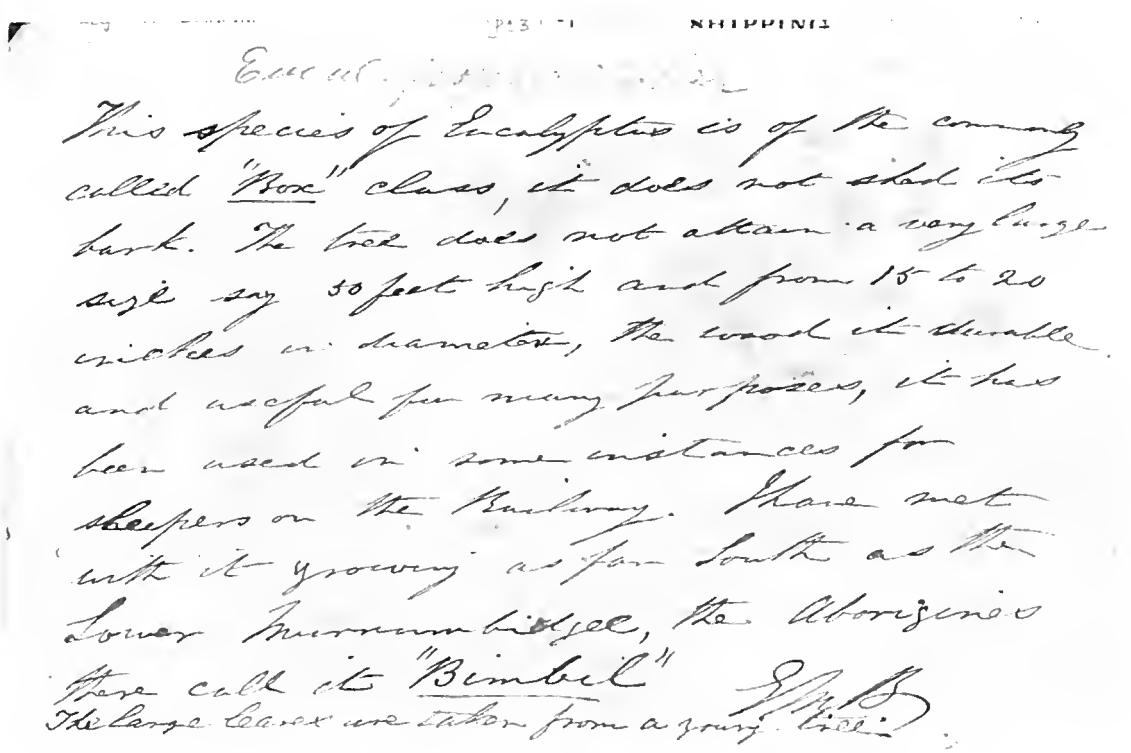
A. The New South Wales collections

In 1859, Bowman began collecting plant specimens, sending them to Ferdinand Mueller in Melbourne, who even then was very well known. His 1859 specimens were labelled as being either from "Dubbo" or the "Lower Macquarie". Based on the known natural distribution of the plant species that Bowman collected from the "Lower Macquarie" (AVH 2018), they were very likely collected close to the town of Dubbo. The "Lower Macquarie" and Dubbo specimens constitute Bowman's oldest extant herbarium specimens, and include the type specimen of *Ricinocarpos bowmanii*, which he probably collected in August or September 1859.[1] Bowman was still at Dubbo on the 4th December 1859, because an envelope attached to a herbarium sheet of *Crotalaria mitchellii* bears that date.[2]

After leaving Dubbo, he travelled to the central-

1 F. Mueller, *Fragmento Phytographioe Australioe*, Vol. 1, fascicle 8 (Melbourne, November 1859), p. 181 [Bowman's collection must have been at least two months before the publication date]

2 Specimen at MEL (MEL 241104).



This species of Eucalyptus is of the commonly called "Box" class, it does not shed its bark. The tree does not attain a very large size say 50 feet high and from 15 to 20 inches in diameter, the wood is durable and useful for many purposes, it has been used in some instances for sleepers on the Railway. I have met with it growing as far South as the Lower Murrumbidgee, the Aborigines there call it "Bimbil"
The large leaves are taken from a young tree.

Figure 1. Sample of the handwriting of E.M. Bowman (from MEL 1614278). Reproduced with permission from the Royal Botanic Gardens Victoria

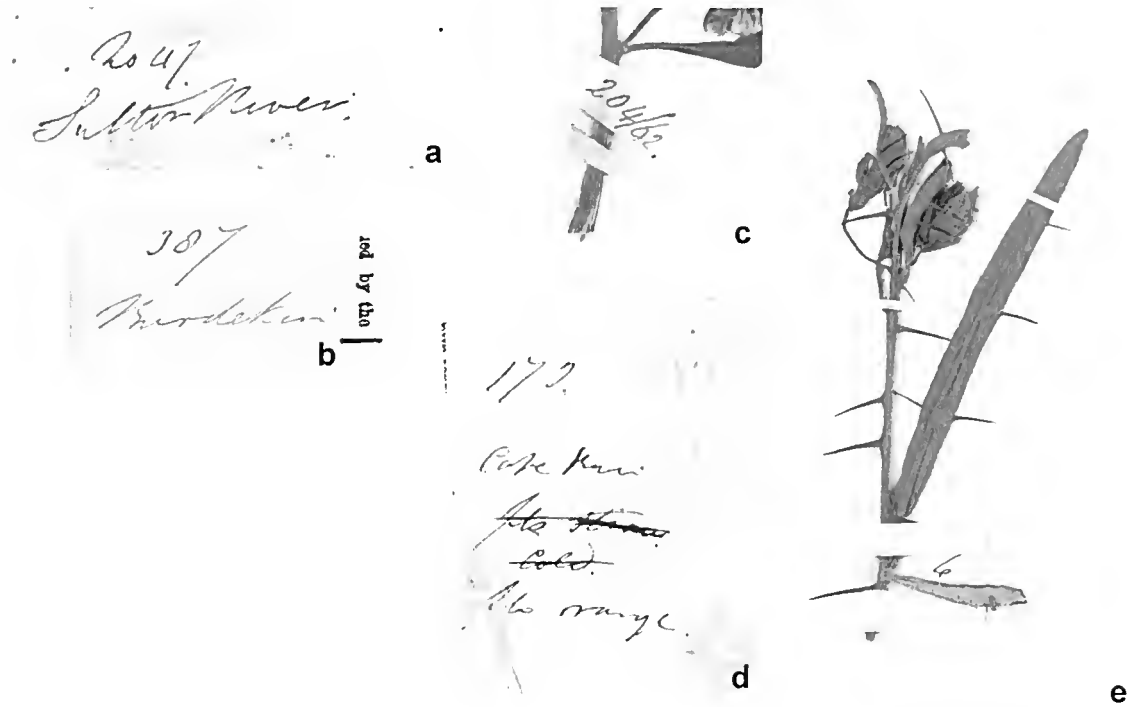


Figure 2. Examples of E.M. Bowman specimen labels; a. label from the 1864 trip to Flinders River (MEL 607647); b. label from the 1863 trip to Burdekin River (MEL 2146925); c. slitted label of the type used by Bowman in 1862 (MEL 611468); d. label from the 1864 trip to Flinders River (MEL 95498); e. slitted label, and plant specimen from 1871 (MEL 11548). Reproduced with permission from the Royal Botanic Gardens Victoria

north of the state, including Walgett.[3] During this time, most of his herbarium specimens bear the very unhelpful locality of "Upper Darling tributaries". However, on some of his later Queensland specimen labels, Bowman mentioned somewhat more precise locations for his former collections in N.S.W., including the Bogan, Castlereagh and Namoi Rivers.[4] Based on the natural distribution of the species he gathered, those from the Bogan River were probably collected between Nyngan and Brewarrina; and those labelled Namoi River were probably collected close to Walgett or even further west. A reference to the presence of *Eucalyptus populnea* on the "Lower Murrumbidgee"[5] seemingly refers back to his time in the Wagga Wagga-Narrandera area in 1854–1856.

There are two citations of specimens saying "Balonne River, Bowman", one for *Calandrinia pumila*[6] and the other for *Zygophyllum fruticulosum*.[7] As there are no known specimens associated with these citations,[8] and as this location is usually associated with Thomas Mitchell, I am confident Balonne River was not a place that Bowman visited.

B. The Queensland collections

Collection set 1: Walloon-Broadsound-Head of the Isaacs, 1862

For his first major collection set, in 1862, Bowman used the format 'number/year' for his labels, for example 66/62. All specimens are apparently part of a single set as there is no duplication of numbers. The labels are small squares of pale blue paper, uniquely numbered, often only 2 cm x 2 cm, with two parallel slits, so that the label could be inserted onto a small branchlet (Fig. 3c). Numerous specimens also have another slitted label with a (different) collecting number that lacks the slash and the '62'. The presence of this second label is confusing, but it is thought that it was associated with a certain locality or sub-collection set, as these numbers often repeat, for example there are three specimens of three species from 1862 where the 2nd label bears the number '16'.

Bowman did not write a locality on any of his 1862 labels, but for a few dozen specimens, Mueller's label states the locality as "Walloon", on the Dawson River, near present-day Theodore, and a few say "Castle Creek", a place close to Walloon. These localities were presumably gleaned from Bowman's covering letter. It seems that most of his 1862 specimens were from Walloon, because some of the low-numbered and high-numbered labels are of species that do not extend to the tropics, and it is presumed that his stay there was lengthy and in the middle of the year.[9]

The other places that Bowman definitely visited during 1862, towards the end of the year, were 'Sources of the Isaacs',[10] that is the Nebo (then called Fort Cooper) district,[11] and 'Broadsound', including Princhester[12] and Amity Creek.[13]

Mueller cited two Bowman specimens from the 'Bowen River' in *Fragmenta* 3: 53 (published in July 1862), implying a visit there in early 1862, but there is considerable doubt as to the authenticity of this. It is difficult to see how (and why) he would travel to Bowen River, far to the NW of Rockhampton to collect two specimens, then immediately go to Walloon, to the SW of Rockhampton. For one of the specimens concerned (MEL240321), the clearly written location is 'Brown River', so this specimen was probably from a quite different (and untraced) location.

Estimated number of gatherings: 206.

3 *New South Wales Government Gozette* (Sydney), 5 July 1861, p. 1435. [Undelivered letter returned to Sydney post office, addressed to Bowman at Walgett]; New South Wales Government Gazette (Sydney), 8 October 1861, p. 2119. [Undelivered letter returned to Sydney post office, addressed to Bowman at Walgett].

4 Localities mentioned on the labels of *Acacia horpophylla* (MEL2077203) and *Solanum stelligerum* (MEL11521).

5 Locality mentioned on the label of *Eucalyptus populnea* (MEL1614278).

6 F. Mueller, *Fragmenta Phytographiae Australiae*, Vol. 10 (Melbourne, 1876), p. 68.

7 F. Mueller, *Fragmenta Phytographiae Australiae*, Vol. 11 (Melbourne, 1878), p. 29.

8 A. McArdle, National Herbarium of Victoria, pers. comm., February 2018.

9 F. Mueller, *Fragmenta Phytographiae Australiae*, Vol. 3 (Melbourne, September 1862), p. 89. [This is the first citation of a Walloon specimen, hence Bowman must have been there some months prior to this].

10 Two specimens with this locality (MEL 2269246 & MEL 287784) bear the label type used by Bowman in 1862.

11 Two letters from Mueller to W. Hooker (L63.05.14 and L63.09.25, Mueller Correspondence Project) show that Bowman made separate gatherings of *Poroceteroch muelleri* from Fort Cooper, a few months apart, one in late 1862 and one in early 1863.

12 Two separate gatherings of *Neoroepera buxifolia* (published 1866) were made by Bowman, a flowering one in late 1862, and a fruiting one in early 1863. Both were sent to Geneva and became type material.

13 F. Mueller, *Fragmenta Phytographiae Australiae*, Vol. 3 (Melbourne, March 1863), p. 147. [This is the first citation of a Broadsound specimen, hence Bowman must have been there some months prior to this].

Collection set 2: Burdekin River trip, 1863

Starting around January 1863, Bowman travelled from Rockhampton to the Burdekin River, and then east to Bowen (Port Denison). The route shown in Fig. 3 is based both on the documented track usually taken by drovers in the 1860s,[14] and from the localities mentioned by Bowman on his specimen labels. There is a very strong correlation between the two. His numbers show a clear chronological pattern; 7–135 are from Broadsound (some labelled Marlborough or Princhester), 161–188 are from the Connors River area, 194–196 are from Funnel Creek, 212–234 are from Nebo Creek or Cooper Creek, 237–313 are from Bowen River, and 324–352 are from Burdekin River and Elliot River. His labels for this trip are typically white, rectangular, not slitted, and include a number and a locality. They are derived from the margins of newspaper pages. No specimen from this collection is dated.

Estimated number of gatherings: 346.

Collection set 3: Cape River-Flinders River trip, 1864

This collection set was associated with Bowman's most successful trip, in terms of new species discovered. The primary purpose of the trip was to drive a mob of sheep to the upper reaches of the Flinders River.

14 T. P. Pugh, 'Country Directory', (Brisbane, 1863), pp. 197–199. http://www.textqueensland.com.au/item/journal/d4befc86e8290056dd4b6b035e554f97, viewed 8 May 2018.

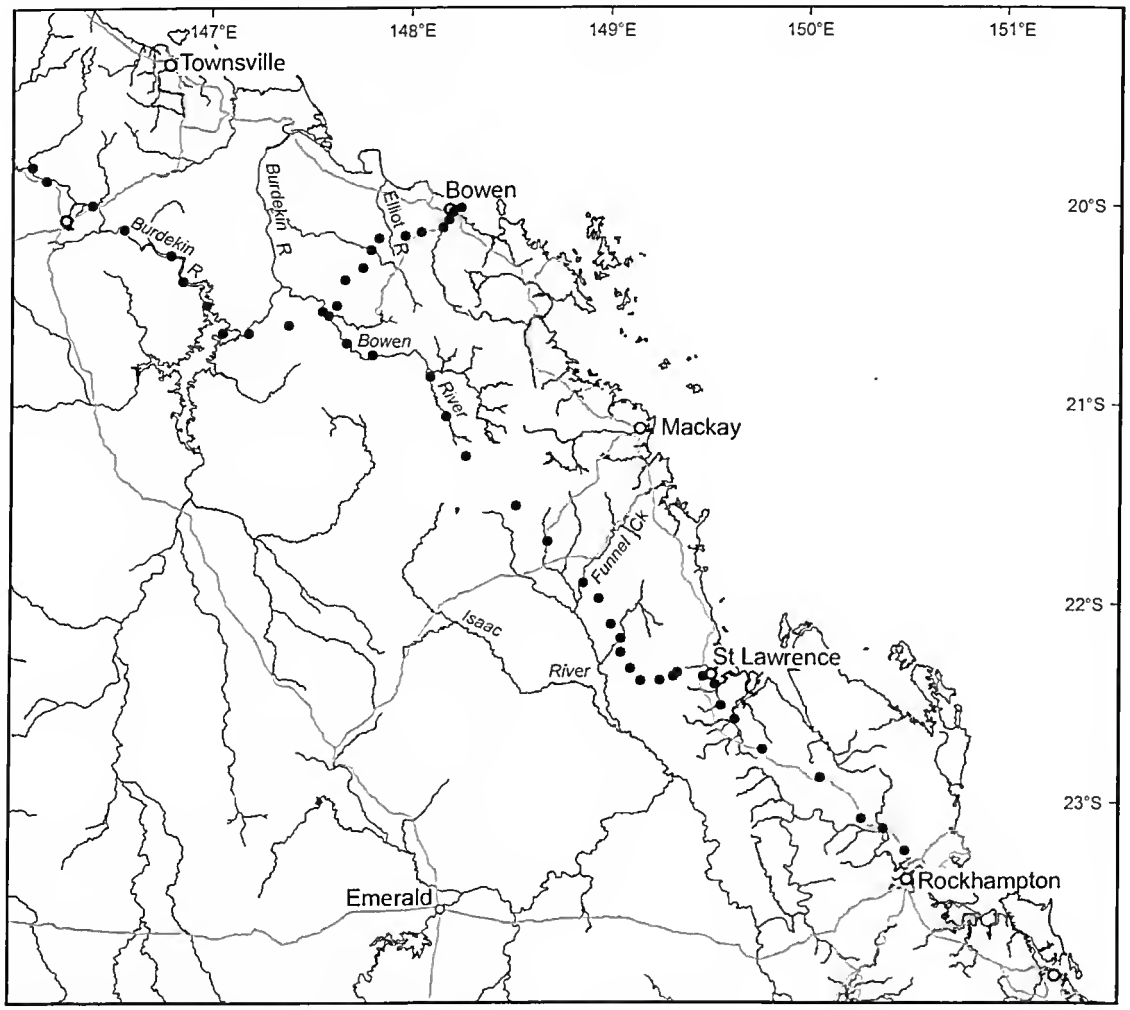


Figure 3. Route taken by Bowman during his 1863 expedition to Burdekin River. The dots represent landmarks along the route and do not indicate the passage of a particular period of time.

Because a newspaper report on the trip was made,[15] it is possible to trace the route taken almost exactly (Fig. 4), and give approximate dates for various parts of the journey. The party started from Port Denison (now Bowen), and headed west through the valley between Mt Abbot and Mt Aberdeen, then crossed the Bogie River and the Bowen River, the Leichhardt Range, reaching Mt McConnell and the Suttor River before 25th February 1864.[16] This is where Bowman started his plant collecting, as the low numbered specimens are all from Suttor River and nearby localities. They then followed the Cape River all the way to its source, at which point they struck westward to the headwaters of the Flinders River. They reached it on or before 2nd May 1864[17], and were still 'on the Flinders' on 15th May. The party deliberately bypassed the White Mountains, a large area of quartzose sandstone, which even then had a reputation as a no-go area for livestock, as there is no palatable grass, and many sheep had died in the previous year after eating a poisonous plant that grows there. Bowman was instrumental in determining that the culprit was *Gastrolobium grandiflorum*, thereafter known as Poison Pea.[18]

The party's return journey followed the same route, but was much quicker because they were no longer driving sheep. Nevertheless, Bowman probably gathered a few extra specimens that he had not seen (or were not fertile) on the outward journey. They reached Mt McConnell on 4th June 1864 and were back at Port Denison later in that same month.

Bowman's annotation on a specimen of *Chamaecrista symonii* (MEL 232583) says "Appears to be rare. I sent specimens of it from the Bowen [River] last year marked No. 268." This statement provides very strong evidence that Bowman kept a notebook recording his collection numbers and the plant species they represented.

There are 215 specimen records at MEL for this trip, while Bowman's numbers run up to at least 316. Therefore around 100 specimens collected and numbered must have been subsequently discarded or distributed by Bowman or by Mueller. The labels are typically white, rectangular, not slitted, include a number and a locality, and they are derived from the margins of newspaper pages. Labels are written in ink (Fig. 3d) or pencil, or pencil overwritten with ink.

There is an endemic *Livistona* (*L. lanuginosa*) that grows on the floodplain of the Cape River and some nearby streams, but there is no Bowman specimen of it at MEL. We learn from the newspaper article that Bowman indeed saw this *Livistona*, but only juvenile plants and dead mature stems were available at that time. Similarly, an '*Inga*' was seen and much admired by Bowman on the Flinders River (from the description, undoubtedly *Vachellia sutherlandii*), but no collection was made because the trees were sterile.

Estimated number of gatherings: 229.

Collection set 4: Cleveland Bay, Rockhampton, Berserker Range, 1865

Bowman visited Cleveland Bay very early in 1865,[19] almost certainly by boat, and collected around 20 plant specimens. This visit was only a few months after the first party of settlers had arrived at was to become Townsville.[20] Immediately after this trip, he visited a part of the Fitzroy River known as the "Upper Flats". This locality is downstream from Rockhampton, in the area now known as Nerimbera. Bowman explored rainforest 'scrubs' at Upper Flats, and it was there that he discovered the beautiful palm *Archontophoenix alexandrae*, named by Mueller in July 1865. In the latter part of 1865, Bowman began a botanical exploration of the Berserker Range (which he referred to as the Bersaker Range), just to the east of Rockhampton. Many other collections, labelled Rockhampton or Fitzroy River are untraceable, as they lack numbers and dates. While some of the Fitzroy River and Rockhampton collections were made in 1865, I suspect that the majority were made during 1868, and a small number even later, including 1871.

His labels of this period are similar to those for the Burdekin River and Cape River trips, however most are without a number.

Estimated number of gatherings: 66.

15 *Notes of Journey from Port Denison to the Flinders. Queensland Times, Ipswich Herald and General Advertiser* (Qld), 22 November 1864, p. 4.

16 Dated specimen of *Aeschynamene indica* from the Suttor River, 25 February 1864 (MEL276203).

17 Label of MEL240719 (*Crotolorio novoe-hollondioe*) specifies this date.

18 *The Sydney Morning Herold* (N.S.W.), 2 December 1872, p. 10.

19 F. Mueller, *Fragmenta Phytagraphioe Australiae*, Vol. 5 (Melbaurne, June 1865), p. 42. [This is the first citation of a Cleveland Bay specimen, hence Bowman must have been there some months prior to this].

20 Townsville history 1770–1900 https://www.townsville.qld.gov.au/about-townsville/history-and-heritage/townsville-history/townsville-1770-to-1900, viewed 2 April 2018.

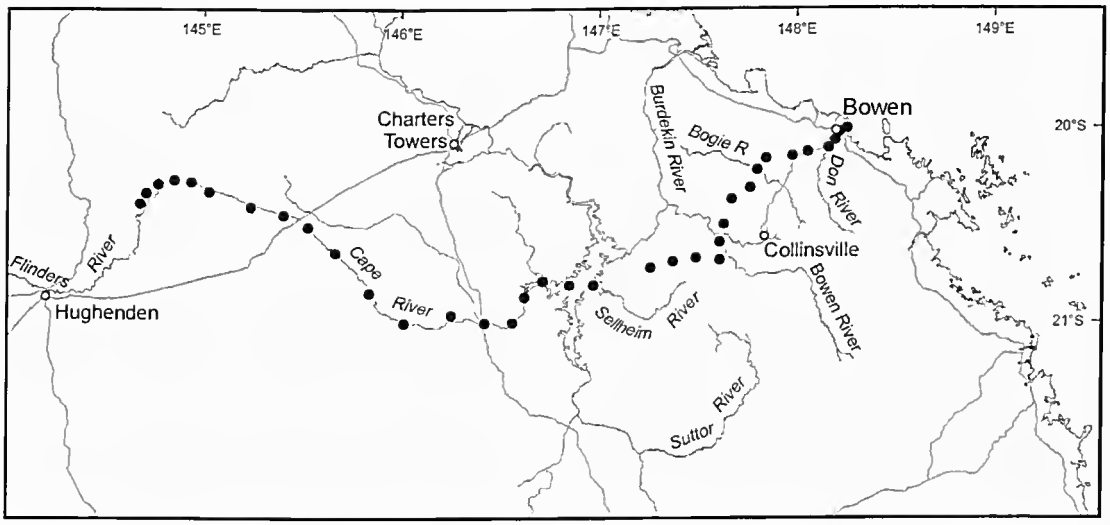


Figure 4. Route taken by Bowman during his 1864 expedition to Flinders River. The dots represent landmarks along the route and do not indicate the passage of a particular period of time.

Collection sets 5, 6 and 7: Neerkol Creek-Crocodile Creek-Table Mountain, 1866–1867

In early 1866, Bowman moved to the south-west of Rockhampton, probably living in the vicinity of Stanwell, as there are many specimen collections from nearby Neerkol Creek. His first dated collection from Neerkol Creek was May 1866. The first collection from Table Mountain was in June 1866, then again in February 1867. The Table Mountain of today is a small hill about 6 km SE of Stanwell, covering around 100 hectares, and reaching an elevation of 340 metres. This is apparently not the Table Mountain of the 1860s: newspaper articles of that era say that Table Mountain is at the head of Crocodile Creek (=Gavial Ck), i.e. south of Bouldercombe, where there is a flat-topped range covering about 1000 hectares and reaching 450 metres altitude; the Dee River has its source in this range, NE of Mount Morgan. Some of Bowman's collections are from the "Head of the Dee", and these have the same date as some of the Table Mountain collections.

Other localities visited in 1866 and 1867 are all close to Neerkol Creek, namely Gracemere, Stuart Creek, Midge Creek (March 1867), and Stanwell (Fig. 5). The last dated specimen from Neerkol Creek is from August 1867. His labels of this period are white and rectangular, but typically larger than those of the Burdekin River and Cape River trips.

Estimated number of gatherings: 412.

Collection set 8: Rockhampton, 1868

Almost nothing is known about Bowman's movements or collections in 1868. Certainly there are no dated collections from that year, but a newspaper article published in August 1868[21] confirms that he then resided in Rockhampton. A specimen of *Galinsoga parviflora* with a label typical of those used by P. O'Shanesy and in his handwriting[22] includes the script "moist places, Rockh. E. Bowman 20/4/68"; this wording suggests that either Bowman was a co-collector, or that he gave the specimen to O'Shanesy. There is an undated, unnumbered Bowman specimen of the same species from "Rockhampton"; presumably it was part of the same gathering. It would appear that Bowman dispensed with field labels upon moving back to Rockhampton, as they are rarely encountered.

Estimated number of gatherings: 175.

Collection sets 8, 9 & 10: Herberts Creek-Gainsford-Kings Creek, 1869–1870

Bowman evidently moved to Gainsford (on the Dawson River, SW of Rockhampton) sometime in 1869. There are numerous specimens from 1869 that say either Gainsford or King's Creek, or both. In June 1870, Bowman gives his address as "Herbert's Creek",[23] a location just

21 *The Australasian* (Melbourne, Vic.), 22 August 1868, p. 25.
22 Specimen at MEL (MEL643605).
23 *The Queenslander* (Brisbane, Qld), 25 June 1870, p. 6.

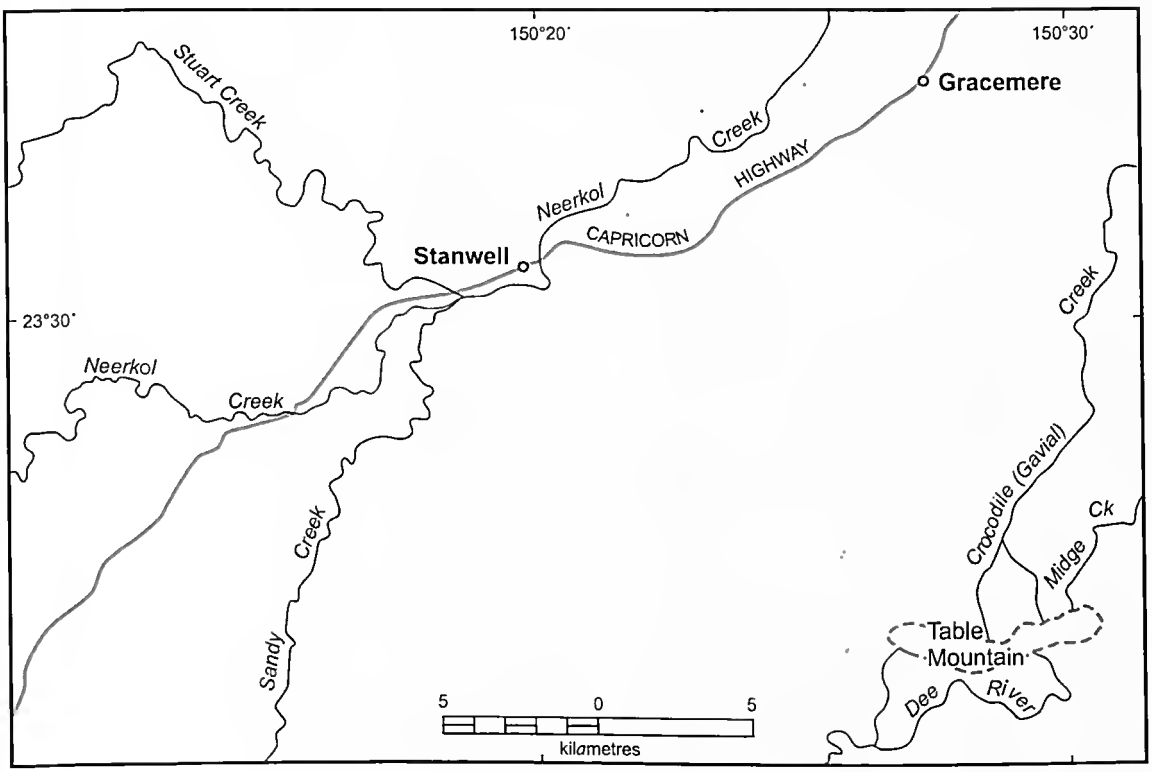


Figure 5. Localities visited by Bowman in 1866–67.

a few kilometres further to the east (Fig. 6). The great majority of 1870 specimens are from Herbert's Creek, but the Gainsford/King's Creek locations also appear for that year, and there are just a few from Westwood and Rockhampton. As with his 1868 Rockhampton collection set, it seems that Bowman only rarely wrote a field label for these specimens, and numbered specimens are very rare indeed. The grasses feature strongly in these collection sets, but a wide range of flowering plants are represented, as well as some fungi and lichens.

Estimated number of gatherings: 408.

Collection sets 11 & 12: Peak Downs-Copperfield-Broadsound, 1871–1872

In 1871, Bowman travelled from Gainsford to Clermont (via Gordon Downs and Lilyvale), with a side-trip to Nogoa River (near where Emerald is now located). After collecting numerous specimens from 'Peak Downs' (the area surrounding Clermont) he travelled ENE of Clermont to the Isaac River, then onto St Lawrence, and southwards to Rockhampton, through "Broadsound" (Fig. 7). A newspaper article from 1873 details the route that he almost certainly took.[24] He must have then gone to the newly settled Keppel Sands area, as there are two specimens from the mouth of the Fitzroy, and one from Keppel Bay. He then returned to Gainsford, where he was residing in December 1871.[25] After that, he returned to Clermont, where he died in June 1872. His last known specimen was one of *Enchylaena tomentosa*, collected from Peak Downs in March 1872. He frequently used slitted labels in these collection sets, as he had done in 1862 (Fig. 2e).

Estimated number of gatherings: 111.

An analysis of the collections made by Edward Bowman

The estimated total number of gatherings made by Bowman is 2033. This figure comprises the total of the

24 *Rackhamptan Bulletin* (Qld), 4 June 1873, p. 2.
25 *Maryborough Chranicle, Wide Bay and Burnett Advertiser* (Qld), 2 January 1872, p. 4.

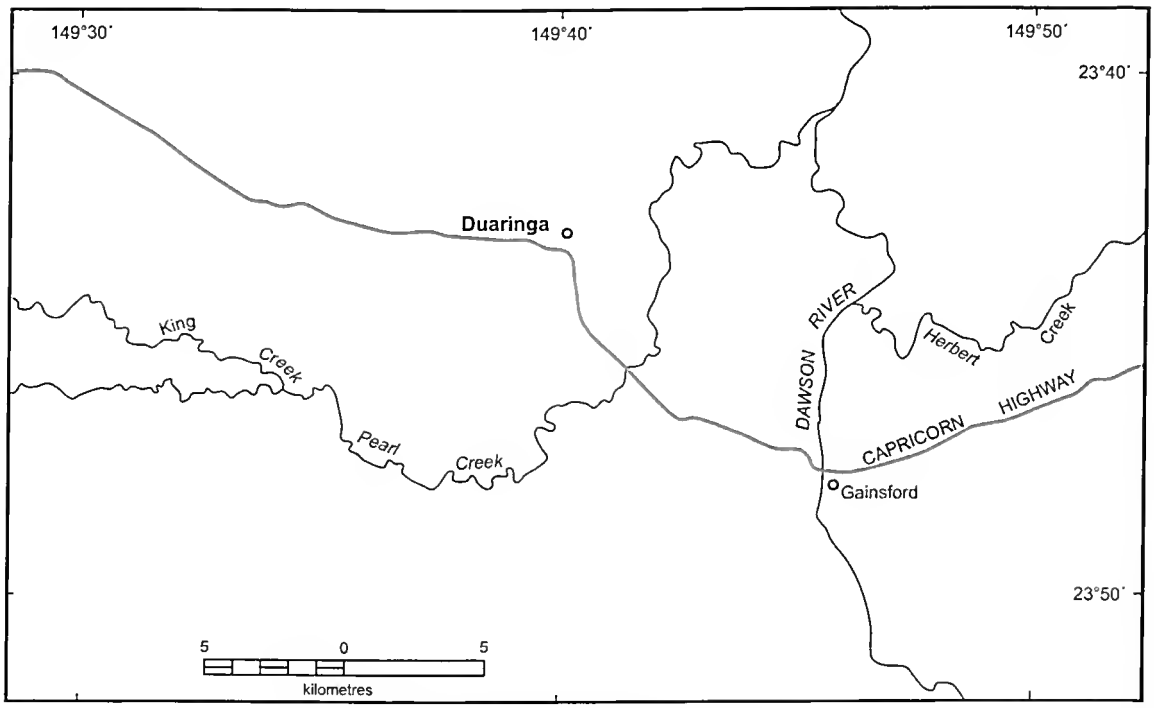


Figure 6. Localities visited by Bowman in 1869–71.

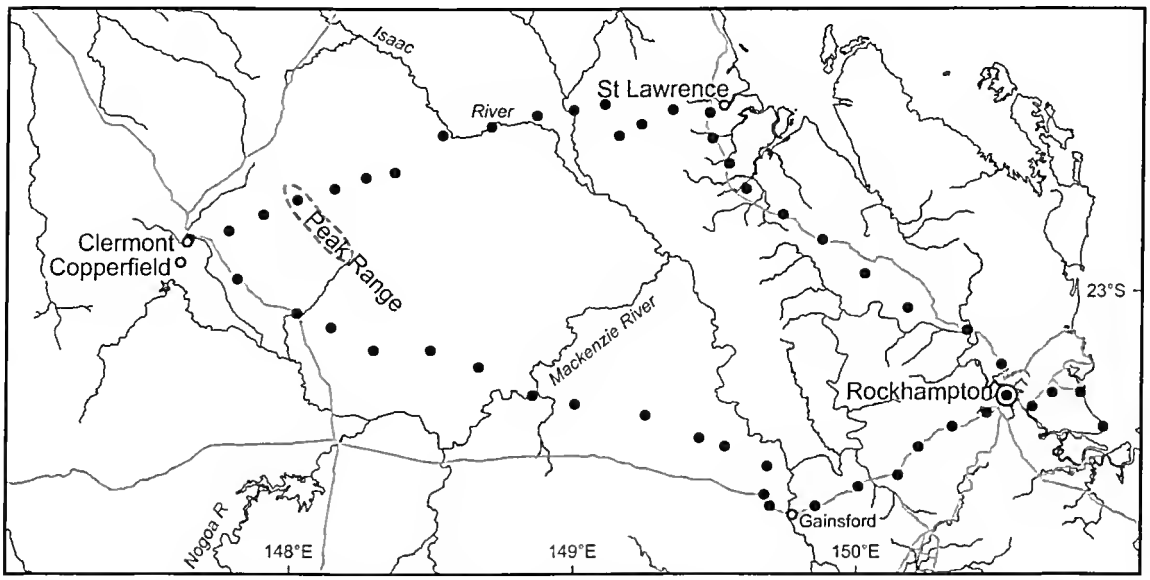


Figure 7. Route taken by Bowman during his 1871 expedition to Clermont and Broadsound. The dots represent landmarks along the route and do not indicate the passage of a particular period of time.

collections documented above, plus 31 Queensland gatherings which cannot be placed due to lack of information, plus 29 New South Wales gatherings, plus 21 specimens (18 fungus specimens at K; 1 *Pterocaulon* at K; 2 specimens at P) that are present at K or P, but absent from MEL. In arriving at this number, the assumption has been made that unnumbered records of species with the same location or date as numbered collections, are part of the same gathering.

The great majority of Bowman's collections are of flowering plants. His favourite plant group was undoubtedly the Fabaceae subf. Faboideae (Papilionoideae). This subfamily accounts for 13% of his total gatherings, and tops the list for every one of the collection sets listed above. A rather distant second is the Poaceae (grasses), followed by Asteraceae and Myrtaceae. There are 65 *Acacia* collections, and just 30 eucalypt (*Eucalyptus* + *Corymbia*) collections. There are relatively few rainforest taxa among his collections, and relatively few swamp plants and water plants, so it seems that his preference was for eucalypt woodlands. Most of his collections were made from alluvial ecosystems, as this is where his work required him to be, and relatively few collections were made from mountaintops. A couple of his 1871 collections give the locality as "top of Peak Range", but I believe that by this he meant the *top of the watershed* where the road crossed it. None of the species he collected suggest that he scaled any of the mountains in the Peak Range.

He made 44 gatherings of Pteridophytes, with nearly half of them from the Table Mountain and Crocodile Creek area. His first collection of a fungus specimen was in 1864, and the second in 1867. In 1868, he collected another six fungi. During his time at Gainsford and Herbert's Creek (1869–70), he made a very significant collection of fungi – some 35 species. Mueller probably asked Bowman to make a special effort with the fungi, in the knowledge that M.J. Berkeley was preparing a paper on Australian fungi (Berkeley 1873). Many of Bowman's fungi specimens are cited there. Bowman did collect a modest number of lower plants (two mosses, eight liverworts, three lichens and an alga).

Bowman made many first-collections for species in eastern Australia. His collections of *Solanum orgadophilum* from Capella in 1871, and *Eucalyptus similis* from Cape River in 1864 are just two examples. He was one of the few collectors of his era to include comments on the species he collected in terms of their value for timber, medicine or ornament. Around 200 of his specimens were used as type material by various botanists, especially Mueller.

Eponymy

The following 11 taxa were named after E.M. Bowman (in chronological order).

Ricinocarpos bowmanii F.Muell. (as 'bowmani'), *Fragm.* 1: 181 (1859).

Eremophila bowmanii F.Muell. (as 'bowmani'), *Fragm.* 2: 139 (1861).

Boronia bowmanii F.Muell. (as 'bowmani'), *Fragm.* 4: 135 (1864).

Eucalyptus bowmanii Benth. (as 'bowmani'), *Fl. Austral.* 3: 219 (1867).

Agaricus bowmanni Berk., *J. Linn. Soc., Bot.* 13: 158 (1873).

Daedalea bowmanii Berk. (as 'bowmani'), *J. Linn. Soc., Bot.* 13: 166 (1873).

Pimelea bowmanni[26] *Benth., Fl. Austral.* 6: 30 (1873).

Dendrobium bowmanii Benth., *Fl. Austral.* 6: 286 (1873).

Cyperus bowmanni F.Muell. ex Benth., *Fl. Austral.* 7: 287 (1878).

Xylaria hypoxylon var. *bowmanii* F.Muell. ex Berk. (as 'Bowmani'), *J. Linn. Soc., Bot.* 18: 389 (1881).

Cynanchum bowmanii S.T.Blake, *Proc. Roy. Soc. Qld* 59: 168 (1948).

Acknowledgements

I gratefully acknowledge the 'Trove' website, provided by the National Library of Australia. I am thankful to Will Smith (BRI) for producing the maps and other images. I thank Pina Milne, National Herbarium of Victoria (MEL), for permission to reproduce portions of Bowman's specimens at MEL. Several members of staff at MEL assisted me during my January 2018 visit and subsequently, including Angharad Johnson and

26 This spelling is considered an intentional Latinisation of Bowman's name that does not concern only the termination, nor omission of the terminal vowel or consonant, nor conversion of the terminal vowel to a different vowel (Art. 60.9, Shenzhen Code), and as such is not correctable (J. McNeill, pers. comm., May 2018).

Nimal Karunajeewa, and especially Aaron McArdle, who cheerfully and promptly responded to my many enquiries. John McNeill advised on the orthography of epithets named for Bowman. Sara Maroske (Royal Botanic Gardens, Melbourne) kindly shared unpublished letters forming part of the Mueller Correspondence Project.

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Appendix 1. Annotated list of E.M. Bowman's Queensland collecting localities

LOCALITY (with approx. number of gatherings)	WHEN VISITED	LAT-LONG	PRECISION	NOTES
Amity Creek (5)	late 1862, early 1863	22° 30′ 149° 33′	2 km	Between Ogmore and St Lawrence
Bersaker Range (25)	late 1865	23° 21′ 150° 34′	5 km	just east of Rockhampton
Blackwater Creek (2)	early 1871	23° 24′ 148° 55′	2 km	About 20 km N of town of Blackwater
Bowen port/town (3)	mid 1863, early 1864	20° 00′ 148° 15′	2 km	also referred to as Port Denison
Bowen River (73)	early to mid 1863	20° 45′ 147° 50′	50 km	Bowman followed this river for about 130 km. This lat/long represents the probable midpoint of collection sites
Brawl Creek (5)	Feb 1864	20° 38′ 147° 31′	2 km	WSW of Collinsville
Broadsound (104)	late 1862, early 1863, mid 1871	22° 42′ 149° 42′	50 km	In the sense used by Bowman, a strip of country about 115 km long, from Canoona to St Lawrence, and including the following locations that are sometimes used without reference to "Broadsound": Princhester, Marlborough, Granite Creek, Amity Creek, Montrose Creek. This lat/long represents the probable midpoint of collection sites
Burdekin River (46)	mid 1863	20° 16′ 146° 51′	75 km	Bowman followed this river for about 170 km. This lat/long represents the probable midpoint of collection sites
Cape River (head of the) (11)	Apr 1864	20° 20′ 145° 03′	15 km	Estimated as the uppermost 27 km of the river. This lat/long represents the probable midpoint of collection sites
Cape River (78)	Mar-Apr 1864	20° 45′ 145° 46′	75 km	Specimens with this locality made over a distance of about 180 km. This lat/long represents the probable midpoint of collection sites
Castle Creek (6)	early to mid 1862	24° 50′ 150° 17′	2 km	Tributary of Dawson River, close to present day Theodore

LOCALITY (with approx. number of gatherings)	WHEN VISITED	LAT-LONG	PRECISION	NOTES
Castle Mount (3)	early 1865	19° 15′ 146° 48′	1 km	Castle Hill, Townsville
Chin Chin Creek (2)	mid 1863			Not traced. Label type suggests Burdekin R trip (1863), and the numbers (319&322) fit into the sequence, placing it near the Burdekin River
Clermont (1)	1871	22° 49′ 147° 38′	2 km	
Cleveland Bay (17)	early 1865	19° 14′ 146° 48′	2 km	
Connors Range (3)	early 1863	22° 22′ 149° 20′	2 km	west of St Lawrence
Connors River (and Connors Ck) (14)	early 1863	22° 12′ 149° 03′	5 km	
Cooper Creek (12)	early 1863	21° 33′ 148° 34′	5 km	NW of Nebo
Copella (1)	early 1871	23° 05′ 148° 01′	2 km	Now Capella
Copperfield (9)	1871	22° 51′ 147° 36′	2 km	A few km south of Clermont
Crocodile Creek (47)	1867	23° 35′ 150° 28′	2 km	S of Bouldercombe; now called Gavial Creek
Dawson River (7)	1869	23° 47′ 149° 45′	5 km	About 13 km SE of Duaringa
Elliot River (17)	mid 1863	20° 07′ 147° 53′	2 km	WSW of Bowen
Fitzroy River (41)	1865, 1868	23° 23′ 150° 31′	10 km	This lat/long represents the probable midpoint of collection sites
Fitzroy River estuary (2)	1871	23° 30′ 150° 51′	2 km	
Fletcher Creek (1)	mid 1863	19° 49′ 146° 04′	2 km	A tributary of the Burdekin River
Flinders River (and head of the Flinders) (26)	May 1864	20° 23′ 144° 42′	10 km	This lat/long represents the probable midpoint of collection sites
Fort Cooper (4)	early 1863	21° 41′ 148° 41′	2 km	Now called Nebo
Frenchmans Ck (5)	late 1865	23° 20′ 150° 33′	2 km	just east of Rockhampton
Funnel Creek (6)	early 1863	21° 55′ 148° 51′	2 km	
Gainsford (58)	1869, 1871	23° 47′ 149° 45′	2 km	About 13 km SE of Duaringa
Glenella Creek (1)	Jan 1864	20° 41′ 147° 31′	2 km	WSW of Collinsville
Gogango scrub (2)	1869 or 1870	23° 40′ 150° 01′	5 km	Remnants of this scrub still exist near the Capricorn Hwy
Gordon Downs (2)	early 1871	23° 16′ 148° 18′	2 km	SE of Capella

LOCALITY (with approx. number of gatherings)	WHEN VISITED	LAT-LONG	PRECISION	NOTES
Gracemere (12)	Jan 1867	23° 26′ 150° 27′	2 km	
Granite Creek (1)	early 1863	22° 36′ 149° 36′	2 km	Near Ogmore
Head of the Dee [River] (8)	Jan-Feb 1867	23° 37′ 150° 27′	5 km	NE of Mount Morgan
Head of the Isaacs (12)	late 1862, early 1863	21° 50′ 148° 44′	5 km	Including Denison Creek and Nebo Creek
Herberts Creek (255)	1869, 1870	23° 44′ 149° 49′	2 km	About 17 km E of Duaringa
Isaac River (4)	mid 1871	22° 25′ 148° 53′	5 km	Near present-day "Batheaston" station
Isabella Creek (3)	Feb 1864	20° 47′ 147° 19′	2 km	
Keppels Bay (1)	1871	23° 22′ 150° 47′	2 km	
Kings Creek (68)	1869, 1870	23° 46′ 149° 35′	2 km	About 12 km SW of Duaringa
Leichhardt Range (3)	early 1864	20° 44′ 147° 23′	5 km	
Lillyvale (1)	early 1871	23° 12′ 148° 20′	2 km	A rest stop for coaches on the road from Gainsford to Clermont, with a waterhole (Crinum Ck)
Limestone Ck (head of) (1)	mid 1863			Not traced, but stated by Bowman to be "a tributary of the Burdekin"
Lotus Creek (1)	early 1863	22° 21′ 149° 06′	2 km	West of St Lawrence
Marlborough (8)	late 1862, early 1863	22° 52′ 149° 51′	2 km	
McKenzie River (5)	early 1871	23° 22′ 148° 50′	2 km	Now Mackenzie River; the crossing was near the Bedford Weir
Midge Creek (4)	Mar 1867	23° 34′ 150° 30′	2 km	Now called Midgee Ck; collections made in the upper reaches
Montrose Creek (3)	early 1863	22° 37′ 149° 37′	2 km	near Ogmore
Moonlight Creek (2)	early 1864	20° 37′ 147° 31′	2 km	WSW of Collinsville
Mount Archer (4)	late 1865	23° 20′ 150° 34′	1 km	just east of Rockhampton
Mount Wyatt (2)	early 1864	20° 53′ 147° 16′	2 km	SW of Collinsville
Mulholland Creek (1)	early 1863			Not traced but label type suggests Burdekin R trip (1863), and the number (190) fits into the sequence, and places it near Nebo or Funnel Creek
Nebo Creek (4)	early 1863	21° 43′ 148° 41′	5 km	
Neerkol Creek (285)	May 1866 to Aug 1867	23° 29′ 150° 21′	5 km	Probably most specimens from the vicinity of Stanwell

LOCALITY (with approx. number of gatherings)	WHEN VISITED	LAT-LONG	PRECISION	NOTES
Nogoa River (1)	early 1871	23° 25′ 148° 25′	10 km	Collection site uncertain, probably NE of present-day Emerald
Peak Downs (18)	1871-72	22° 45′ 147° 45′	10 km	Bowman used this term for the country surrounding Clermont
Peak Range (near) (5)	mid 1871	22° 39′ 148° 10′	10 km	Cotherstone Rd, but from the species collected, this locality is broadly circumscribed. This lat/long represents the probable midpoint of collection sites
Peak Range (top of/ summit of) (4)	mid 1871	22° 40′ 148° 01′	2 km	Cotherstone road, ENE of Clermont
Pearl Creek (1)	1869 or 1870	23° 47′ 149° 38′	2 km	About 10 km SSW of Duaringa
Pelican Creek (1)	mid 1863	20° 33′ 147° 37′	2 km	W of Collinsville
Percy Douglas Creek (2)	Feb 1864	20° 53′ 147° 14′	2 km	About 60 km N of Mt Coolon
Port Denison (6)	mid 1863, early 1864	20° 00′ 148° 15′	2 km	now Bowen
Princhester (and Princhester Ck) (11)	late 1862, early 1863	22° 55′ 150° 01′	5 km	
Rockhampton (141)	1865, 1868, 1870, 1871	23° 23′ 150° 30′	5 km	
Ross's River (1)	early 1865	19° 16′ 146° 49′	2 km	Ross River, Townsville
Sandy Creek (3)	Jan 1867	23° 30′ 150° 18′	2 km	A tributary of Neerkol Creek, just west of Stanwell
Saunders Creek (1)	1864			Not traced, but evidently on the 1864 expedition, perhaps flowing into the Flinders River
Sellheim River (7)	early 1864	20° 48′ 146° 59′	5 km	Mt McConnell homestead is on the Sellheim River
St Lawrence Creek (or Lawrence Ck) (2)	early 1863	22° 20′ 149° 32′	2 km	Collections made on tidal part of the creek
Stanwell (6)	1866 or 1867	23° 29′ 150° 20′	2 km	
Stewarts Creek (5)	1866 or 1867	23° 28′ 150° 17′	2 km	Now spelled Stuarts Creek, near Stanwell
Suttor River (70)	Feb-Mar 1864	20° 49′ 146° 51′	5 km	
Table Mountain (29)	Jun 1866, Feb 1867, Apr 1867	23° 36′ 150° 28′	2 km	S of Bouldercombe
Upper flats (5)	early 1865	23° 24′ 150° 35′	2 km	Fitzroy River, Nerimbera, Rockhampton
Walloon (37)	early to mid 1862	24° 53′ 150° 13′	5 km	Close to present-day Theodore
Westwood (11)	1870, 1871	23° 37′ 150° 09′	2 km	

Muelleria

37: 101–107

ROYAL
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Three new species of *Gyroporus* (Boletales, Basidiomycota) from Australia

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Introduction

Gyroporus Quél. is a widely distributed genus of obligately ectomycorrhizal boletes (stipitate-pileate fungi with poroid hymenophores of the order Boletales) that harbours a high level of undescribed diversity (Davoodian *et al.* 2018). A significant portion of this diversity is in Australia, where species of *Gyroporus* are putatively mycorrhizal primarily with Myrtaceae. In addition to its global diversity and ectomycorrhizal trophic mode, *Gyroporus* is notable as being one of few stipitate-pileate genera in the otherwise gasteroid suborder Sclerodermatineae (Wilson *et al.* 2012). Here, we formally describe three new species of *Gyroporus* from Australia that have become apparent after sustained fieldwork, morphological study, and phylogenetic research by the authors. Two of the species described are members of the Australian *cyanescens* complex, a Southern Hemisphere clade sister to the classic European/Northern Hemisphere taxon *Gyroporus cyanescens* (Bull.:Fr.) Quél. (Davoodian *et al.* 2018).

Abstract

Three novel Australian species of *Gyroporus* Quél. are formally described here. *Gyroporus noronjus* Davoodian, Bougher, Fechner & Halling sp. nov. is an orange *Gyroporus* phylogenetically linked with undescribed African *Gyroporus* species. Two Western Australian species, *Gyroporus occidentolis* Davoodian, Bougher & Halling sp. nov. and *Gyroporus robinsonii* Davoodian sp. nov. are dark blue oxidizing and light blue oxidizing (respectively) members of the Australian *cyonescens* complex.

***Keywords*:** ectomycorrhizal fungi, taxonomy, systematics, Australasia, boletes

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

The Australian *cyanescens* complex is composed of two clades, one of light color oxidising and one of dark color oxidising species (see Davoodian *et al.* 2018). The light-oxidising species are represented by the clade including *Gyroporus australiensis* Davoodian, Fechner & Halling, *"Gyroporus allocyanescens"* nom. prov., and *Gyroporus robinsonii* Davoodian sp. nov. In these species the bluing reaction on injured flesh is gradual and relatively weak, generally not occuring in all tissues. *G. australiensis* is thus far only known from Great Sandy National Park in Queensland and is readily diagnosable by the combination of its brown pileus and gradual cyanescent reaction that is present in the flesh and on the pores but absent from the tubes. *Gyroporus robinsonii* sp. nov., thus far only known from Western Australia, is described below. The dark-oxidising species are represented by the clade including *Gyroporus furvescens* Davoodian & Halling, *"Gyroporus austrocyanescens"* nom. prov., *"Gyroporus neocyanescens"* nom. prov., *Gyroporus brunnescens* Davoodian, Fechner & Halling, and *Gyroporus occidentalis* Davoodian, Bougher & Halling sp. nov. In these species, the tissues stain immediately and intensely deep blue, with the exception of *G. brunnescens*, which is the only true *Gyroporus* known to have a brown oxidation reaction. *Gyroporus occidentalis* sp. nov., thus far only known from Western Australia, is described and illustrated. Several undescribed species (e.g. *"G. neocyanescens"*) belong to the Australian *cyanescens* complex, however, beyond whether they are members of the light-oxidising or dark-oxidising clades, the boundaries and characteristics of these species cannot be fully ascertained until more collections are acquired.

Gyroporus cyanescens sensu lato (i.e. the Northern Hemisphere *cyanescens* complex) includes several segregate species, such as *Gyroporus pseudolacteus* G.Moreno, Carlavilla, Heykoop, Manjón & Vizzini and *Gyroporus pseudocyanescens* G.Moreno, Carlavilla, Heykoop, Manjón & Vizzini (Crous, Wingfield, Richardson *et al.* 2016; Crous, Wingfield, Burgess *et al.* 2017). *Gyroporus castaneus* (Bull.:Fr.) Quél., a classic European taxon, has not been reliably documented in Australia; previous Australian collections under this name are now known to be either *Gyroporus mcnabbii* Davoodian, Bougher & Halling or *Gyroporus naranjus* Davoodian, Bougher, Fechner & Halling sp. nov.

Taxonomy

Gyroporus naranjus Davoodian, Bougher, Fechner & Halling **sp. nov.**

MycoBank No.: MB828913

Differs from other species of *Gyroporus* in Australia by its orange colouration throughout the pileus and stipe surfaces.

***Type*: QUEENSLAND.** Wide Bay District, Great Sandy National Park, Fraser Island, 25°28'41"S, 153°03'42"E, 15.ii.2011, *Halling 9411* (holo: BRI AQ0797904 photo!, iso: NY 1194004!). GenBank – RPB2: MF818233. ATP6: MF818157.

Pileus 1.5–7 cm broad, convex to planoconvex, dry, brown to pale brownish orange to light orange, sometimes nearly white, finely matted to barely subvelutinous to furfuraceous to nearly glabrous. *Flesh* white, unchanging, with mild odour and taste. *Tubes* adnexed, unchanging, white then yellow when mature, some parts occasionally discolouring to orange or orange-brown. *Stipe* brown to cinnamon brown to pale brownish orange to faint orange, 3–7 cm long, 0.8–3 cm broad, dry, equal to subclavate, fine matted to glabrous, chambered to hollow. *Spores* (7)7.2–9.7 × 4–5(5.5) µm (Q=1.79), smooth, light yellow-hyaline to yellow-hyaline, subreniform to ellipsoid to subovoid to elongate subovoid, sometimes slightly peanut shaped, sometimes appearing apiculate. *Basidia* 25–30 × 9–10 µm, clavate. *Cheilocystidia* 29–40 × 6–9 µm, versiform (ventricose-acuminate, cylindrical, cylindrical-tapering, or slightly clavate). *Pileipellis* a shortened, tightly-arranged trichoderm with inflated elements. *Clamp connections* present.

***Additional specimens examined*: QUEENSLAND.** Wide Bay District. Great Sandy National Park. Fraser Island. Central Station, 25°28'34.3"S, 153°03'21.6"E, 90m, 07.iii.2011, R.E. Halling 9471 (BRI, NY); W of Central Station (Wanggoolba Creek Road), 25°28'16.3"S, 153°02'09.6"E, 24m, 18.ii.2011, R.E. Halling 9429 (BRI, NY); Road from Eurong to Central Station, 25°28'41.2"S, 153°03'43.2"E, 116m, 15.ii.2011, R.E. Halling 9413 (BRI, NY); Road from Central Station to Lake Birrabeen, 25°29'42.0"S, 153°03'50.4"E, 160m, 13.ii.2009, R.E. Halling 9068 (BRI, NY); Road from Central Station to Lake Birrabeen, 25°29'49.9"S, 153°03'03.6"E, 140m, 08.ii.2009, R.E. Halling 9020 (BRI, NY); Walkamin, south of Mareeba. Along Kennedy Highway, 24.ii.1993, N.L. Bougher E4879 (PERTH).

Distribution and ecology: Thus far known only from Queensland. Gregarious to scattered in sand with Myrtaceae (*Leptospermum* J.R.Forst. & G.Forst., *Eucalyptus* L'Hér., *Syncarpia* Ten., *Lophostemon* Schott) and possibly Casuarinaceae (*Allocasuarina* L.A.S.Johnson) and Fabaceae (*Acacia* Mill.).

Comments: Based on analysis of the protein-coding genes *atp6* (mitochondrial) and *rpb2* (nuclear), *Gyroporus naranjus* sp. nov. is sister to several undescribed species from mainland Africa (Davoodian *et al.* 2018 and unpublished data), which together may represent a Gondwanan lineage. In this context, molecular comparisons with *G. austrobrasiliensis* A.C.Magnago from Brazil and *G. paramjitii* K.Das, D.Chakraborty & Vizzini from India would be illuminating (Das *et al.* 2017; Magnago *et al.* 2018). A similar species that occurs in Australia, *Gyroporus mcnabbii* Davoodian, Bougher & Halling, is distinguishable from *G. naranjus* in that *G. mcnabbii* displays deeper, mottled colours, a more subvelvety pileus texture, and larger spores. A photograph of the holotype of *G. naranjus* taken shortly after collection is provided (Fig. 1).

Gyroporus occidentalis Davoodian, Bougher & Halling **sp. nov.**

MycoBank No.: MB828914

This is the only species of *Gyroporus* thus far known from Western Australia with a rapidly bluing oxidation reaction. It is also unique for its robust size and stature.

Type: **WESTERN AUSTRALIA.** Capel Shire, Ludlow State Forest, Tuart Forest National Park, 33°36'51.1"S, 115°27'39.6"E, 20.vi.2006, *Halling 8821* (holo: PERTH 8019118 photo!, iso: NY 1194024!). GenBank - RPB2: MF818213, FJ536639. ATP6: MF818177. 18S(part)-ITS1-5.8S-ITS2-25S(part): EU718103.

Pileus 4–10 cm broad, irregular (roughly subhemispherical to subconvex to irregular to irregularly planar), dry, floccose to matted woolly to heavily appressed tomentose, yellow-white to yellow buff to dirty yellow, cyanescent, with slightly extended margin. *Flesh* white, rapidly cyanescent, with mild odor and taste. *Tubes* adnexed to subfree, whitish to yellowish white to pale yellow, cyanescent. *Stipe* 5.5–12 cm long, 2.2–4.5 cm broad, irregular (subequal to slightly

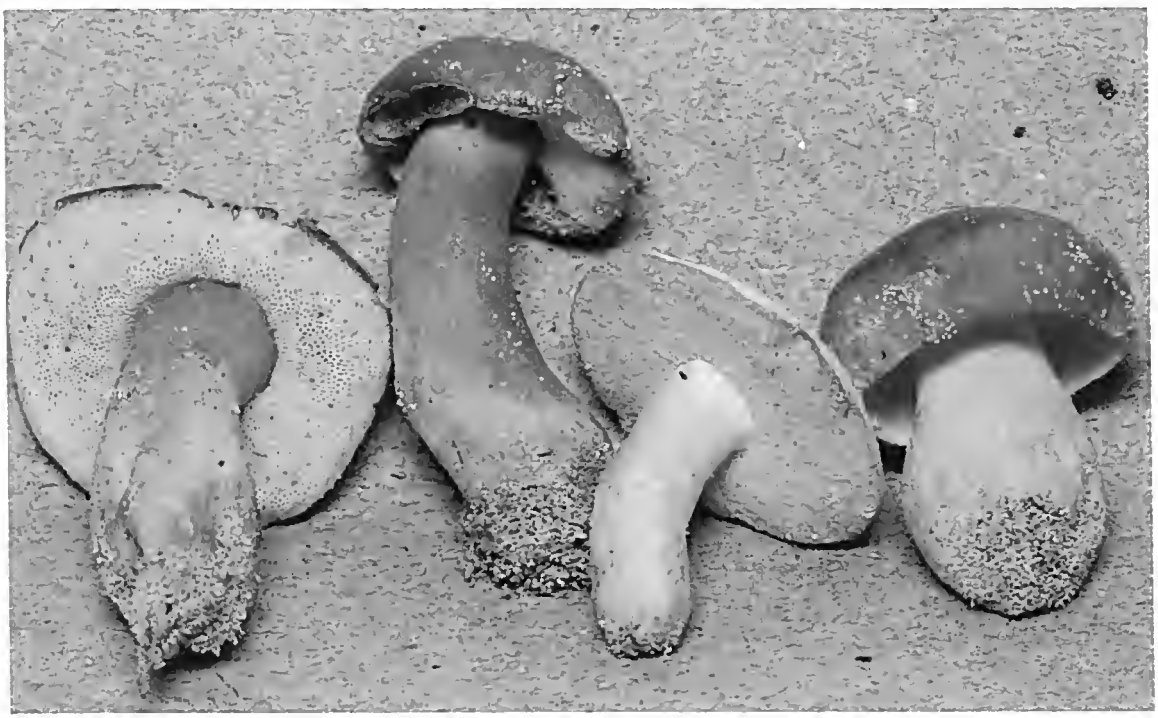

Figure 1. *Gyroporus naranjus* (holotype *Halling 9411*). Photo: Roy Halling

ventricose to subclavate to tapering downward), dry, finely appressed lanose, often with annular zone/ridge, subconcolorous with pileus, cyanescent, pithy to chambered (hollowing). *Spores* 7.7–8.4(–9.1) × 3.5–4.2 µm (Q=2.17), smooth, yellow. *Basidia* 28–32 µm long. *Cheilocystidia* clavate to more or less fusoid to tapering, sometimes elongate. *Pileipellis* an elongated, tangled trichodermium; elements yellow-hyaline, septate, clamped, 8–16 µm wide. *Clamp connections* present.

***Additional specimens examined*: WESTERN AUSTRALIA**. Perth. Floreat. Elphin Road, 31°59'12.1"S, 115°53'16.8"E, 17.vi.2006, R.E. Halling 8819 (PERTH, NY); Perry Lakes, N.L. Bougher E8164 (PERTH).

***Distribution and ecology*:** Thus far known only from Western Australia. On sand in association with Myrtaceae (*Eucalyptus* and possibly *Agonis*).

***Comments*:** This is a quickly dark blue-staining *Gyroporus cyanescens* (a classic Northern Hemisphere taxon) relative from Western Australia, embedded in a clade of other quickly dark blue-staining species from Eastern Australia (e.g. *G. furvescens* Davoodian & Halling supported with ATP6 and RPB2 data in Davoodian *et al.* 2018). A photograph of the holotype arranged in the field is provided (Fig. 2), as well as a photograph of the exposed flesh taken indoors during collection processing (Fig. 3).

Gyroporus robinsonii Davoodian **sp. nov.**

MycoBank No.: MB828915

This is the only species of *Gyroporus* thus far known from Western Australia with a slowly and faintly bluing oxidation reaction.

***Type*: WESTERN AUSTRALIA.** Trent, London Forest Block, edge of Mountain Road, 1.6 km west of Nornalup Road, 34°46'39"S, 116°58'48"E, 8.vi.2010, *R.M. Robinson s.n.* (holo: NY 1292999!). GenBank - ATP6: MF818178.

Pileus plane to subplanoconvex, margins turning upward or recurving, dry, matted, fibrils sometimes aggregating

Figure 2. *Gyroporus occidentalis* (holotype *Halling 8821*). Photo: Roy Halling

into small scales, yellow-white to straw yellow to buff to dirty buff. *Flesh* white, slowly and faintly cyanescent. *Tubes* adnexed, whitish to yellowish, not cyanescent, pores likewise. *Stipe* dry, very finely matted, more or less subconcolorous with pileus, pithy to chambered. *Spores* (8.4–)8.8–10.5(–12) × 4.7–5.6(–6) µm (Q=1.75–2.14), smooth, cloudy yellow to yellow to yellow-hyaline, subreniform to ellipsoid to subellipsoid to subovoid to ovoid-elongate, sometimes appearing apiculate. *Basidia* 28–29 × 12–13 µm. *Pileipellis* an elongated, repent, subparallel to tangled trichodermium; elements up to 12–16 µm wide. *Clamp connections* present.

***Additional specimen examined*: WESTERN AUSTRALIA**. Near Scotsdale and Denmark, near Hamilton Road, 34°54'33.1"S, 117°20'27.6"E, 16.vii.2011, N. Davoodian ND13 (NY).

***Distribution and ecology*:** Thus far known only from Western Australia. On sandy soil in association with Myrtaceae (*Eucalyptus marginata* and possibly other species).

***Comments*:** This is a slowly and faintly blue-staining *Gyroporus cyanescens* (a classic Northern Hemisphere taxon) relative from Western Australia, in a clade of other slowly and faintly blue-staining species from Eastern Australia (e.g. *G. australiensis* Davoodian, Fechner & Halling supported with ATP6 data in Davoodian *et al.* 2018). Two photographs of specimen ND13 taken within minutes of being encountered in the field are provided (Figs. 4, 5). The number ND14 was assigned to the holotype (NY 1292999) after acquisition of the

Figure 3. *Gyroporus occidentalis* (holotype *Halling 8821*). Exposed flesh. Photo: Robert Garvey

specimen by N. Davoodian from R.M. Robinson. This species is primarily distinguished by the combination of molecular data, known distribution, and oxidation reaction; further collection of this species may reveal additional distinguishing characters.

Identity of previous records of *Gyroporus* from Australia

Several *Gyroporus* taxa have previously been reported from Australia, though documentation has generally been insufficient for unambiguous identification. A

Figure 4. *Gyroporus robinsonii* (Davoodian 13). The slow, faint oxidation reaction in the flesh is apparent closest to the edges of the context. Photo: Naveed Davoodian

Figure 5. *Gyroporus robinsonii* (Davoodian 13). Hymenophore view. Photo: Naveed Davoodian

Gyroporus (reported alternately as *Gyroporus* sp. and "*Gyroporus variabilis*" – an invalid name) is treated in Bougher & Syme (1998), and the authors suggest that "The name Variable *Gyroporus* is appropriate because both slowly/weakly blueing and rapidly/intensely blueing varieties occur in south-western Australia." Nevertheless, the description and illustrations provided on pp 308–309 and the voucher cited on p 378 in Bougher & Syme (1998) are exclusively based on PERTH5507022, which appears to represent *G. robinsonii*. "*Gyroporus* aff *cyanescens*" in McMullan-Fisher *et al.* (2014) appears to correspond to *Gyroporus furvescens*, based on its swift grey blue to deep blue to blackish oxidation reaction (that can eventually become very dark brown), ivory/yellowish-white tones at the stipe apex, and spore measurements that mostly agree with the original description. Also, *G. furvescens* is recorded from rainforest habitat in eastern Australia (based on collections thus far). *Gyroporus caespitosus* Cleland is not a *Gyroporus*. Cleland (1924) initially described this taxon under *Boletus* (*Gyroporus*) *caespitosus* Cleland, which is illegitimate (the earliest homonym is *Boletus caespitosus* Massee 1892). Grgurinovic (1997) synonymised *G. caespitosus* Cleland with *Boletus ovalisporus* Cleland, and treated the latter as *Chalciporus ovalisporus* (Cleland) Grgur. She effectively lectotypified *G. caespitosus* and *B. ovalisporus* by indicating a holotype for each taxon from among the syntypes (AD 10831 [ND !] and AD 10832 [ND !], respectively – neither are true *Gyroporus*). Li and Watling (1999) later combined *G. caespitosus* into *Rubinoboletus* Pilát & Dermek.

Acknowledgments

Some of the data presented here were generated with support from U.S. National Science Foundation awards DEB0414665 and DEB1020421 and National Geographic Society Committee for Research and Exploration grant 8457-08.

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Muelleria

37: 109–117

ROYAL
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Reinstating *Olearia stricta* (Asteraceae) for an uncommon shrub from montane regions of SE Australia, and notes on *O. ramulosa*

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Introduction

Olearia ramulosa (Labill.) Benth., as outlined in recent treatments (e.g. Lander 1992, Walsh and Lander 1999), is a morphologically diverse species causing much difficulty and confusion for taxonomists attempting to distinguish and describe various infraspecific taxa within it. In the most contemporary revision dedicated to this species, Willis (1956) recognised six varieties for Victoria. Three of these taxa have since been rejected (Lander 1992; Walsh and Lander 1999; Walsh and Stajsic 2007; VicFlora 2019) although some local variants have been documented. For example, a distinct form from subalpine and montane areas of Victoria with a strong, curry-like odour, stems with dense, stalked glandular-hairs, virtually no woolly hair, and blue-mauve ligules was accounted for by Walsh and Stajsic (2007) and the most recent iterations of VicFlora (2019) as *Olearia aff. ramulosa* (Omeo). Similar plants have also been observed in comparable habitats in the Namadgi area in the ACT and Tinderry Ranges in New South Wales, but differ from those in Victoria in that at least some mature leaves are lobed and the abaxial leaf surface is woolly. Lobing is common in juvenile leaves of *O. ramulosa s.l.* and related species (including the variants mentioned above; e.g. MEL2384920 and

Abstract

Olearia stricta Benth. is here reinstated for plants from subalpine and montane areas in Victoria previously regarded as an unnamed taxon affiliated with *O. romulosa* (Labill.) Benth. A new subspecies, *O. stricto* subsp. *parviloboto* Messina is described to accommodate a distinct entity from similar environments in the ACT and New South Wales. This change in nomenclature affects the taxonomic concept of *O. romuloso* var. *stricta* (Benth.) J.H.Willis. The majority of plants previously included in that variety are excluded from *O. stricto* and subsumed into a broadly-defined *O. ramuloso* var. *romuloso*.

Keywords: Taxonomy, Daisy-bush, *Oleorio off. romuloso* (Omeo)

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

MEL2369533), but these soon transition to the entire, more or less linear leaves of the adult plants. Likewise, young stems and leaves of *Olearia aff. ramulosa* (Omeo) may be woolly, but this indumentum type is soon lost. It is suggested that the Namadgi/Tinderry variant represents a neotenous state, retaining juvenile leaf features.

Olearia stricta

During the process of preparing descriptions for these entities, it became apparent that Victorian specimens clearly matched Bentham's description and type specimen of *Olearia stricta* Benth. (Fig. 1). Willis (1956) reduced *O. stricta* to *O. ramulosa* var. *stricta* (Benth.) J.H.Willis, concluding that this glandular-septate form was at best an extreme local development that could not be taxonomically segregated from other forms of *O. ramulosa* from mountainous/inland regions which have mixed eglanduiar-septate and woolly hairs and sessile glands. This perspective was largely based on collections by Mueller of both plants with glandular-septate hairs (as per the type) and others with mixed eglandular-septate and woolly hairs from the type location for *O. stricta* (Mt Buffalo), with the latter specimens apparently not been seen by Bentham at the time of describing *O. stricta* (Willis 1956). However, following examination of additional specimens and extensive field observations, it is clear that this glandular-septate form is morphologically distinct and occurs in discrete populations that are not found in close proximity to the eglanduiar-septate/woolly-haired form. The only records of the eglandular-septate/woolly-haired form in high montane/subalpine areas in eastern Victoria and the southern highlands of NSW are historic, with vague location information (e.g. Mt Buffalo, a large c. 300 km^2 massif) and it seems likely that these were collected from lower elevations on these mountains.

Plants from high elevations in Victoria, the ACT and New South Wales have a unique combination of characters that clearly distinguish them from *Olearia ramulosa s.s.* (Type from Tasmania). As well as the dense glandular setae on the stems (Fig. 2a), plants are highly viscid, lack woolly hair except when young (retaining this juvenile state in the Namadgi/Tinderry entity), have capitula that are terminal on main shoots and short side shoots (Fig. 2b), and have blue-mauve ligules. Some of these characters are occasionally encountered in the various forms of *O. ramulosa*, but never in combination, as outlined above. This unique combination of characters, together with the distinct geographic and ecological niche, suggest that *O. stricta* is more appropriately treated at species rank.

Olearia ramulosa

Reinstating *Olearia stricta* with a restricted circumscription has implications for the other plants previously also included in *O. ramulosa* var. *stricta* (i.e. plants predominantly with eglandular-septate hairs on their stems and dense woolly hair on the abaxial leaf surface from the Grampians (Fig. 2c, see note in Taxonomy section), Mt Cole, Brisbane Ranges and Warby Ranges, and plants with a mixture of woolly and eglandular-septate hairs on their stems from East Gippsland in Victoria, and the South Coast of New South Wales). It is unclear at this stage whether or not these represent a distinct taxon within *O. ramulosa*. If these prove to be distinct from the more widespread coastal forms (previously treated as a distinct variety), there are several names at varietal rank that may be suitably applied, including *O. ramulosa* var. *longisetosa* J.H.Willis, *O. ramulosa* var. *rigida* J.H.Willis, *O. ramulosa* var. *intermedia* Ewart, and *Eurybia ramulosa* var. *aculeata* (Labill.) Hook.f. However, an initial inspection of specimens suggests that plants exhibit a range of continuous variation, from entirely woolly to almost entirely eglandular-septate, and that characters used to distinguish these taxa (e.g. Willis 1956) are unreliable. It remains unclear if these extremes can reasonably be divided into taxa on the basis of being 'mostly woolly' or 'mostly setose'. Similar variation in stem indumentum (woolly and/or eglandular-septate) is also present in the closely related *O. microphylla* (Vent.) Maiden & Betche from New South Wales and, as yet, no such attempt has been made to further divide this species on the basis of predominant hair type. It seems unwise to propose a new and potentially short-lived taxonomy prior to the completion of a revision of this group which may ultimately conclude that the indumentum variants are unworthy of recognition. In the interim, these varieties are recommended to be subsumed into a more broadly

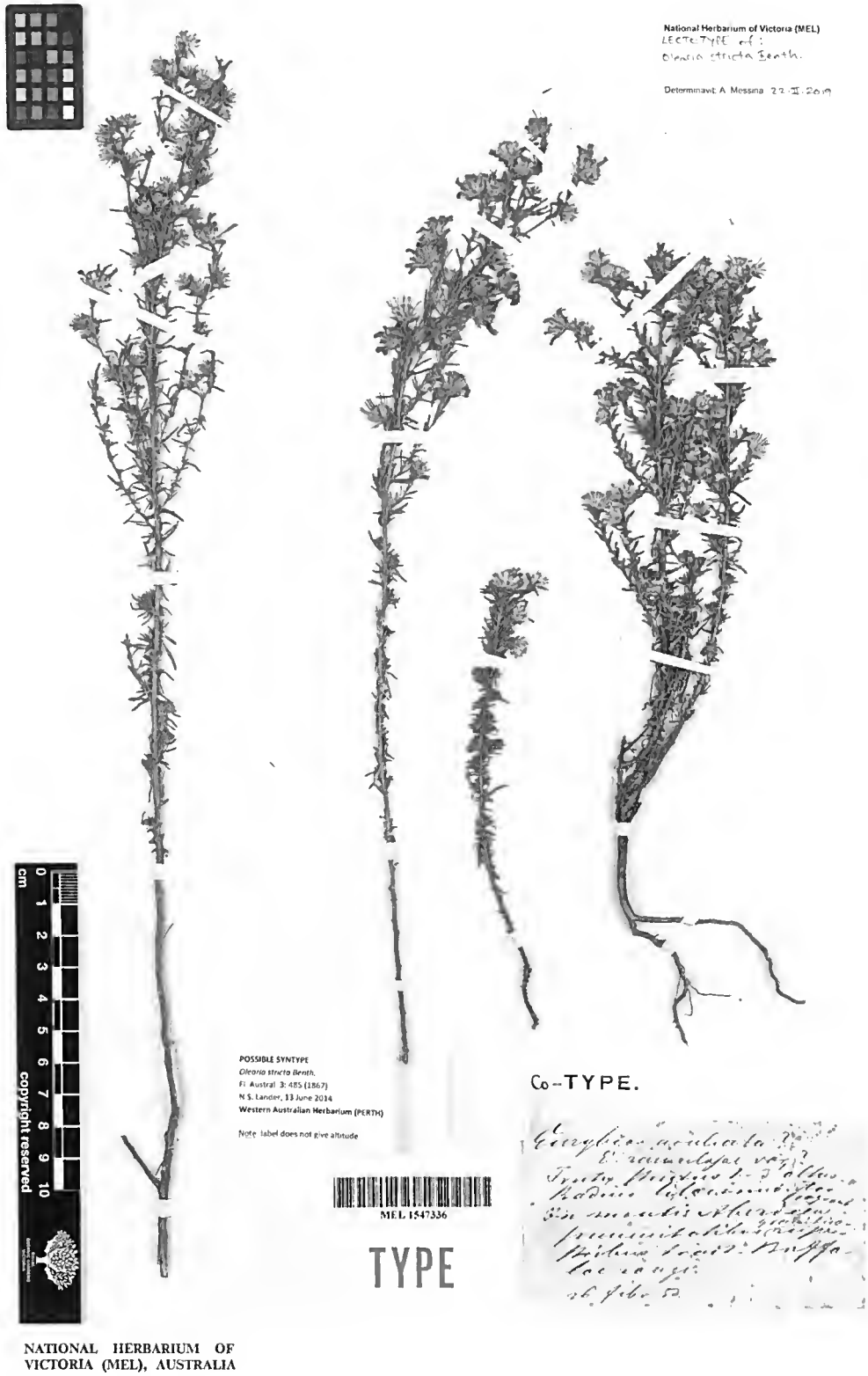

Figure 1. Lectotype of *Olearia stricta* (MEL1547336).

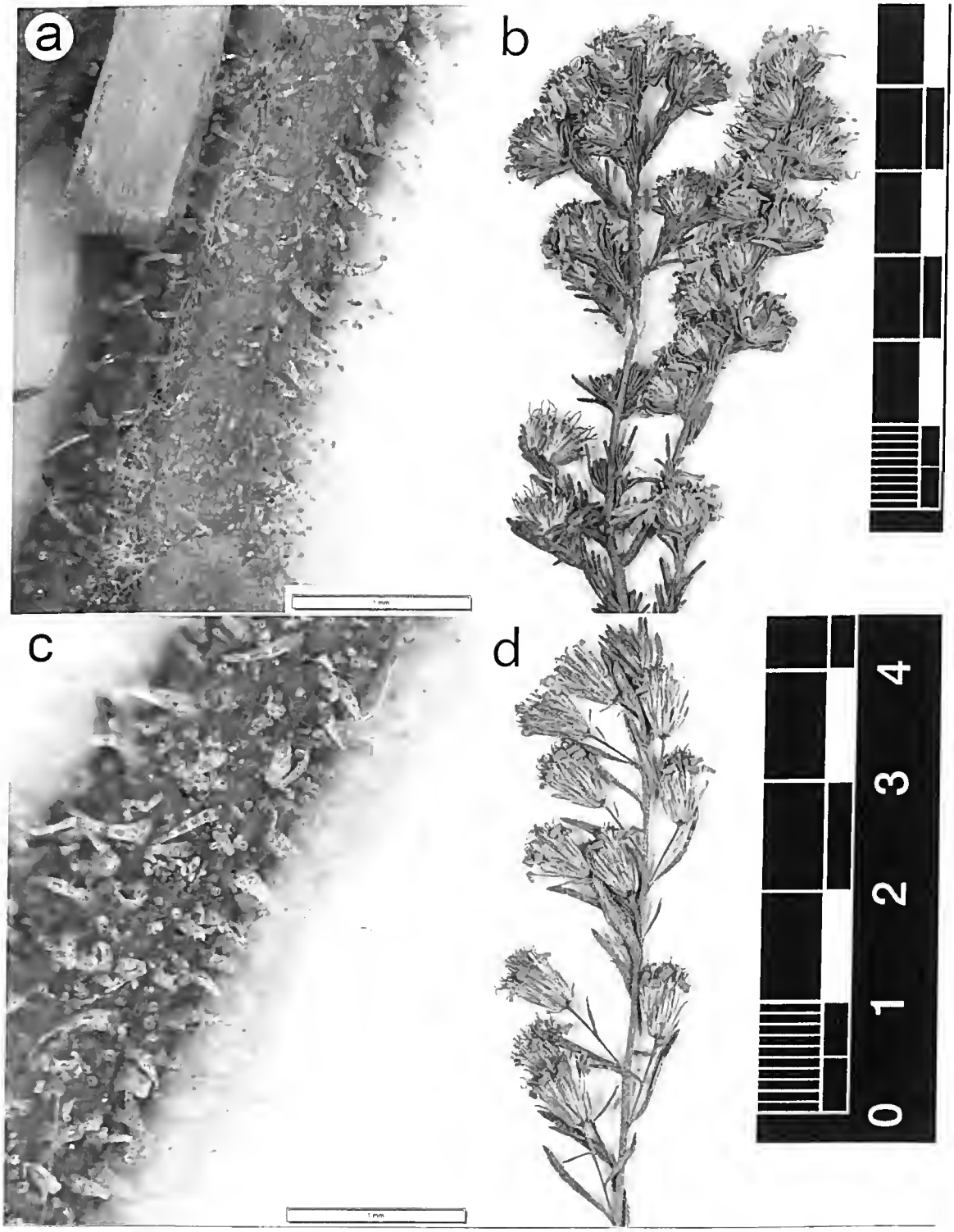

Figure 2. Comparison of stem indumentum and inflarescence structure in *Olearia stricta* and *O. ramulasa*. **a.** *Olearia stricta* subsp. *stricta*, glandular setae (*A. Messina 295*, MEL2361219); **b.** *Olearia stricta* subsp. *stricta*, capitula terminal main and short side branches (*M.G.Carrick 6492*, MEL564801); **c.** *Olearia ramulosa* (long-setose Grampians form) long eglandular setae and short glandular hairs (*M.G. Carrick* 10217, MEL689000); **d.** *Olearia ramulasa* (East Gippsland form) capitula axillary and pedunculate (*N.G.Walsh 8540*, MEL2404828).

circumscribed *O. ramulosa* var. *ramulosa*, leaving *O. ramulosa* var. *tomentosa* J.H.Willis as the only other reliably recognised entity within *O. ramulosa*. This taxon is currently only known from the St Andrews area north-east of Melbourne (see note on typification of this taxon in Taxonomy section). Plants are rhizomatous (currently believed to be unique in the group) and have long, linear leaves with dense woolly hair on the abaxial surface that extends out from beyond the revolute margins (VicFlora 2019).

Taxonomic implications

Ongoing work into the boundaries of the many forms of *Olearia ramulosa* continues, and it is now clear that a full revision of several poorly-defined species is required (i.e. *O. ramulosa*, *O. tubuliflora* (Sond. & F.Muell. ex Sond.) Benth., *O. microphylla*, *O. minor* (Benth.) Lander, *O. floribunda* (Hook.f.) Benth., *O. algida* N.A.Wakef., *O.* sp. 1 (*sensu* Walsh & Lander 1999), *Eurybia propinqua* DC., *Olearia brachyphylla* (F.Muell. ex Sond.) N.A.Wakef., *Eurybia dampieri* A.Cunn. ex DC.). Preliminary investigations have revealed that *O. ramulosa* has been largely misapplied in South Australia and Queensland. Most of the specimens from South Australia held at AD under the name *O. ramulosa* appear to represent a distinct species or possibly relate to *Olearia* sp. 1 (*sensu* Walsh and Lander 1999), *Eurybia proprinqua* or *Eurybia dampieri*. These plants have little to no setose hair on stems, the capitula are sessile in leaf axils and typically have a reduced number of florets. An initial inspection of AD specimens suggests that *O. ramulosa* only occurs in the South East region of South Australia. Similarly, *O. ramulosa* specimens held at BRI from the Darling Downs region in Queensland appear better placed within *O. minor*. These plants have short, non-clustered, flat leaves and relatively large capitula that are terminal on main branches. As currently understood, *O. minor* also occurs on the western slopes in New South Wales, further supporting the placement of the BRI specimens.

A full revision of the *Olearia ramulosa* complex is outside the scope of the current paper. However, to avoid delays in the recognition of this distinct, rather rare species of the montane and subalpine regions of eastern Australia, *O. stricta* Benth. is here reinstated. Geographically isolated plants from Namadgi and Tinderry Ranges with retained neotenous features are recognised as *O. stricta* subsp. *parvilobata* Messina.

Taxonomy

Olearia stricta Benth. *Fl. Austral.* 3: 485 (1867)

Olearia ramulosa var. *stricta* (Benth.) J.H.Willis, *Muelleria* 1:27 (1956) p.p.

Olearia aff. *ramulosa* (Omeo) *sensu* Walsh and Stajsic (2007).

Type: **VICTORIA**. Rocks of Mount Aberdeen, Buffalo Range, at an elevation of 4000 ft., *F. Mueller s.n.*, 26.ii.1852 (lecto: MEL1547336!; probable isolecto: K1089779!; MEL2165250!).

Viscid shrubs to c. 1 m high with a curry-like odour; branchlets glandular with moderate to dense cover or stalked glandular hairs (0.1–0.5 mm long) and sessile glands, sometimes with arachnoid or woolly hairs on new growth. Leaves alternate, sessile to subsessile, forming lax clusters, spreading to subappressed; lamina linear, 5–10(–15) mm long, (0.2–)0.5–1.0(–1.2) mm wide (excluding lobes), entire or with a pair of lobes in middle to upper third; margins recurved to revolute, abaxial surface remaining visible to obscured by margins; apex usually obtuse; adaxial surface asperate, with scattered sessile glands and glandular hairs, sometimes with

Key to *Olearia ramulosa* and *O. stricta*

1 Stems with dense glandular setae and sessile glands, occasionally with some sparse woolly or arachnoid hairs (often restricted to young growth, where initially quite dense); adult leaves with abaxial surfaces lacking woolly hair or, if woolly hair present, then at least some leaves lobed; capitula sessile or subsessile, terminal on main shoots and short leafy lateral branches; ligules blue-mauve; montane and subalpine areas mostly above 1000 m elevation (ACT, NSW, VIC): ..... ***O. stricta***

1: Stem indumentum variable, with eglandular setae and (usually) woolly hairs and usually at least some (sometimes abundant) sessile glands, glandular setae absent, or rarely present and shorter than the more abundant eglandular setae; capitula sessile, terminal on short lateral shoots or pedunculate from leaf axils, rarely some terminal on main stems; ligules often white, sometimes blue-mauve; widespread, from coastal to montane regions, usually below 1000 m elevation (SA, NSW, VIC, TAS): ..... ***O. ramulosa***

Figure 3. *Olearia stricta*. **a.** *Olearia stricta* subsp. *stricta*, Howitt Rd., Snowy Range (*A. Messina 814*, MEL2384920); **b.** *Olearia stricta* subsp. *parvilobata*, cultivated plant, RBGV.

scattered broad-based eglandular hairs; abaxial surface glabrous to glabrescent, with scattered sessile glands and short glandular hairs along midrib, sometimes with very sparse woolly hair, or with a moderate cover of woolly hair. Capitula sessile to subsessile, solitary, occasionally in 2–3-flowered clusters, terminal on ends of stems or short lateral branches, 6–8 mm diam. (excluding ligules); bracts 2–3-seriate, graduating, 2.5–5 mm long, often purple-tipped, viscid, glabrous to glabrescent or with a patch of woolly hair near apex; ligulate florets 12–20, ligule 5–8 mm long, longer than bracts, pink, mauve or blue, very rarely white; disc florets 6–20, yellow or mauve. Cypsela flattened obovoid, 1.5–2 mm long, 5–6-ribbed, with simple hairs and sessile glands; pappus c. 3 mm long, in 2 rows, the outer bristles shorter than the inner.

Typification notes: Willis (1956) cites MEL1547336, which has detailed notes on the plant and location and is dated 26 Feb 1853 as the only specimen seen by Bentham and hence the type for *Olearia stricta*. However, in Bentham's protologue he cites the elevation (albeit erroneously) as 4000 ft., a detail not on the label of this specimen. Two other specimens (K1089779 and MEL2165250) are simply labelled 'Mt Aberdeen 5000 ft., F. Mueller'. It is almost certain that at least the specimen at K was viewed by Bentham, and that the three were all part of the same gathering. Clearly the MEL specimen with Bentham's mark (a distinctive handwritten 'B') on the label (MEL1547336) was seen, and is here selected as the lectotype. The other two specimens with less detailed labels are regarded as probable isolectotypes. A fourth specimen at MEL is labelled 'rocky summit of Mt Aberdeen, March 1853' (MEL2165251). This was collected by Mueller on the same trip to Mt Buffalo, but was apparently gathered on a different day and so cannot be treated as a type.

Another Mueller specimen at MEL with the same label information'Mt Aberdeen, 5000 ft.' (MEL2163612) doesn't match the type of *Olearia stricta*, and, despite the label, is presumed to have been collected at a lower altitude on Mt Buffalo as it conforms with other *O. ramulosa* specimens from Mt Buffalo foothills (e.g. MEL2109790).

Olearia stricta subsp. *stricta*

Viscid shrubs; branchlets with dense glandular hairs and sessile glands, rarely with scattered arachnoid or woolly hairs (usually restricted to young growth). Leaves lobed when young, soon entire; margins revolute to recurved, sometimes obscuring abaxial surface; adaxial surface usually with broad-based eglandular hairs, glandular hairs and sessile glands; abaxial surface glabrescent, with sessile glands and stalked glandular hairs restricted to the midrib, woolly hair absent or very sparse. Involucral bracts viscid, green, glabrous to glabrescent, lacking woolly hair. Flowers Feb.–Apr. (Figs. 1, 2a, b, 3a).

Selected specimens examined: **VICTORIA.** Nunniong-Timbarra-Tambo State Forest, Watts Creek Track area, 6.5 km ESE of Ensay, 03.v.1985, *A.C.Beauglehole 79511* (CANB, MEL, NSW); Gorge Creek, near Buchan River, 2.iii.1969, *K.C.Rogers s.n.* (MEL); Omeo Highway, c. 26 km (by road) N of Omeo, 6.ii.2005, *N.G.Walsh 6246* (CANB, MEL, NSW); Alpine National Park, Mt Cobbler area. Head of waterfall on creek draining Cobbler Lake, c. 350 NNW from lake's edge, 11.iii.2013, *N.G.Walsh 7795* (CANB, MEL); Road edges of jeep track from Doolan's Rd. to the Moroka R. [River] below Mt. Kent, 13.iii.1966, *J.H.Willis s.n.* (MEL); Beside logging track leading to The Pinnacles (ca. 45 km direct SE of Mt. Howitt), 10.iii.1980, *M.G.Corrick 6492* (MEL); 3.2 km south of Anglers Rest (Bridge over Cobungra River), 19.v.2011, *A.Messina 510* (MEL); Alpine National Park, Snowy Range, Howitt Rd, just S of the Bastards Neck, 19.ii.2015, *A.Messina 814* (CANB, K, MEL); Alpine National Park, walking track to Long Hill (extension of Dingo Hill Rd), slight knoll before rock shelter, approx. 6.8 km west of Tamboritha Saddle, 2.iv.2011, *A.Messina 488* (MEL); Walking Track, south side of Big Hill, on saddle at foot of hill, approx. 2 km SW of Mount Howitt, 26.iii.2009, *A.Messina 295* (LTB, MEL); Snowy Range, 1.1km east of Horseyard Gap campground on road to the Pinnacles, 25.iii.2008, *A.Messina 184* (MEL); Mt Buffalo National Park, beside Mt Buffalo Tourist Rd, 250 m W from Mackeys Lookout., 4.iv.2006, *N.G.Walsh 6435* (CANB, MEL, NSW).

Key to subspecies of *O. stricta*

1 Adult leaves lacking woolly hair on abaxial leaf surface, margins entire; involucral bracts lacking woolly hair near apex; dry rocky hills in montane and subalpine regions of eastern Victoria: ..... ***O. stricta*** subsp. ***stricta***

1: Adult leaves with woolly hair on abaxial surface, margins of at least some leaves with one or two pairs of oblong lobes; involucral bracts with scattered woolly hairs in upper third; subalpine regions of ACT and NSW: ..... ***O. stricta*** subsp. ***parvilobat***

Distribution: Occurs on granite near Omeo, Ensay and Mt Buffalo, but also on Silurian sediments near Buchan and the Snowy Range and Mt Cobbler areas, Victoria, between c. 700–1400 m elevation.

Notes: Sometimes approaches *Olearia ramulosa*, which can be distinguished by the dense woolly indumentum on the abaxial leaf surface, stems that are either moderately to densely woolly or, if mainly setose, hairs mostly eglandular, and capitula either sessile and terminal on very short lateral branches (rarely terminal on main stems) or axillary and pedunculate (Fig. 2d).

Densely glandular plants from the Grampians with blue ligules resemble *Olearia stricta* subsp. *stricta*, but the stem indumentum includes glands that are usually sessile or only shortly stalked and overtopped by much longer eglandular setae (Fig. 2c). They have very long and broad-based setose hairs on adaxial leaf surface and bracts, and the capitula are often pedunculate from leaf axils. As such, these are retained in *O. ramulosa*. Plants growing on dry rocky hills at lower elevations (c. 500 m) from the central western slopes in New South Wales (e.g. Cudal, Boorowa and Cobar etc.) also have a tendency to have gland-tipped hairs on stems and terminal capitula. However, these plants are also very woolly on stems, leaves and involucral bracts, and are white-flowered. These appear to be somewhat intermediate between *O. ramulosa* and *O. minor* (but are distinguished from the latter by the clustered leaves).

A form on Mt Elizabeth in Victoria is quite delicate with stem indumentum more woolly than typical. However, plants possess a moderate to dense cover of glandular hairs on stems and have terminal capitula, and are best placed in *O. stricta* subsp. *stricta*.

Olearia stricta subsp. *parvilobata* Messina subsp. nov.

Type: **AUSTRALIAN CAPITAL TERRITORY**: Booroomba Rocks, 9.ii.2006, *P.Carmen 229* (holo: CANB679681!; iso: MEL2447642!).

Viscid shrubs; branchlets with dense glandular hairs, sessile glands and often some woolly or arachnoid hairs. Adult leaves in clusters, with at least the lowest leaf of some clusters with one or two pairs of oblong lobes; margins revolute to recurved, not obscuring abaxial surface; adaxial surface with sessile glands; abaxial surface with woolly hair and scattered sessile glands. Involucral bracts viscid, green, with woolly hair in upper third. Flowers Jan.–Apr. (Fig. 3b).

Selected specimens examined: **AUSTRALIAN CAPITAL TERRITORY.** 3 km NW of Booroomba Rocks, 15.ii.1986, *I.R.Telford 10188* (CANB); Namadgi National Park, 100 m W of Boboyan Rd, 1 km N of Yerrabi Track walking trail, 6.iii.1994, *D.Mallinson 342* (CANB); Namadgi National Park, c. 0.5 km S of Nursery Creek, 4.iii.1993, *C.H.Broers 368* (CANB); Booth Range, N of Shanahans Mountain, 6.ii.1986, *F.Ingwersen s.n.* (CANB); Sentry Box Hill, Boboyan Divide, 40 Miles SSW of Canberra, 14.iii.1971, *L.G.Adams 2572* (CANB); Booroomba Rocks, 9.ii.2006, *P.Carmen 300* (CANB); Namadgi National Park, c. 1.69 km due NE of Honeysuckle Campground, on W edge of granite slab, c. 50 m W of Great Alpine Track, S.iv.2013, *A.Messina 680* (MEL). **NEW SOUTH WALES.** Tinderry Mountains, 12.iii.1972, *T.G.Hartley 13614* (CANB).

Distribution: Very restricted in distribution, known from relatively few small populations in Namadgi National Park, Australian Capital Territory and Tinderry Ranges, New South Wales, growing amongst granite boulders in low, open subalpine woodland and heathland at c. 1000–1330 m elevation.

Notes: A specimen from Shanahans Mountain walking track (CANB 797741) is somewhat intermediate between this taxon and *Olearia ramulosa*. It is very woolly hairy and has few stalked glands on stems, and leaves are quite long and apparently not lobed. This may just represent an unusual individual, as other records from this area exhibit features typical for this taxon. Other plants with largely unlobed leaves have been observed (eg. MEL 2379755).

A note on the typification of *Olearia ramulosa* var. *tomentosa* J.H.Willis

In assigning the holotype of this taxon, Willis (1956) was uncertain of the collector, citing 'Victoria centrali, "Mt. McIvor, Nov.". ?F. Mueller' (MEL658694A). Presumably Mueller was thought to be the collector as the detailed labels on the specimen are in his hand. Subsequent to his publication, Willis appears to have annotated the specimen noting the year of collection as 1854. Mueller was known to be in this area in the summer of 1852–53 but not in 1854, as he was collecting in the Victorian Alps during that time. There are several other specimens at MEL with this location and year (1854) attributed to J.W.T.L. von Blandowski, and inspection of the original label (not the detailed ones of Mueller) shows that

they match labels on other Blandowski specimens. Consequently Blandowski should be attributed as the collector of this specimen. The sheet at MEL has three elements, namely the holotype (labelled part A) and two other elements assigned by Willis as 'paratypes' (part B and C). Part B also has a Blandowski label, but the label on part C is written by Mueller. A fragment of part C appears to have been remounted on a separate sheet (MEL658695). Additionally there is a sheet at K (K1089750) with two elements and labelled 'Mt. Korong and Mt. McIvor, F. Mueller'. It seems likely that all of these were collected by Blandowski (not Mueller), and possibly some or all are from the type gathering. It is unclear on the K specimen which element (if any) was collected at Mt. Korong, or if this is just an indication that similar plants occur there. Due to this uncertainty, it seems most appropriate to treat these other specimens (MEL658694B, C, MEL658695, K1089750) as possible isotypes.

Acknowledgements

We would like to thank Angharad Johnson (MEL) for photographing herbarium specimens, Wayne Gebert and Aaron McArdle (MEL) for assistance with curation of type specimens, curation staff at BRI, CANB, and HO for provision of loans, and Helen Vonow (AD) for assistance with collections held there. We also thank the two reviewers who helped improve this manuscript, particularly for providing an additional location for *Olearia stricta* var. *parvilobata*. Finally we would like to thank the Australian Daisy Study Group for providing initial funding for this project through the Esma Salkin Studentship.

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Muelleria

37: 119–126

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Pluchea rubelliflora and *Pterocaulon sphacelatum* (Asteraceae): new to Victoria's semi-arid floodplains

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Introduction

Environmental watering or flows are being implemented by Governments to improve the health of river and floodplain ecosystems. A key component of environmental watering is monitoring vegetation responses to these managed flood events. As such, an increase in botanical surveys in these riparian systems has occurred over recent years. While undertaking recent botanical surveys on the semi-arid (mean annual rainfall ~300 mm, ABOM 2019) floodplains of Hattah-Kulkyne and Murray-Sunset National Parks, in north-western Victoria, two species new to the state were discovered. Specimens submitted to the National Herbarium of Victoria were identified as *Pluchea rubelliflora* (F.Muell.) B.L.Rob. and *Pterocaulon sphacelatum* (Labill.) Benth. ex F.Muell. Subsequent to these discoveries, in February 2019, *Pterocaulon sphacelatum* was also discovered on the Lindsay River anabranch creek floodplain. This part of north-west Victoria is arid, with approximately 270 mm mean annual rainfall (ABOM 2019). Thus far, Victoria has been

Abstract

Two species of Asteraceae, *Pluchea rubelliflora* (F.Muell.) B.L.Rob. and *Pterocaulon sphacelatum* (Labill.) Benth. ex F.Muell., have been discovered for the first time in Victoria on the semi-arid floodplains of Hattah-Kulkyne National Park and the adjacent Murray-Kulkyne Park. *Pterocaulon sphacelatum* was also discovered on a floodplain of Lindsay Island at Murray-Sunset National Park. The species' taxonomy, distribution and ecology are discussed.

Keywords: Hattah Lakes, Lindsay Island, flooding, rare plants

ISSN: 0077-1813 (print) • ISSN: 2204-2032 (online)

the only mainland state from which both of these genera of native Asteraceae have yet to be found. Both species belong to the *Pluchea*-group of genera (Inuleae-Plucheinae) and are well distributed across much of central and northern Australia.

Taxonomy

The subtribe Plucheinae consists of 34 genera and approximately 270 species, with a cosmopolitan distribution. The subtribe is best represented in Africa and, to a lesser degree, in the Americas, Asia and Australasia. In Australia there are 10 genera (six endemic), and 50 species, all indigenous (Bean 2015a, b; APC 2018). *Pluchea* Cass. is a genus of about 50 species, found predominantly in tropical and subtropical regions of the world. In Australia there are 13 *Pluchea* species, 12 of which are endemic (Bean 2015a). *Pluchea* can be recognised based on a combination of characters: plants are usually aromatic; capitula are simple, solitary to several in terminal peduncles or in terminal panicles, disciform, homogamous or heterogamous; involucral bracts unequally 3–4-seriate; florets all tubular; outer (i.e. marginal) florets are female, pappus of free uniseriate capillary bristles; disc florets fewer, bisexual or functionally male (Bean 2015a; Stajsic 2018a).

Pterocaulon Elliott comprises 26 species distributed across North and South America, south-east Asia, Malesia, Melanesia, and Australia. It is represented in Australia by 13 species, six of which are endemic (Bean 2015b). *Pterocaulon* is readily recognised by its winged stems, formed from decurrent leaf bases, sessile capitula grouped into secondary heads, and a pappus of capillary bristles (Bean 2011; Stajsic 2018b).

Pluchea rubelliflora (F.Muell.) B.L.Rob.

Perennial herb or subshrub to 15–60 cm high. Stems ascending to erect, usually conspicuously narrowly winged from decurrent leaf bases, glabrous or glabrescent. Leaves narrowly lanceolate to oblanceolate to broadly oblanceolate, 9–50 mm long, 2–7 mm

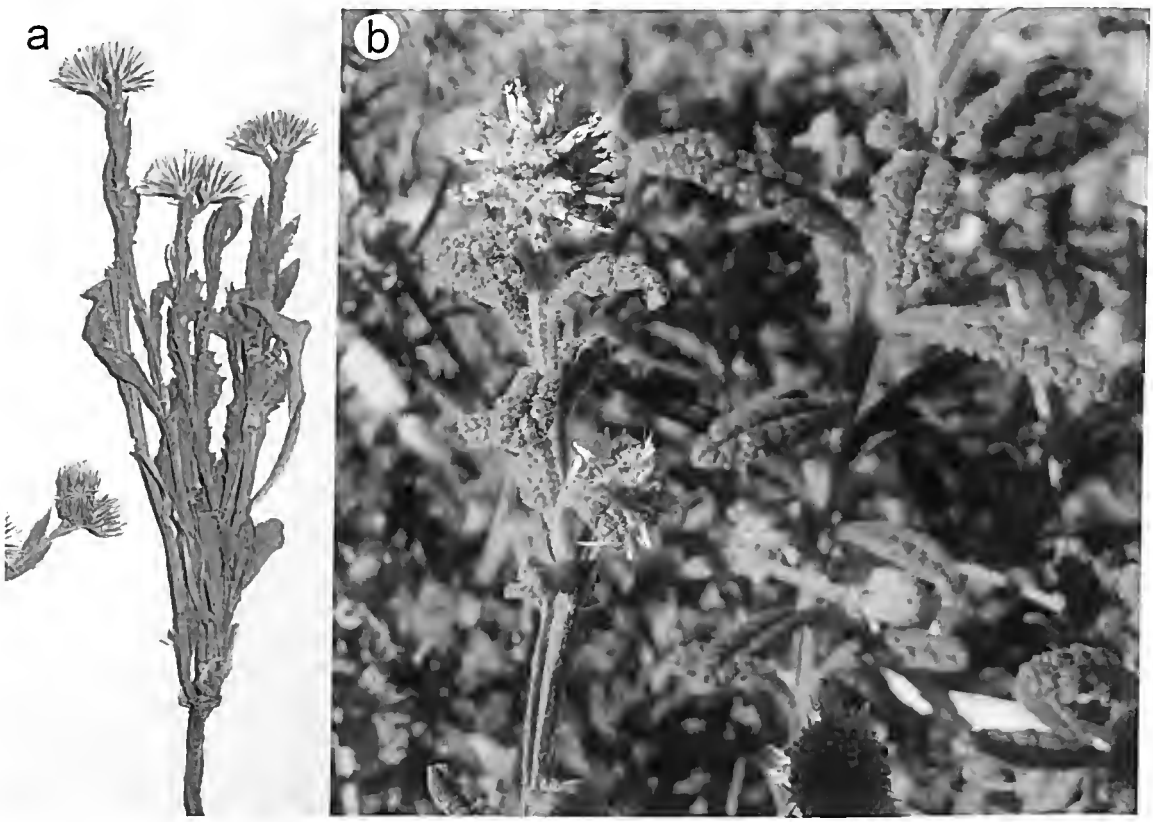

Figure 1. a. *Pluchea rubelliflora*, dried specimen, Hattah Lakes, Lake, Yelwell (MEL 2439613).
b. *Pterocaulon sphacelatum*, Murray-Kulkyne Park (MEL 2439614).

wide, 4.5–12 times longer than wide, margins entire or denticulate to dentate, apex acute, glabrous or glabrescent. Capitula solitary to several in terminal clusters, hemispherical, 4–5 mm long, peduncle 1–12 mm long; outer involucral bracts 1.3–1.8(–2.6) mm long, lanceolate, apex acute to acuminate, glabrous to sparsely glandular or with a mixture of glandular and eglandular hairs, margin scarious; inner involucral bracts (2.8–)3.0–4.2(–4.5) mm long, lanceolate, linear, apex acute. Outer florets (i.e. female) numerous, 2.0–2.5(–3.5) mm long, corolla tube filiform, white or pink-tinged; style white; achenes 0.6–0.8 mm long, glabrous, red-brown; pappus bristles 10–13, 1.8–2.5 mm long. Disc florets 5–30, 2.0–3.0(–4.0) mm long, corolla tube cylindrical; style mauve; achenes pale, abortive (adapted from Hunger 1997; Bean 2015a; Stajsic 2018c).

Phenology: The Victorian plants were collected in flower in April 2018 (Figs. 1a, 2). Outside Victoria, the flowering and fruiting period is (April–)May to November (Bean 2015a).

Notes: *Pluchea rubelliflora* (Winged Plains-bush) is distinguished from other Australian *Pluchea* species by its glabrous or glabrescent stems and leaves, relatively small capitula and decurrent leaves (Bean 2015a).

Specimen examined: **VICTORIA**. Hattah Lakes National Park. Lake Yelwell area, 19.iv.2018, *C. Moxham s.n* and *S. Kenny* (MEL2439613).

Habitat and ecology: *Pluchea rubelliflora* is widespread in lower rainfall areas of Australia, mainly in the tropics and subtropics, but extending almost to Port Augusta in South Australia (Bean 2015a). Indeed, *Pluchea rubelliflora* and a number of species from other genera in Plucheinae are known to inhabit seasonally wet areas, swamps, claypans, dry rivers and tidal flats (Jessop and Toelken 1986; Cunningham *et al.* 1992; Bean 2015a). Hunger (1997, p. 211) commented that the species is abundant, and that "During a collecting trip in the Pilbara region I found this species on nearly every dry river bank and near every waterhole on sandy soil or red clayed loam…"

In Victoria, a population of approximately ten plants was discovered at a long-term monitoring site at Lake Yelwell, in Hattah-Kulkyne National Park (Moxham *et al.* 2018, 2019). The population occurs on the higher floodplain in the Intermittent Swampy Woodland Ecological Vegetation Class (Fig. 3). This vegetation

Figure 2. *Pluchea rubelliflora*, dried specimen, Hattah Lakes, Lake, Yelwell (MEL 2439613). **a**. capitula. **b**. leaf, showing diagnostic decurrent base. Photo: Ian Clarke, Honorary Associate at National Herbarium of Victoria

type is characterised by a mixed overstorey of River Red Gum (*Eucalyptus camaldulensis* Dehnh. subsp. *camaldulensis*), Black Box (*E. largiflorens* F.Muell.) and Eumong (*Acacia stenophylla* A.Cunn. ex Benth.). The variable flood-respondent understorey is dominated by a range of flood-stimulated species in association

with flora tolerant of inundation (White *et al.* 2003). This woodland type occurs on low elevation river terraces of the floodplain often adjacent to lakes and waterways. Soils often have a shallow sand layer over heavy and frequently slightly brackish soils (White *et al.* 2003).

The Lake Yelwell site has had detailed floristic monitoring annually since 2014 as part of a five-year monitoring program examining vegetation responses to environmental watering (Moxham *et al.* 2018, 2019). The site appears to have had a disturbance history that has resulted in low vegetation quality; with a high amount of bare ground (20%) and litter (60%) cover, but low weed cover (< 5%). The cover of vegetation (both native and exotic) and ground layer substrate appears to fluctuate annually in relation to water availability, likely from both rainfall and flooding. *Pluchea rubelliflora* was discovered at the site for the first time in 2018. The species was not detected in another monitoring site at Lake Yelwell, nor any other of the 18 sites monitored throughout the Hattah Lakes system as part of this program. A search was conducted in a 300 m area surrounding the population, but no further plants were detected.

In the spring and summer of 2017/2018, a large environmental watering event inundated this site (to an elevation of 45 m above sea level). The two previous flood events in the spring/summer of 2014/15 and 2016/17 did not reach this part of the site which occurs on the higher elevation floodplain. Indeed, it is probable that inundation from the 2017/2018 environmental watering event stimulated seed germination from the soil seed bank, although studies would need to confirm the species presence in the soil seed bank. While little information is available on the seed dispersal of *P. rubelliflora*, other species within the genus (e.g. *P. carolinensis* (Jacq.) G.Don, *P. dentax* R.Br. ex Benth., *P. indica* (L.) Less., *P. odorata* (L.) Cass. and *P. rosea* Godfrey) are wind dispersed (Jurado *et al.*

Figure 3. *Pluchea rubelliflora* habitat on the higher floodplain in Intermittent Swampy Woodland at Lake Yelwell, Hattah-Kulkyne National Park

1991; Alyokhin *et al.* 2001; Francis 2004; Mossman 2009). The seeds of *P. odorata* may require wet bare soil to germinate (Mild 2003) and the pappus of *P. carolinensis* may provide seeds with a temporary buoyancy thus facilitating dispersal by water (Francis 2004; Erickson and Puttock 2006). *Pulchela rubelliflora* has been noted to be often short-lived and more abundant in wet years (Cunningham *et al.* 1992). It is unlikely that seed from this species was dispersed in floodwaters from the Murray-Darling Basin as occurrences in other States are predominantly outside the Basin waterways (e.g. ALA 2018). Furthermore, the discovery of this population represents a large range extension for the species (e.g. over 500 km; ALA 2018). The closest known occurrence is an 1861 collection from northeast of Broken Hill (MEL2165775). Whilst an adventive origin is conceivable for such a disjunct occurrence, consistency of habitat with that of indigenous occurrences outside Victoria suggests that the Victorian occurrence is also indigenous.

Conservation Status: *Pluchea rubelliflora* is known in Victoria from a single population of approximately 10 plants, with all individuals at the same location with an area of c. 225 m^2. The species is assessed as Critically Endangered in Victoria since it qualifies under criterion CR D sensu IUCN (2012) based on its very limited population size and, arguably, also criterion CR B1ab(iii) c(iv)+2ab(iii)c(iv) based on its highly disjunct occurrence at a single Victorian location subject to declining frequency of middle and higher order flood events, observed intense browsing impacts and physical damage at the site caused by feral pigs and goats, and the reported and inferred seasonal fluctuation in population size.

Pterocaulon sphacelatum (Labill.) F.Muell.

Biennial or short-lived perennial, strongly aromatic, herb or subshrub to 20–100(–120) cm high, and often as wide. Stems single or numerous, ascending to erect, conspicuously winged from decurrent leaf bases, densely lanate and sometimes with occasional globose sessile glands; wings entire or sparsely toothed, 0.7–2.0 mm wide. Leaves oblanceolate to obovate, 20–65 mm long, 4–15 mm wide, 3.3–5.8 times longer than wide, margins recurved, denticulate, with 6–14 pairs of blunt teeth, apex obtuse or acute; upper surface moderately bullate, sparsely to moderately densely lanate; lower surface moderately to densely lanate, and also with dense, globose, sessile, yellow glands. Capitulescences in terminal clusters, globose or ellipsoid, 10–15 mm long, 1–1.4 times longer than wide; peduncles 0–22 mm long. Outer involucral bracts 2.2–3.7 mm long, spathulate, apex acute, with dense spreading lanate hairs throughout, glands absent; longest inner involucral bracts 3.5–4.6 mm long, linear, apex acute, upper margins conspicuously toothed or lacerate. Outer florets (i.e. female) 17–30, 2.4–3.2 mm long, corolla tube filiform, always partly pink or violet, fertile; achenes 0.7–1.0 mm long, red-brown with 20–50 twin hairs; pappus a single row of barbellate capillary bristles, connate at base, persistent. Disc floret (hermaphrodite, functionally male), solitary, 2.5–3.7 mm long, corolla tube cylindrical, pink; achenes pale, abortive (Adapted from Bean 2011; Bean 2015b; Stajsic 2018d).

Phenology: Two Victorian plants were collected in flower, the first in May 2018 and the second in February 2019 (Fig. 1b). Outside Victoria, flowers and fruits occur from June to October in northern parts of the range, and from August to December in southern parts (Bean 2011).

Notes: *Pterocaulon sphacelatum* (Applebush, Fruit Salad Plant) is distinctive in having the upper margins of the inner involucral bracts often lacerate, and entire or sparsely toothed. Secondary heads all terminal, often ellipsoid, up to 1.4 times longer than wide; inner bracts always partly pink to violet; leaves oblanceolate, with the upper surface bullate; corolla lobes of disc floret short (Bean 2011).

Specimens examined: **VICTORIA**. Murray-Kulkyne Park. Approximately 1.6 km NW of the junction of River and Goosefoot tracks, 2 km N of Kulkyne Station and 9 km SE of Colignan, 14.v.2018, *K. Bennetts s.n.* (MEL2439614); Murray-Sunset National Park, Lindsay Island, eastern end, 26.ii.2019, *Ian Sluiter IRKS 19/68* (MEL).

Habitat and ecology: A single plant was discovered approximately 1.6 km north-west of the junction of River and Goosefoot tracks in the Murray-Kulkyne Park south-east of Colignan. The plant was found on a river terrace in the Intermittent Swampy Woodland Ecological Vegetation Class (described above), an area that had been flooded within the last year (Fig. 4). The second plant, with flowering heads showing at least two seasons of growth, was discovered in Murray-Sunset

National Park at the eastern end of Lindsay Island. The plant inhabited Shrubby Riverine Woodland Ecological Vegetation Class, which was dominated by River Red Gum *Eucalyptus camaldulensis* subsp. *camaldulensis* and composed of a range of drier-floodplain species with a sparse shrub layer of: Nitre Goosefoot (*Chenopodium nitrariaceum* (F.Muell.) F.Muell. ex Benth.), Tangled Lignum (*Duma florulenta* (Meisn.) T.M.Schust.), Black Cotton Bush (*Maireana decalvans* (Gand.) Paul G.Wilson), Bignonia Emu-bush (*Eremophila bignoniiflora* (Benth.) F.Muell.), Spotted Emu-bush (*Eremophila maculata* (Ker Gawl.) F.Muell.). This vegetation type occurs on the less flood-prone waterway fringes and more elevated lower terraces, where flooding is infrequent (White *et al.* 2003). The site, however, was inundated in 2016 under an environmental flow regime designed to inundate floodplain and wetland sites at the eastern end of Lindsay Island.

Pterocaulon sphacelatum is the most widespread Australian *Pterocaulon* species (Bean 2011). It grows on a range of sandy to clay-loam soils, on stony hillsides (higher rainfall areas) or creek-beds (arid areas), in grassland (often dominated by *Triodia* spp.), eucalypt woodland, or low open woodland with Mulga (*Acacia aneura* F.Muell. ex Benth.) and other *Acacia* spp. The species is common in areas subject to flooding (Cunningham *et al.* 1992). Based on herbarium collections, the closest known occurrence of this species to the Victorian one is a single 1976 collection (NSW582322) from the Wentworth district in New South Wales. There are also herbarium collections from Scotia Sanctuary in New South Wales in 2011, and from Danggali Conservation Park and Wilderness Protection Area in South Australia in 1980. In 2011/12, following heavy La Niña rainfall events across south-west New South Wales, *Pterocaulon sphacelatum* was observed to germinate in a flooded run-on depression herbland/ grassland covering approximately five hectares at a

Figure 4. *Pterocaulon sphacelatum* habitat on a river terrace in Intermittent Swampy Woodland near Raak Track and Chalka Creek SE of Colignan, Murray-Kulkyne Park.

grazing property 40 km west of Pooncarie. Several thousand plants persisted for two years at that site until eventually senescing and dying. The soils at that site were Worrinen Formation clay loam above poorly draining Callabonna Clay and Blanchetown Clay subsoils (Ian Sluiter, pers. obs., September 2012). The Hattah and Lindsay Island specimens represent a small but important range extension. It is unknown whether these plants were found due to increased survey effort – that is, surveying previously unsurveyed habitat – or as a result of a recent colonisation event into previously unoccupied habitat. *Pterocaulon sphacelatum* fruit is wind dispersed (Jurado *et al.* 1991; Erickson *et al.* 2016) as are those of other species within the genus e.g. *P. lanatum* Kuntze (de Cassia Frenedozo 2004). The species is known to be tolerant of disturbances and is, hence, likely to be an opportunistic recruiter. However, the discovery of the second plant at Lindsay Island makes it more likely that the species is indigenous to Victoria rather than a new arrival.

The vernacular name Fruit Salad Plant is derived from the "sweet, fruity aroma emitted from the plant when it is crushed or rubbed" (Cunningham *et al.* 1992, p. 685).

Conservation Status: *Pterocaulon sphacelatum* is known in Victoria from two plants. The species is assessed as Critically Endangered in Victoria since it qualifies under criterion CR D sensu IUCN (2012) based on its small population size.

Concluding remarks

The two species discussed here were discovered while conducting botanical surveys investigating floodplain vegetation responses to managed flood events. Both species naturally occur in these riparian environments and can respond to increased water availability, from both rainfall and flood events. However, it is difficult to ascertain whether the discovery of these species was the result of recruitment due to flooding events or the increase in survey effort in these systems. Nevertheless, these two new species records for Victoria are important additions to the state's flora.

Acknowledgements

The botanical field surveys were funded by The Living Murray initiative of the Murray-Darling Basin Authority. The Living Murray is a joint initiative funded by the New South Wales, Victorian, South Australian, Australian Capital Territory and Commonwealth Governments, all coordinated by the Murray–Darling Basin Authority. We thank Geoffrey Allen for field inspection of the *Pluchea* site following initial detection of the Hattah-Kulkyne National Park species. Thanks also to Ian Clarke (MEL) for providing the images of the *Pluchea*.

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Muelleria

37: 127–132

ROYAL
BOTANIC GARDENS
VICTORIA

Book Review

A Feast of African Monocots

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The Amaryllidaceae of Southern Africa

Graham Duncan, Barbara Jeppe, Leigh Voigt (2016)

Umdaus Press, Hatfield, Pretoria, South Africa

ISBN: 978-1-919766-50-8, Hardback i-x + 1–709 pages; 27 x 21 cm; 2.9 kg weight. RRP AU $268.99

With the most recent ordinal and familial classification of the angiosperms, the Angiosperm Phylogeny Group (2016) (APG IV) places 14 families in the Asparagales; together they comprise c. 35,513 species of global distribution. Orchidaceae (26,460 species) dwarfs all other Asparagoid families and makes the order the far most speciose of all monocot orders.

Amaryllidaceae (Christenhusz *et al.* 2017) is largely warm-temperate and tropical in distribution with representatives on all the habitable continents. The amaryllids, with c. 2,140 species constitute the fourth largest family in Asparagales after Orchidaceae (25,000 species), Asparagaceae (3,220 species) and Iridaceae (2,244 species), followed by Asphodelaceae (1,200 species). All other families are considerably smaller (Christenhusz *et al.* 2017). Three subfamilies are recognised in Amaryllidaceae: *Amaryllideae* (c. 1,000 species), *Allioideae* (1,134 species) and *Agapanthoideae* (7 species). A major radiation of *Amaryllideae* has occurred in southern Africa, with c. 250 species (11.6% of global total of *Amaryllideae*). The greatest radiation of Amaryllidaceae is in the Neotropics with 375 species (17.5% of global total) with a lesser centre of distribution in the Mediterranean basin. Australia has a very depauperate amaryllid flora – only c. 21 species (Hewson 1987; Lang 2008; Lehmiller

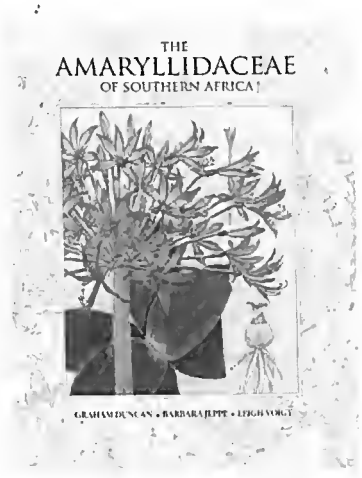

Figure 1. Cover art for *The Amaryllidaceae of Southern Africa.*

ISSN: 0077-1813 (print) · ISSN: 2204-2032 (online)

et al. 2012 a, b; Barrett and Barrett 2015), 0.98% of the global total of amaryllids.

In this splendid book Duncan, Jeppe and Voigt treat 263 amaryllid taxa (250 species, as well as subspecies and varieties), but exclude six species undescribed at that time (e.g. *Gethyllis* species). Also excluded from the book are the former Agapanthaceae (*Agapanthus* – 7 species) (Agapanthoideae) and Alliaceae (*Allium* – 1 species, *Tulbaghia* c. 20 species in southern Africa) (Allioideae) which were not recognised as families in Amaryllidaceae by APG III when the book was in preparation. Their area of geographic interest takes in all or part of seven countries from about 17–35° south in latitude, that is southward of the Kunene, Okavango, Zambesi and Limpopo rivers: Botswana, Lesotho, southern Mozambique, Namibia, South Africa, Swaziland and Zimbabwe.

Four of the thirteen tribes of Amaryllidaceae are covered in the book: *Amaryllidoideae*, *Cyrtantheae*, *Haemantheae* and *Pancrateae*. Almost all tribes, genera and species are endemic to southern Africa.

The Amaryllidaceae of Southern Africa is a taxonomic account and a picture gallery of the amaryllids. Graham Duncan authored the text and the late Barbara Jeppe, and her daughter Leigh Voigt, provided the superb watercolour portraits of the plants in 262 colour plates. Duncan has made a reputation for himself as a great authority on the taxonomy and horticulture of petaloid monocots in South Africa, evidenced by the citation of many of his publications in this work (under their respective generic entries). His hitherto most notable and recent contribution is the excellent monograph *The Genus Lachenalia* (Duncan 2012), a landmark in botanical publication. *The Amaryllidaceae of Southern Africa* will cement this reputation. No new names or combinations are published in the book.

As stated in the *Introduction* there are four primary aims of the book: 'to stimulate greater appreciation of the diversity of southern African Amaryllidaceae through the medium of botanical art; to draw attention to the conservation plight and the urgent need to conserve habitats; assist readers with plant identification; and encourage cultivation and propagation of plants acquired through reputable sources'. Four brief introductory chapters establish the context and provide background information before the meat of the book – the generic and species accounts and keys spanning 666 pages. This introductory text (of nine pages) comprises an *Introduction*, *Brief History* (of discovery by Europeans and taxonomic history), *Biogeography* and *Survival Strategies* (of these bulbous, rarely rhizomatous, seasonally-dormant geophytes). Each chapter is comprehensively referenced.

The generic and species accounts deal with 18 genera and 263 species, subspecies and varieties. The genera, arranged alphabetically, are *Amaryllis*, *Ammocharis*, *Apodolirion*, *Boophone*, *Brunsvigia*, *Clivia*, *Crinum*, *Crossogyne*, *Cryptostephanus*, *Cyrtanthus*, *Gethyllis*, *Haemanthus*, *Hessea*, *Namaquanula* (placed in *Hessea* in Mabberley 2017), *Nerine*, *Pancratium*, *Scadoxus* and *Strumaria*. Each genus is introduced over three to six pages before the alphabetically arranged species accounts, and each is given a generic description; etymology; brief history; distinguishing features and affinities; distribution; habitat and life cycle; pollination; medicinal uses and poisonous properties; and references. Numerous high-quality colour photographs (see below) illustrate representative species, often of *in-situ* plants in habitat; they provide a wealth of information and delight. Photo credits accompany photo captions.

The accounts of the species and infraspecific taxa are each given two (rarely three) facing pages, the text on the left and the paintings on the right; 13 taxa are not illustrated because of lack of material. The text gives the botanical name with author(s), common names (in various languages) and a detailed description before the subheads: major synonyms; etymology; flowering period; brief history; distinguishing features and affinities; distribution; habitat and life cycle; conservation status; and cultivation. The distribution of each taxon is shown by dots on a small monochrome map of the region, shaded to show altitude in 500 m increments; the small scale and lack of colour sometimes render altitudinal information difficult to read.

Keys to genera and species within genera follow the species accounts over 17 pages. Infraspecific taxa are keyed in the species accounts. Then follows a detailed 10- page chapter on cultivation, propagation, 'feeding', pests and diseases, useful addresses (of bulb societies), and South African sources of plant material. A glossary then follows and three indices: botanical and common

names; artists, botanists, authors and other contributors; and medicinal and other uses. Finally, lists are given of people involved in supporting the Sponsors', Collectors', and Subscribers' editions (what these are is unexplained).

The text, as we would expect from Duncan, is comprehensive, authoritative, lively, well-written and abundantly referenced. The references constitute as good a bibliography on the subject as we are likely to find. Throughout there is a beautiful integration of text and illustrations, the result of very high-class design and production values.

The glory of this book lies of course in its illustrations – the faultless, vivid and elegant watercolours of Barbara Jeppe (1921–1999), to whom the book is dedicated and who conceived the book in 1971 – and her daughter Leigh Voigt. Both are very highly accomplished artists and together they illustrate 262 taxa (Jeppe 167 taxa and Voigt 95). Thirteen species are not illustrated in the book and five illustrations are reproduced from *Curtis's Botanical Magazine* and *The Flowering Plants of South Africa*.

Individual plates are usually reduced to 50–90% (mostly 85%) of the original life size. A scattering of plates are life size (*Apodolirion*, *Hessea*, *Strumaria*). The provenance of the material used for illustration is given where known. It is interesting that for some paintings the artists relied on photographs and herbarium specimens only (you would never guess this). A few of Jeppe's paintings were reworked or modified by Voigt.

The design of the plates by Jeppe and Voigt is very beautiful and almost all show the vegetative and floral parts – the bulb or rhizome, leaves, and the inflorescence and infructescence. Enlarged floral details are not depicted, but this hardly matters in a group with large flowers as in the amaryllids. For species with unusually small flowers (e.g. *Nerine frithii, N. rehmannii, Strumaria tenella* and *S. bidentata*) enlarged floral details, revealing the range of floral morphological variation in the genera, would have been welcome, as given in several plates originally published in *The Flowering Plants of South Africa* (e.g. *N. hessioides*).

Because so many of the species are large, robust herbs, they must be depicted showing partial or truncated leaves and inflorescences but this is in no way a limitation; the artists' outstanding design sensibilities result in no loss of information or aesthetic compromise.

South Africa has a very fine tradition of botanical artistic practice (Arnold 2001; Hickman *et al.* 2017) in the service of taxonomy and horticulture, as well as for more purely aesthetic motives. This book is and will remain a landmark publication to the glory of that tradition. The first of the four primary aims of the book, 'to stimulate a greater appreciation of diversity among the southern African [...] Amaryllidaceae through the medium of botanical art', has been nobly achieved, but also achieved is a superb marriage in the book of botanical art and of photography. The 143 photographs of plants, most *in situ*, and of paintings works remarkably well – because of the quality of both, and because each mode conveys information not available in the other, particularly so in the invaluable ecological information of plants viewed in habitat. To integrate these into the whole is also a triumph of book design and very high-quality production, the exceptional work of the designer Tersia van Rensen and editor Emsie du Plessis. This is as good as it gets in publishing.

Conservation Status, if it has been assessed, is given for each species according to the South African National Biodiversity Institute Red List of South African Plants (www.redlist.sanbi.org) and for a few species the assessments of the National Botanical Research Institute, Namibia (www.nbri.org.na) (but without criteria given) and in the text conservation threats are given only fairly cursory treatment if mentioned at all. One can't help feeling that there is much more to be said about threats and conservation status of species. This information is all the reader is given despite conservation being identified in the *Introduction* as one of the four primary aims of the book, 'to draw attention to the perilous position of an increasing number of [...] species in the wild and [...] the urgent need to conserve ever-dwindling habitats'. Nothing in the texts actually conveys this and the reader has to go to the individual SANBI Red List evaluations on the SANBI and NBRIN websites to see how each conservation status is derived, i.e. what constitutes the threats for the amaryllid flora. The reader would not unreasonably expect a separate chapter (among the introductory chapters) presenting an overview of conservation issues for Amaryllidaceae in southern Africa and indicating the classes of natural and anthropogenic threats that prevail, and *in situ* and *ex situ* measures to ensure conservation of the

taxa. One species, *Cyrtanthus striatus* is extinct, and *C. rhododactylis*, collected once in the wild, has never been found again and many species are rare, vulnerable or endangered.

The fourth aim of the book is 'To encourage amaryllid cultivation and propagation through plant material acquired from reputable sources'. The paintings and photographs in this book will have horticulturists salivating, but apart from a few genera and species in common cultivation world-wide, most species are never or rarely encountered in general horticulture. In Australia we are very familiar with *Amaryllis belladonna*, a few *Clivia*, *Cyrtanthus*, *Haemanthus* and *Nerine* species. Remarkably, only 15 of the amaryllid species of southern Africa are included in the *Horticultural Flora of South-eastern Australia* (Spencer *et al.* 2005) and these are all easily cultivated. A chapter in the book is devoted to cultivation, and notes are given for almost all species in the individual species accounts. Many are grown in South Africa in specialist collections in botanic gardens, notably Kirstenbosch, and privately, but some are apparently difficult subjects in horticulture, such as those that occur in very arid climates, on low-nutrient soils or that are pyrophytes, flowering only after fire. While some of the pyrophytes are easily grown, they rarely or never flower in cultivation. From the cultivation notes given many are extremely sensitive to overwatering or 'wet feet'. How many are amenable to general horticulture in Africa and around the world remains to be seen.

The chapter *Survival Strategies* outlines the morphology and phenology of the plants in the wild and is crucial in understanding the horticultural management of amaryllids. Of the taxa, 12 (*Clivia*, *Cryptostephanus* and *Scadoxus* species), are rhizomatus, all other species are bulbous. A primary division with few exceptions in the amaryllid flora exists between summer rainfall-winter dormant species, and winter rainfall-summer dormant species; dormancy is characterised by deciduousness, i.e. death of leaves. For each species the information given in *Distribution, Habitat and Life Cycle* provides essential information relevant to horticultural management, along with cultivation notes (in species accounts) and the chapter *Cultivation*. Management of southern African amaryllids in cultivation demands a watering regime that reflects the climate in the species' geographic distribution. Most species strictly adhere to these climactically programmed growth/dormancy responses and must be treated accordingly in cultivation, then if not with lethal consequences for many species.

The book is bound to be a big stimulus to would-be commercial and non-commercial growers world-wide but a note of caution should be sounded and that is the weed potential of species in similar climates outside southern Africa. There is no mention by Duncan of any species naturalised anywhere in the world or of potential weediness. In Australia only *Amaryllis belladonna* appears to be naturalised, but it is only weakly invasive, unlike the highly invasive *Agapanthus praecox* subsp. *orientalis*. But what about other African amaryllids (including *Agapanthoideae* and *Allioideae*)? Duncan should have mentioned this issue but it seems to be ignored in the botanical literature of South Africa generally, including Duncan's (2012) excellent monograph on *Lachenalia*. More particularly, the problem potentially assumes frightening dimensions in the explicit horticultural promotion of South African Iridaceae by Manning *et al.* (2002), a family that is spectacularly invasive, at least in Australia. That these authors and Duncan can ignore the weed potential of the species they promote is puzzling and unfortunate, if not reprehensible, given the catastrophic invasion of South African biomes by weed species that have 'escaped' cultivation, a conservation threat that Duncan identifies for a number of amaryllids.

We are reminded throughout the book of the crucial role that horticulture has historically played and currently plays in taxonomy, given in the *Brief History* chapter and in species accounts. Many species have been described from cultivated material in Europe and South Africa, while many of Jeppe's and Voigt's lovely paintings were executed using cultivated material (sources or provenance identified in Duncan's text where known).

Several caveats concerning the text are noted here as a personal preference and they concern nomenclature and etymology. The first thing I usually look for in a serious taxonomic botanical publication is the full citation of a taxon's name: the binomial or trinomial citing the author(s), where published, as well as the date. Here Duncan only gives us the taxon name and the author(s). This also applies to the major synonyms

given, for which we might have expected at least a date. This kind of ready information which Duncan would have had at his fingertips provides a *de facto* potted taxonomic history of the taxa and the family overall and would add to the interest of each account of the species, subspecies and varieties. The *Brief History* given under each taxon only indirectly and always incompletely provides the above information.

There is one unexplained and curious exception to the citing of authors for botanical names in the book, namely for *Clivia robusta*, described in the treatment by Murray *et al.* (2004), in which this species and two varieties are described. These names are relegated to synonymy under *C. gardenii* var. *gardenii* and *C. gardenii* var. *citrina* by Duncan with a convincing justification. The full citation is given (under the subheading *Synonym*), including details of the type collection, herbarium etc. The citation of full details for *C. robusta* is a stand-alone inconsistent departure in the book; the species is recognised by others, for example in the SANBI Red List (www.redlist.sanbi.org).

Etymology, as given for each genus, species, subspecies and variety, is often not etymology, rather it is what the overall meaning of the name is without its etymological derivation. 'Etymology' as given in the book usually says, 'descriptive of the ... [attribute alluded to]' and not the expected breakdown of its parts, its Latin or Greek derivations etc. Again, this information must have been at Duncan's fingertips and would have enhanced the book.

Does *The Amaryllidaceae of Southern Africa* live up to its four stated primary aims? The answer to the first aim – 'to stimulate a greater appreciation of the diversity among southern African [...] Amaryllidaceae through botanical art' – is yes with bells on! The book falls short on its stated conservation aim (the second aim) in drawing attention to the perilous conservation status of species and urgent need to conserve ever-dwindling habitats. This I think is the book's most significant limitation because, apart from very scant textual information, all further accessing of conservation information depends on the reader viewing online SANBI Red List data; additionally there is no overview of conservation issues as they apply to Amaryllidaceae in the text – the reader has to go mining in other territory. The book likely fulfils very well its stated third aim ' to assist readers with identification of plants'. Because of the time of year (autumn) I have attempted to identify only one amaryllid using the generic key and description and images (ie. *Nerine bowdenii* subsp. *bowdenii*). I got the answer quickly and easily. The fourth aim, 'to encourage their cultivation and propagation...' probably succeeds very well, but with such self-proclaimed botanical and horticultural glories as most amaryllids are, no hard-sell is needed, they are their own promoters. For many species the success of horticultural aspirations is likely to be contingent on how amenable they are to cultivation in southern Africa.

Every once-in-a-while a book is published that leaves the reader reaching for superlatives; this is such a book. The authors, Graham Duncan, Barbara Jeppe and Leigh Voigt and all involved in the production of this book are to be warmly congratulated. It is sad that Barbara Jeppe did not live to see the results of her labours but she has earned an enduring place in the pantheon of South African botanical artists, as has her daughter, Leigh Voigt.

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ISSN 0077-1813

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