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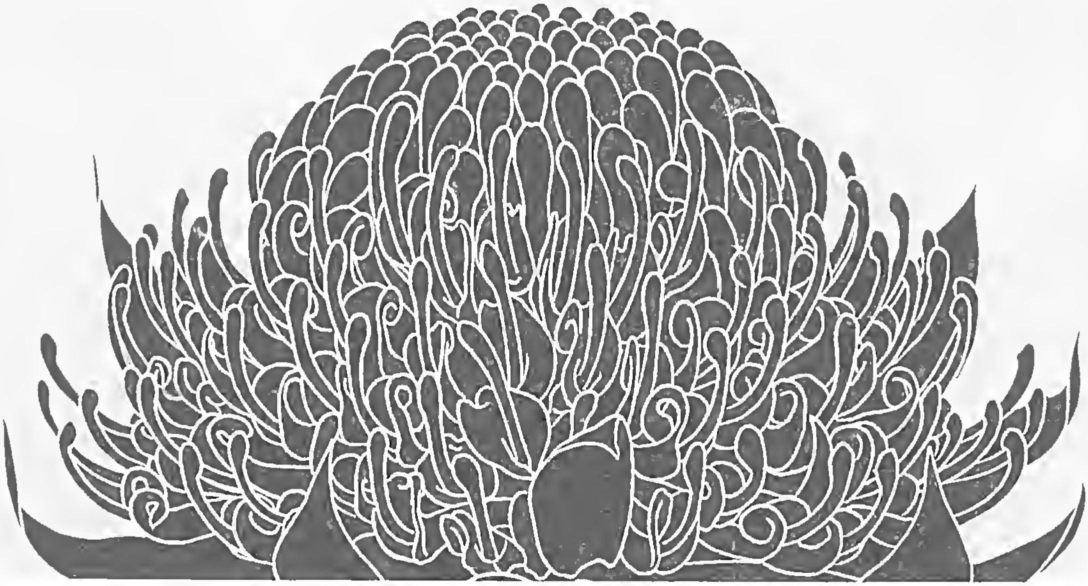

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Telopea 11(2) 99–104

Viola silicestris, a new species in *Viola* section *Erpetion* from Australia

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Abstract

Viola silicestris, a distinctive new species found in sandstone and rhyolite habitats in eastern New South Wales and far south-eastern Queensland, is described. It has previously been confused with *Viola sieberiana* and *V. hederacea*, from which it differs in habit, leaf, flower and habitat characters.

Introduction

Viola section *Erpetion* (Sweet) Benth. & Hook.f. comprises c. 12 taxa of endemic Australian violets, and constitutes the majority of the Australian species of *Viola*. Ongoing studies of members of the section are helping to resolve species boundaries in what has traditionally been regarded as a difficult group, resulting in the description of a number of new species (see Thiele & Prober, 2003). The present paper describes *Viola silicestris*, a distinctive new species from sandstone and rhyolitic habitats on the coast and ranges of New South Wales and south-eastern Queensland.

Viola silicestris K.R.Thiele & Prober ***sp. nov.***

Affinis *Viola sieberiana* Spreng. sed foliis plerumque latioribus, basi late cuneata, et dentibus minoribus aequioribusque differt. Affinis *Viola hederacea* Labill. sed foliis latioribus, floribus concoloribus, pallide caeruleo-violaceis, glandibus antherarum angusto-sinuatis, et seminibus atro-purpureis differt.

Type: Australia, New South Wales, Carrington Falls, 3 Jan 1998, *K.R.Thiele 2568 & S.M. Prober* (Holo: CANB; Iso: MEL, NSW, BRI)

Perennial herb spreading by stolons; rootstock not or scarcely swollen at the stem bases, with a slender, ± woody taproot. *Stems* varying from contracted so that the leaves form rosettes (in exposed plants) to elongate and scrambling to 0.4 m high with caulescent leaves (in sheltered plants). *Leaves* broad, the largest (4–)6–10(–15) mm long, (5–)10–25(–38) mm wide, (1–)2–4(–5) times wider than long, usually truncate at base (the basal angle c.180°), occasionally sub-reniform or ± tapering; lamina with (5–)7–12(–14) obscure teeth, the apical tooth not prominently larger than the rest, glabrous or occasionally sparsely short-pubescent when young, green above and beneath; *petioles* 2–11 cm long; *stipules* scarious, narrowly triangular with several irregular, elongate,

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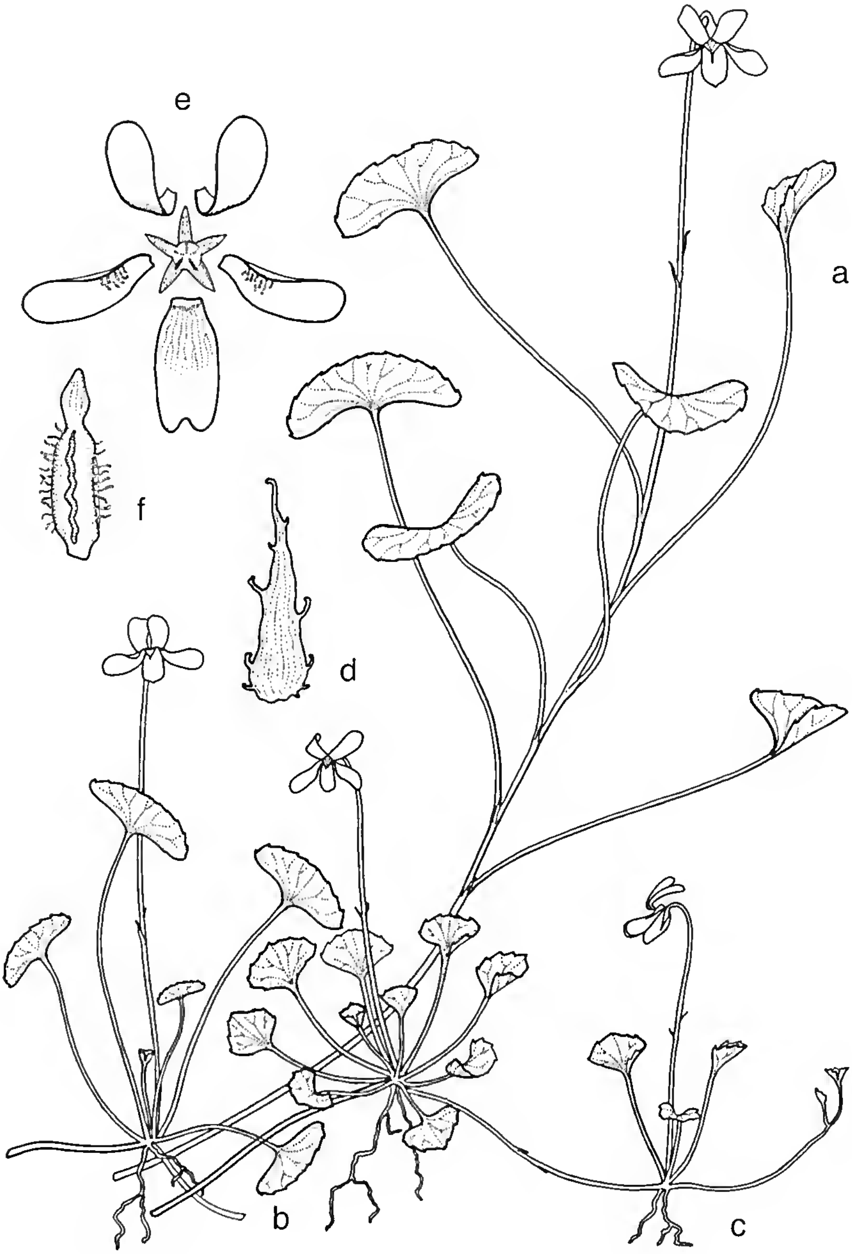

Fig. 1. *Viola silicestris.* **a–c,** habit ×1. **a,** caulescent plant from sheltered site; **b,** non-caulescent plant from sheltered site; **c,** non-caulescent, small-leaved plant from exposed site; **d,** Stipule ×5; **e,** Flower ×4; **f,** Ventral anther showing gland ×10. (K.R. Thiele 2542, CANB).

glandular teeth on each side. *Flowers* prominently displayed, on scapes longer than the leaves, concolorous pale mauve-blue (rarely somewhat discolorous); *anterior petal* (5–)6–7(–8) mm long, 3–4 mm wide, ± rectangular to ovate, usually emarginate, with a small green blotch at the base then concolorous or with a whitish base, without a white apex, ± regularly triplinerved with darker veins ; *lateral petals* spreading, 6–8 mm long, twisted usually to c. 90° and usually reflexed, concolorous; beard absent or present, comprising pale hairs; *dorsal petals* 6–7 mm long, 2–3 mm wide, narrowly obovate, erect to reflexed, concolorous. *Anthers* 1.5–2.5 mm long, violet-tinted, the terminal appendages straw-coloured, with short, irregular hairs on the outer margins of the anther cells; *anther glands* pale, slightly shorter than the anther cells, irregular, narrow; *pollen* and interior margins of the anther cells pale cream. Ovary and fruit pale green with or without purple spots or blotches; style distinctly kinked at its insertion on the ovary. Seeds 1.5–1.7 mm long, glossy purplish-black when mature. Figure 1.

Derivation of name: from the Latin *silice* (silica), and *-estris* (inhabiting), in reference to the characteristic occurrence on siliceous, sandy soils.

Suggested common name: Sandstone Violet

Distribution and habitat: *Viola silicestris* occurs in scattered localities on the coast and Great Dividing Range in eastern New South Wales and far south-eastern Queensland.

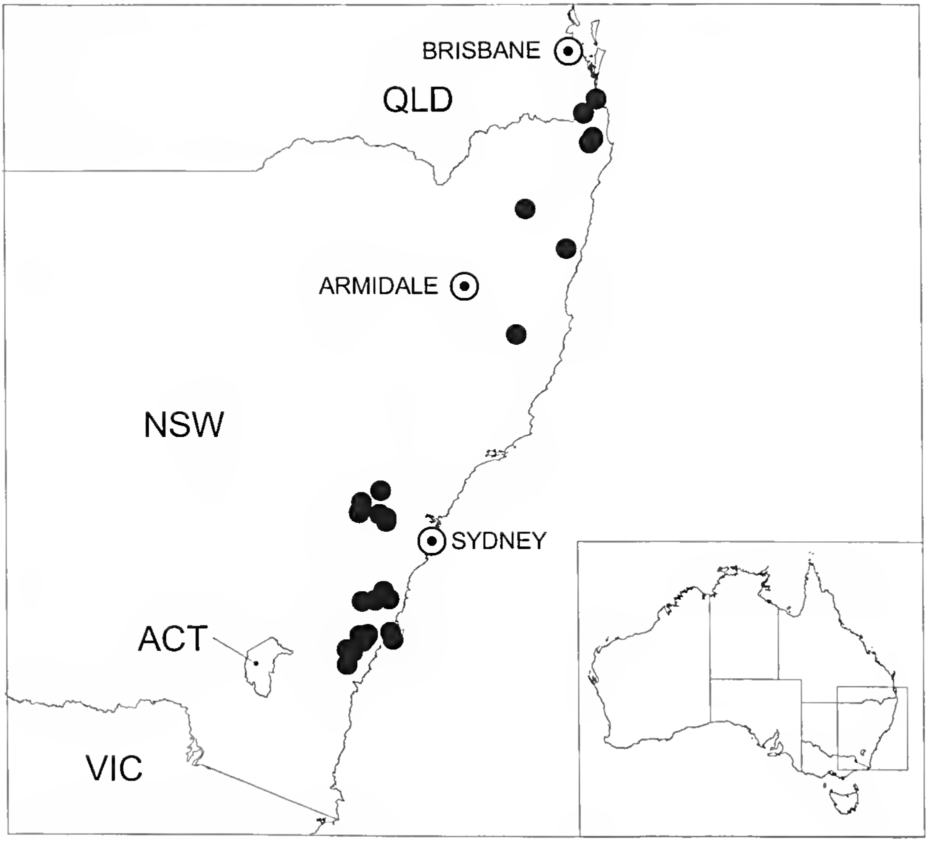

Fig. 2. Distribution of *Viola silicestris*

There are three main centres of distribution – from the northern Budawang Ranges and Jervis Bay to Bundanoon and Robertson, in the Blue Mountains from Bowen Mountain to the Newnes Plateau, and in northern New South Wales and south-eastern Queensland from Werrikimbe National Park to Lamington National Park (Fig. 2).

Viola silicestris is typically found in seasonally moist (but often summer-dry) sites in sclerophyllous, heathy vegetation on acid, sandy soils derived from sandstones or silica-rich igneous intrusives, particularly rhyolite but possibly also on related rocks such as porphyries and adamellite. It appears to be absent from better-quality soils derived from non-sandstone sedimentaries, granites etc. (although it may be found on the contact zones where the influence of silica-rich parent materials is high).

Conservation Status*:* *Viola silicestris* is a relatively common species with a wide distribution including secure populations in several National Parks. It is not under any known threat.

Notes: *Viola silicestris* may be distinguished from all other Australian violets by its combination of very broad leaves with ± even teeth across the apex, concolorous, pale, bluish-violet flowers and (in suitable sites) caulescent habit.

Like other species in section *Erpetion*, leaves of *Viola silicestris* are highly plastic and vary greatly depending on their conditions of growth (Fig. 3). Plants growing in exposed positions, such as on track verges and in other areas with high sunlight, have reduced leaves which are much smaller and narrower than leaves from plants growing in more sheltered positions amongst vegetation. It is often possible in the field to find a complete gradation from small, narrow, reduced leaves in exposed positions to large, broad, typical leaves in adjacent sheltered sites. Most herbarium specimens, however, fail to represent such local variation adequately. This is a problem throughout the

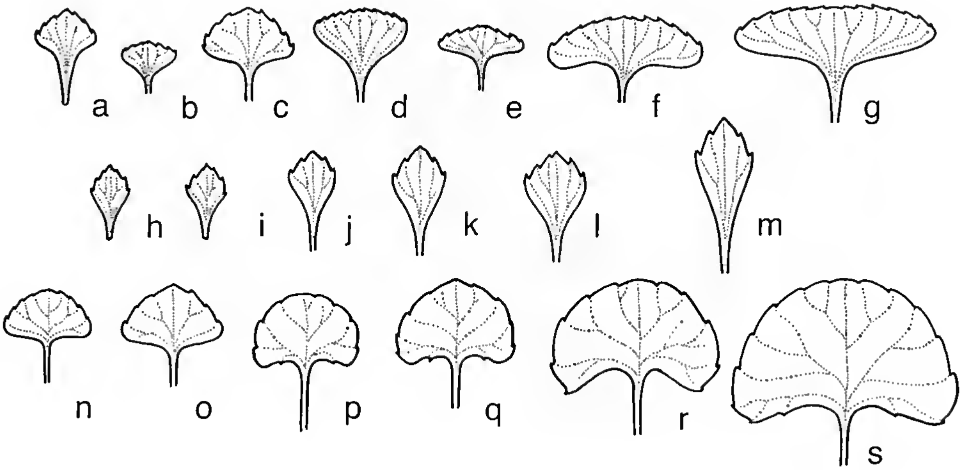

Fig. 3. Range of leaf shapes in three species of *Viola* ×1. **a–g,** *Viola silicestris*; **h–m,** *V. sieberiana* (Sydney population); **n–s,** *V. hederacea s.s.* Leaves to the left are from exposed plants with small leaves, leaves to the right are from sheltered plants with fully expressed leaf shapes.

section, with reduced leaves of all species converging in shape (e.g. Fig. 3c cf Fig. 3o), while fully developed leaves from sheltered sites are usually highly distinctive.

Specimens of *Viola silicestris* with small leaves have often been placed in *V. sieberiana*, while specimens with broad leaves have generally been placed in *V. hederacea sens. lat.*, largely because the broad leaves rule out *V. sieberiana* and *V. hederacea* has been incorrectly regarded as highly polymorphic. Specimens with intermediate leaves (e.g. NSW522386, NSW522398) have sometimes been regarded as hybrids between *Viola hederacea* and *V. sieberiana*. There is no evidence that such hybrids exist.

Leaves of *Viola sieberiana* and *V. silicestris* differ in that the former are always narrowly spathulate, even in sheltered sites (see Fig. 2h–m) and have an acute terminal tooth that is distinctly larger than the lateral teeth, whereas even reduced leaves of *V. silicestris* are generally more or less flat-topped with the central tooth no larger than the lateral teeth. Leaves of *Viola hederacea* differ from both species in being ± semicircular, at least when fully developed (Fig. 3n–s).

Flowers of *Viola silicestris* and *V. sieberiana* are similar in shape, size and colour; together, flowers of these two species are very different from any other species in section *Erpetion*. They are usually concolorous pale bluish-violet, without distinct white tips to the petals. The anterior petal is narrowly oblong, with a very small green blotch at the base, a whitish region traversed by pale bluish veins in the lower third or half, grading to a concolorous pale bluish-violet apex. In contrast, *V. hederacea* and most other species (with the exception of the very small-flowered *V. fuscoviolacea* and *V. cleistogamoides*) have broader anterior petals with a large green blotch at the base, a pale to bright violet middle section, and a distinct and often sharply contrasting white apex.

Viola silicestris plants often develop a caulescent growth habit when growing in sheltered sites amongst other vegetation, with elongate, weakly erect, scrambling aerial stems to 30 cm high and scattered leaves. Plants in exposed sites have contracted stems and fasciculate leaves. *Viola hederacea* and *V. sieberiana*, by contrast, never develop such a habit, even when growing amongst dense vegetation.

As with other species in the *Viola hederacea* species complex, it is not unusual to find *V. silicestris* growing allopatrically with other species. It has been found growing more or less intermingled with *V. hederacea* near Robertson, NSW, and with *V. sieberiana* and *V. fuscoviolacea* near Clarence. In such situations, *V. silicestris* is usually found in drier sites on poorer, sandier soils. No hybrids between *V. silicestris* and any other species have been seen.

Viola silicestris was included in the key to known Australian species in section *Erpetion* (Thiele & Prober 2003) as *Viola sp. nov. A*. It appears to correspond with *Viola hederacea* forma A of James (1990), although specimens at NSW have also been annotated as formas B, C and D.

Morphologically, *Viola silicestris* appears to be most closely related to *Viola sieberiana*. However, relationships in section *Erpetion* are largely unknown, and will probably require DNA sequence data and chromosome counts to elucidate.

Selected specimens examined: New South Wales: Northern Tablelands: About 0.5 km along Minyon Falls walking track, Whian Whian State Forest, 5 Oct 1987, *R. Johnstone 57* (NSW209787); Gibberagunyah Mountain, Whian Whian State Forest, Sep 1967, *W.T. Jones 3630* (CANB210906); Peach Mountain, Whian Whian State Forest, 15 miles N of Lismore, 3 Nov

1967, *K. Grieves s.n.* (NSW137263); Cangai Rd, Cangai Boards Flora Reserve, Dec 2000, *NSW NPWS s.n.* (NSW444497); Branch of Middle Ck, c. 5 km NE of Glenreagh, Sherwood Nature Reserve, 13 Mar 1997, *P. Gilmour 7722* (NSW434270); Grass Tree Swamp, Werrikimbe National Park, 7 Nov 1992, *T.A. James 1328* (NSW423018); Central Tablelands: Nayook Ck, Deep Pass east of Glow Worm Tunnel Rd, Newnes Plateau, Wollemi National Park, 13 Jan 1993, *P. Hind 6579* (NSW362405); 14.2 km WNW along Culoul Range Rd towards Colo River, 8 Apr 1977, *R. Coveny 9222* (NSW522386); 1.5 km from Bilpin along Mountain Lagoon Rd, 1 Nov 1988, *P. Hind 5703* (NSW212907); c. 3 km W of Bell, 25 Feb 1968, *R. Coveny s.n.* (NSW137315); Track to Tabaraga Rill, c. 2.5 km NW of Bowen Mt, 9 Feb 1988, *T.A. James 916* (NSW213497); End of Lt. Bowen Drive, Bowen Mountain Settlement, 9 Mar 1987, *T.A. James 867* (NSW196953); Southern Tablelands: Butlers Swamp, Tourist Rd, 7 km N of Robertson, 4 Dec 1992, *T.A. James* (NSW273260); Bundanoon, 27 Oct 1987, *M. O'Neill s.n.* (NSW216079); Fitzroy Falls, 30 Nov 1930, *F.A. Rodway* (NSW137314); 3.6 mls. [5.5 km] from The Jumps turnoff toward Tomerong Nerriga Rd, 12 Nov 1972, *M. McMillan 72/87* (CBG50924); 4 km NNE of Mount Tianjara, 2 May 1981, *K. Paijmans 3980* (CANB333663); Boolijah Creek, ca 4 km ESE of Sassafras, 15 Oct 1982, *L.G. Adams & R. Pankhurst 3897* (CANB376712); c. 4 miles SW of Corang Peak, Budawang Range, 2 Feb 1974, *T.G. Hartley14243* (CANB245755); Tianjara Falls, near Nerriga, 1961, *Walker ANU1032* (CANB122254); 10 miles [16 km] S of Sassafras, 24 Oct 1965, *T. & J. Whaite s.n.* (NSW522398); The Castle, Northern Budawang Range, 31 Jan 1998, *I.R. Telford 12381* (CBG9800212); 4.3 km E of Tianjara Falls along Turpentine Road to the north, 27 Oct 1988, *S. Donaldson 32* (CBG8803775); South Coast: Currowan State Forest: ca 18 km NNW of Nelligen, 8 Mar 1973, *L.G. Adams 3138* (CANB381723); Huskisson, Jervis Bay, 13 Sep 1931, *F.A. Rodway 507* (NSW137280); 400 m along Stoney Creek Road heading towards Steamers Beach, 29 Sep 1993, *M. Kennedy 587* (NSW277654). Queensland: Daves Creek Country, Binna Burra, 23 Nov 1961, *R. Jones s.n.* (AQ478594); Lamington National Park, c. ¾ mile [1.2 km] towards Binna Burra from Coomera Falls on the Coomera Track, 15 Jan 1960, *R. Schodde 1153* (AQ115410); Upper Tallebudgera Creek, Dec 1917, *C.T. White s.n.* (AQ115411).

Acknowledgments

We would like to thank the directors and staff of BRI, CANB, MEL, NSW and AD for access to their collections, Rob Price and Alan Fairley for assistance with field work, and Laurie Adams for discussions on *Viola* and for the Latin diagnosis. Chris Allen is thanked for his work on the distribution map.

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Thiele KR & Prober SM (2003) Two new species and a new hybrid in the *Viola hederacea* species complex. *Muelleria* 18: 7–25.

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Telopea 11(2) 105-110

Philotheca papillata (Rutaceae), a new endangered species from north-eastern New South Wales

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Abstract

Philotheca papillata I.Telford & L.M.Copel., apparently endemic to Sherwood Nature Reserve, north-eastern New South Wales, is described as new. Notes on its distribution, habitat and conservation status are provided. The species is illustrated, its distribution mapped and some of its attributes compared with related taxa.

Introduction

In 2000, while collecting material of *Homoranthus floydii* in Sherwood Nature Reserve near Glenreagh for a revision of that genus, one of us collected material of an associated species of *Philotheca*, then thought to be the widespread and variable *P. salsolifolia*. Recent revisionary studies in *Philotheca* sect. *Philotheca* (Wilson 1998) and the treatment of *Philotheca* for *Flora of New South Wales* (Weston & Harden 2002), however, present no taxon with the unique combination of attributes of our material. The species which appear closest morphologically are *P. reichenbachii* Sieber ex Spreng., particularly similar vegetatively, and *P. salsolifolia* (Sm.) Druce.

Methods

Specimens of *Philotheca reichenbachii* and *P. salsolifolia* representing the known range of the taxa in New South Wales were borrowed from the National Herbarium of New South Wales (NSW) to augment the collections held in the N.C.W. Beadle Herbarium (NE). In this study, eight populations of *P. reichenbachii* and 21 of *P. salsolifolia* were scored. For morphological observations and measurements, dried herbarium material was reconstituted. Leaf characters (direction relative to axis of stem, length, shape in transvese section, presence of enlarged oil glands and indumentum) and floral characters (pedicel length, petal length, petal indumentum, petal colour, anther shape and indumentum of anther apicula) were recorded.

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Discussion

Philotheca reichenbachii is restricted to the Sydney region (Wilson 1998, Weston & Harden 2002). Wilson (1998) recognised two subspecies of *P. salsolifolia* with their distributions recorded (Wilson 1998, Weston & Harden 2002) as follows. *P. salsolifolia* subsp. *salsolifolia* is widespread in coastal and near-coastal New South Wales from near Taree south to near Bega, inland to Pilliga and West Wyalong. *P. salsolifolia* subsp. *pedicellata* Paul G.Wilson is restricted to the Angourie district of coastal north-eastern New South Wales.

The *Philotheca* population closest geographically to the locality of the new collection is of *P. salsolifolia* subsp. *pedicellata* at Sandon, c. 80 km to the north. This taxon differs from the Glenreagh plants in its triquetrous, non-verrucose, spreading leaves, long pedicellate flowers, glabrous keel of the petals and anther shape. *P. salsolifolia* subsp. *salsolifolia* has its closest population at North Haven, c.180 km to the south. Specimens from here and other coastal populations differ in almost terete, non-verrucose leaves, petal indumentum and anther shape (Table 1). Inland populations of *P. salsolifolia* show considerable morphological differences and will not be discussed further here. This morphological variability and the disjunct distribution pattern of this species suggest a species complex in need of further investigation. Attributes scored for *P. salsolifolia* subsp. *salsolifolia* in Table 1 are for coastal 'type' populations from between Port Macquarie and Bega.

Comparison of the Glenreagh collections with *P. reichenbachii* show a remarkable similarity in vegetative attributes. In floral characters they differ in bearing smaller flowers with white to pale pink petals, the petal keel pubescent, anther shape and anther apicula lacking hair tufts (Table 1). It could be postulated that this new species and *P. reichenbachii* constitute a vicariant pair, but testing of relationships must await elucidation of end taxa. The Glenreagh material clearly represents a new species, described below.

Philotheca papillata I.Telford & L.M.Copel. ***sp. nov.***

P. reichenbachii similis sed petalis minoribus albidis vel subroseis atque pubescentibus in mediano abaxiali et antheris ad apicem glabris differt.

Type: New South Wales: North Coast: Sherwood Nature Reserve, *I.R. Telford 12786, J.J. Bruhl & L.M. Copeland*, 14 Sep 2004 (holo: NSW; iso: BRI, CANB, HO, K, MEL, MO, NE, PERTH). (Specific locality details withheld for conservation purposes)

Shrub, erect, multistemmed, to 60 cm tall, bearing root suckers. *Branchlets* pilose, pale green beneath the white indumentum. *Leaves* incurved, narrow-elliptic, 9–12 mm long, 1–1.5 mm wide, acute, the margins recurved, crenate, verrucose with 4 or 5 glands on each side of lower surface, both surfaces papillate. *Stipules* minute, dark purple to black. *Flowers* solitary, terminal, on pedicels c. 0.5 mm long. *Sepals* 5, suborbicular, 1.5–2 mm long, pubescent. *Corolla* of 5 free petals, white to pale pink. *Petals* elliptic, 7–10 mm long, pubescent on both surfaces, the abaxial surface sparsely verrucose. *Stamens* 10, 6.5–8 mm long. *Filaments* fused at base for 4–5 mm. *Anthers* ovate, apiculate, c. 1.2 mm long, the apicula glabrous or minutely papillate. *Gynoecium* of 5 basally-fused carpels, the carpels tomentose, pale green; style terete, broadening towards the base, c. 4 mm long, pilose on lower three-quarters; stigma capitate, minutely 5-lobed. *Disc* obscure. *Fruit* not seen. (Fig. 1).

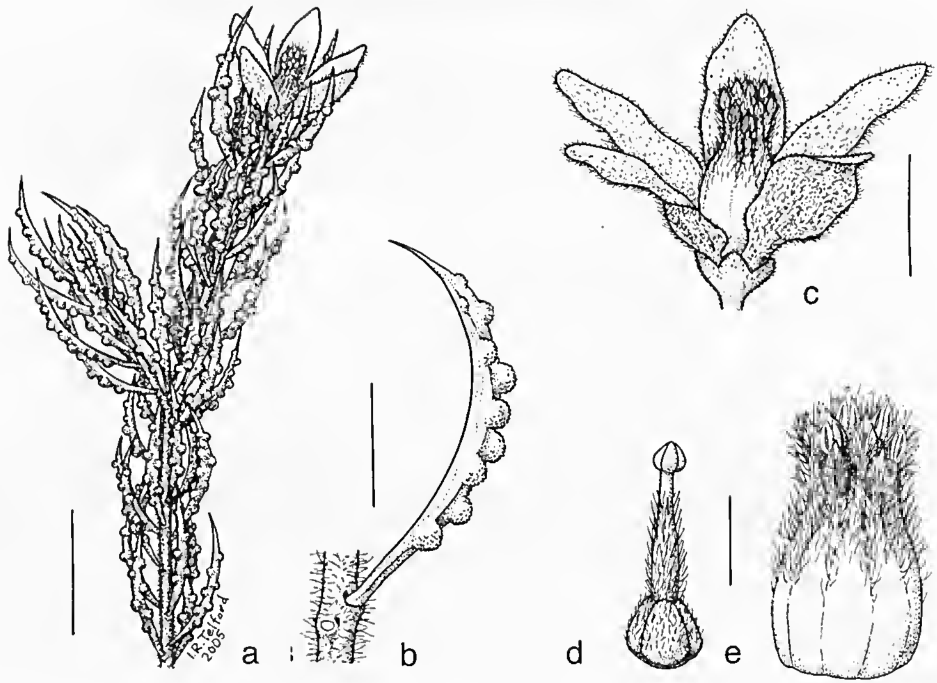

Fig. 1. *Philotheca papillata* **a**, flowering branch; **b**, leaf; **c**, flower; **d**, androecium; e, gynoecium. Scale bar: a = 10 mm; b, c = 5 mm; d, e = 2 mm. (all from *L.M. Copeland 2605 & P.R. Sherringham*).

Additional specimens examined: New South Wales: North Coast: Sherwood Nature Reserve, *L.M. Copeland 2605 & P.R. Sherringham*, 2 Sep 2000 (NE); *L.M. Copeland 3758*, 4 Jul 2004 (CANB, NE, NSW); *I.R. Telford 12787, J.J.Bruhl & L.M.Copeland*, 14 Sep 2004 (NE). (Specific locality details of all specimens withheld for conservation purposes).

Distribution: *Philotheca papillata* is known only from the type locality in Sherwood Nature Reserve, east of Glenreagh (Fig. 2). In spite of widespread searches in areas of similar geology and geomorphology (sandstone cliff lines and rocky slopes of the Grafton Formation and Kangaroo Creek Sandstone) between Chambigne Nature Reserve, Whitemans Creek, Coaldale and Flaggy Creek Nature Reserve, no further populations were discovered. The dissected sandstone country between Glenreagh and Woolgoolga provides habitat for several other narrowly endemic species including *Homoranthus floydii, Boronia umbellata, B. hapalophylla* and an undescribed species of *Lasiopetalum.*

Flowering: flowers have only been observed in September although the species is likely to flower from mid August through to at least early October.

Habitat: this species occurs in a heath community with *Banksia oblongifolia, Leptospermum trinervium, Phebalium woombye, Bossiaea rhombifolia, Xanthorrhoea johnsonii* and *Philothrix deusta* with occasional emergent malleed *Eucalyptus planchoniana.* The substrate is a shallow sandy soil over sandstone (Grafton Formation) along escarpment cliff tops at an altitude of c. 350 m. The site appears to have a high fire frequency and the root-suckering habit of the species probably assists in maintaining the population.

Table 1. Comparison of some distinguishing attributes between *Philotheca papillata*, *P. reichenbachii* and *P. salsolifolia* s.s.

Character	*P. papillata*	*P. reichenbachii*	*P. salsolifolia s.s.*
Leaf lamina	incurved	± incurved	± straight
Leaf surface	papillate	hispid, papillate	glabrous–sparsely ciliate
Leaf margin	verrucose	verrucose	smooth
Petal length	7–8 mm	8–13 mm	6–10 mm
Corolla outer surface	keel tomentose	keel ± glabrous	keel glabrous
Corolla colour	white–pale pink	purple	pink–purple
Anther apex	glabrous	with hair tuft	glabrous
Anther shape	ovoidal	cylindroidal	narrow-ellipsoidal

Conservation status: *Philotheca papillata* is apparently restricted to Sherwood Nature Reserve where a single population is known of c. 150 individuals along c. 200 m of escarpment edge. An inappropriate fire regime could present a major threat but resprouting by root suckers could potentially allow survival. The population is also close to an informal lookout and a series of obscure walking tracks. Although all known plants occur within the reserve, the species should still be considered endangered due to its highly restricted distribution and small population size. Following the criteria of Briggs and Leigh (1996) a conservation code of 2ECit is recommended.

Etymology: the epithet *papillata* is from the Latin (*papillatus*=bearing papillae), in reference to the distinctive leaf surfaces.

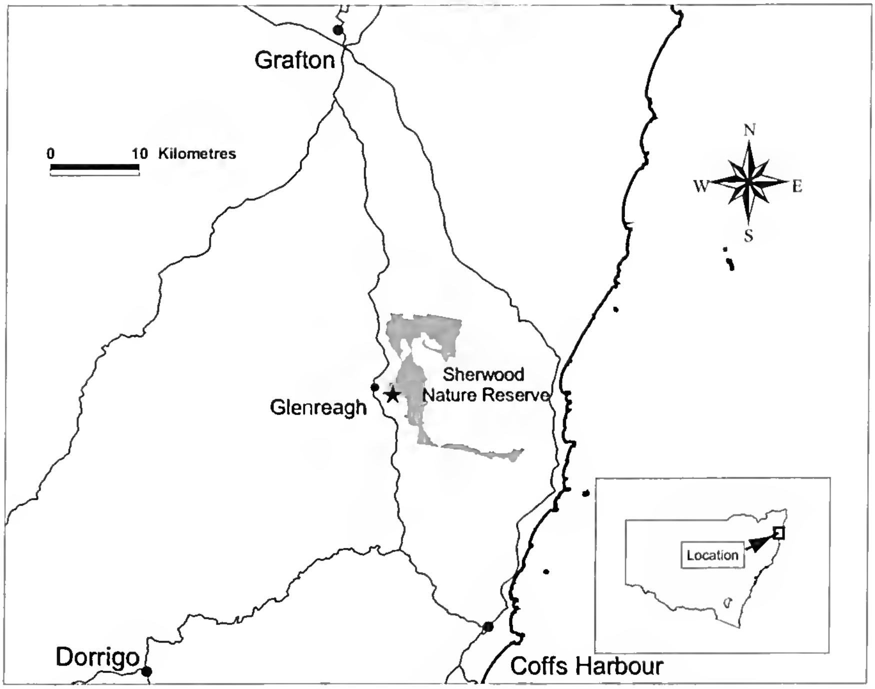

Fig. 2. Approximate location of *Philotheca papillata* (denoted by ★) in Sherwood Nature Reserve, north-eastern New South Wales.

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We would like to thank Jeremy Bruhl for assistance in the field and constructive comments on the manuscript. Paul Sherringham of the NSW National Parks and Wildlife Service is also thanked for field assistance and jointly discovering the new species. Peter Wilson kindly provided the Latin diagnosis.

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Telopea 11(2) 111-116

Pimelea cremnophila (Thymelaeaceae), a new species from the New England Tablelands escarpment of northern New South Wales

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Abstract

Pimelea cremnophila L.M.Copel. & I.Telford, a rare new species endemic to the Macleay Gorges east of Walcha, is described. Notes are given on its distribution, habitat and conservation status. Although all plants are known from a conservation reserve the species is considered to be endangered due to its restricted distribution and small population size.

Introduction

The gorge country of the eastern escarpment of the New England Tableland is well known as a 'hot spot' for endemism. Narrowly endemic taxa in the Macleay and Guy Fawkes River gorges include *Hakea fraseri*, *Phebalium squamulosum* subsp. *verrucosum*, *Leucopogon trichostylus*, *Zieria floydii* and *Bertya ingramii*. Other taxa thought to be endemic to the area include undescribed members of *Westringia*, *Persoonia*, *Acalypha*, *Zieria*, *Callistemon*, *Eucalyptus*, *Leionema* and *Olearia* (Briggs & Leigh 1996; Copeland 1997). Recent fieldwork in Oxley Wild Rivers National Park has yielded a species of *Pimelea* which did not fit any currently known taxa in the treatments of Threlfall (1983), Rye (1990) and Harden (1990). An examination of *Pimelea* specimens held in CANB, NSW and NE also supported the recognition of the Macleay Gorges *Pimelea* as distinct (herbarium abbreviations follow Holmgren et al. 1990). This paper describes the new species and gives notes on its distribution, habitat and conservation status.

Pimelea cremnophila L.M.Copel. & I.Telford ***sp. nov.***

P. umbratica similis sed indumento foliari caulinoque longiore densioreque et filamentis staminum distinctis differt.

Type: New South Wales: Northern Tablelands: Oxley Wild Rivers National Park, c. 40 km ENE of Walcha, 30° 55′ S, 151° 52′ E, *L.M. Copeland 3816*, *I.R. Telford & P.J. Lupica*, 13 Oct 2004 (holo NSW; iso BRI, CANB, CHR, HO, K, MEL, MO, NE). (Specific locality details withheld for conservation purposes).

Erect shrub to 2.5 m tall. *Stems* red-brown, hirsute with strigose white antrorse hairs to 3 mm long, glabrescent with age. *Leaves* opposite, petiolate; petioles c. 1 mm long, densely

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hairy; lamina narrow-elliptic to narrow-ovate, acute, 10–37 mm long, 2.5–6 mm wide, secondary venation indistinct, the adaxial surface glabrous or sparsely hairy mainly along the midvein, the abaxial surface paler and hirsute with scattered white, strigose hairs, the hairs denser and longer, to 2.5 mm long, on the margins. *Inflorescences* axillary or terminal, extending up to 15 nodes below shoot apex,1–4 flowered, condensed racemes 2–3 mm long; peduncle c. 1 mm long, strigose; bracts leaf-like, c. 2.5–5 mm long, caducous. *Flowers* functionally male, bisexual or functionally female; subsessile. *Hypanthium* antrorse hairy outside, glabrous inside, greenish-white; sepals 4, narrow-ovate. *Male flowers* with hypanthium 6–8 mm long; sepals 3–4 mm long; stamens 2, rarely 3, inserted near summit of hypanthium; filaments c. 1 mm long; anthers narrow-oblong, c. 1.7 mm long; pistillode c. 1 mm long. *Bisexual flowers* protandrous, with hypanthium 4–6.5 mm long; sepals 3–4 mm long; stamens similar to male flowers; ovary c. 1.5 mm long, with erect hairs at apex; style eventually exserted; stigma brush-like. *Female flowers* with hypanthium 3–4.5 mm long, circumscissile c. 1 mm below sepal attachment; sepals 1.5–2.5 mm long; staminodes minute; gynoecium similar to bisexual flowers. *Fruit* dry, ovoid, enclosed in the persistent base of the hypanthium, pale green. *Seed* ovoid, 3–3.5 mm long, c. 2 mm wide, with minute longitudinal, foveate furrows, red-brown (Fig.1).

Additional specimens examined: New South Wales: Northern Tablelands: Oxley Wild Rivers National Park: c. 40 km ENE of Walcha, 30°55'S, 151°52'E, *L.M. Copeland 3444 & P. Lupica*, 24 Oct 2002, (BRI, CANB, MEL, NSW, NE); c. 40 km ENE of Walcha, 30°55'S, 151°52'E, *L.M. Copeland 3608 & S. Doak*, 8 Oct 2003, (CANB, MEL, NE, NSW); rim of gorge of Spring Ck., c. 38 km E of Walcha, 30°55' S, 151°51'E, *L.M. Copeland 3735, J.J. Bruhl & I.R. Telford*, 4 May 2004, (BRI, CANB, NSW, NE); c. 38 km ENE of Walcha, 30°55'S, 151°51'E, *L.M. Copeland 3819, I.R. Telford & P.J. Lupica*, 13 Oct 2004, (AD, NSW, NE); c. 37 km ENE of Walcha, edge of gorge of Redmans Ck, 30°56'S, 151°51'E, *L.M. Copeland 3822, I.R. Telford & P.J. Lupica*, 13 Oct 2004, (AD, AK, BRI, CANB, CHR, HO, MEL, NSW, NE). (Specific locality details of all specimens withheld for conservation purposes).

Distribution: apparently confined to gorge rims in the southern part of Oxley Wild Rivers National Park, approximately 40 km E of Walcha. Several small populations are scattered along a 5 km stretch of gorge rim. A large area of similar habitat exists within the park and further searches of this area of gorge rim could potentially yield additional populations.

Habitat: all plants observed grow in a shallow, skeletal loam over metasediments on exposed cliff tops or more sheltered cliff-side sites with south-westerly to south-easterly aspects. Altitude ranges from 1050–1090 m. Associated species include *Allocasuarina littoralis, Eucalyptus retinens, E. campanulata, Acacia blakei* subsp. *diphylla, Maytenus silvestris, Prostanthera rhombea, Dodonaea rhombifolia, Astrotricha longifolia, Ozothamnus obcordatus, Persoonia media, Callistemon* sp. nov., *Correa reflexa* var. *reflexa, Lepidosperma elatius* s.l., *L. laterale, Rhodanthe* sp. nov. and *Notodanthonia longifolia*.

Flowering: flowers have only been observed in early to mid October, but the presence of unopened floral buds and young fruits on specimens suggests that the species is likely to flower throughout spring.

Conservation status: the species is currently known from fewer than 100 individuals and relatively few juveniles have been observed. Potential threats include an inappropriate fire regime and grazing by feral goats. Several mature individuals appeared to die during

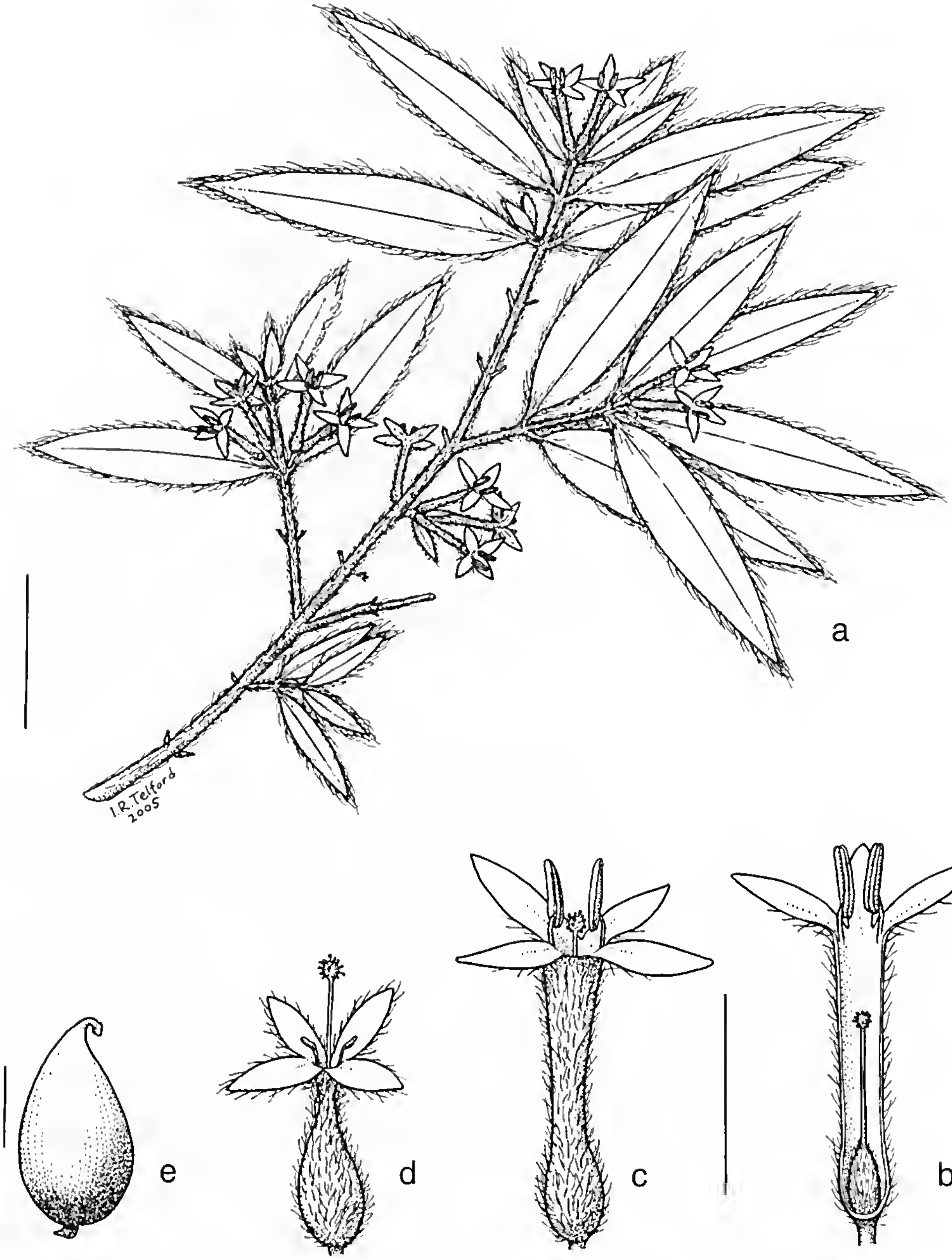

Fig. 1. *Pimelea cremnophila* **a**, flowering branch; **b**, bisexual flower prior to elongation of style, with part of hypanthium and one sepal removed; **c**, bisexual flower; **d**, functionally female flower; **e**, seed. Scale bar: a = 10 mm; b–d = 5 mm; e = 1 mm. (a, b, e, from *L.M. Copeland 3608 & S. Doak*; c, d, from *L.M. Copeland 3816, I.R. Telford & P. Lupica*)

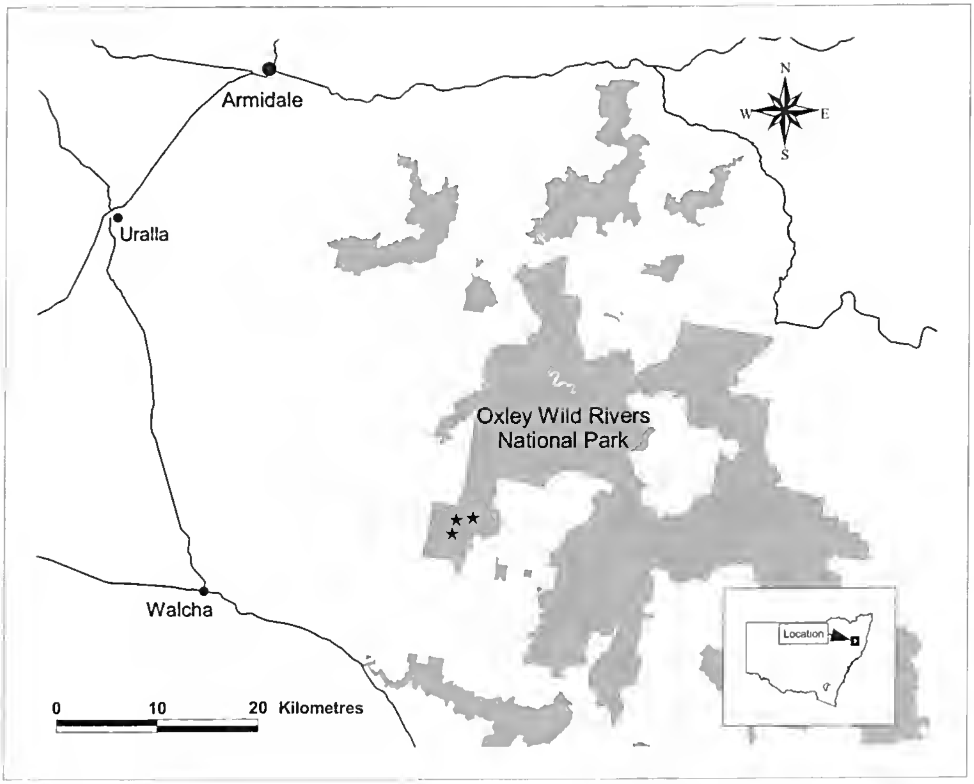

Fig. 2. The distribution of *Pimelea cremnophila* (denoted by ★) in northern New South Wales.

the period 2002–2003, presumably due to the extreme drought conditions endured at the time. Although all known plants are reserved in Oxley Wild Rivers National Park, the species should still be considered endangered due to its highly restricted distribution, small population size and the potential threats. A ROTAP code of 2ECit is recommended following the criteria of Briggs & Leigh (1996).

Etymology: the specific epithet *cremnophila* is derived from the Greek *cremnos* (cliff) and *philos* (loving), in reference to its habitat.

Comparison with similar species: *Pimelea cremnophila* belongs to section *Epallage* (Endl.) Benth. and appears to be most similar to *P. umbratica*. It differs from *P. umbratica* by its longer, denser indumentum, less prominent secondary leaf venation, predominantly axillary inflorescences, and smaller anthers on distinct filaments (Table 1).

Sexuality in sect. *Epallage* requires further study. Threlfall (1983) stated that in *P. umbratica*, male, female and bisexual flowers may occur on the same individual. However, Threlfall included *P. leptospermoides* under *P. umbratica* and did not cite which specimens had been studied for that observation. Rye (1990) claimed *P. umbratica* has bisexual and female flowers. We have observed apparently functionally male (with pistillodes) and functionally female (with staminodes) flowers on the same plant. In *P. cremnophila*, plants appear to be polygamous, with functionally male and bisexual flowers on the same plants and only functionally female on others.

Note that in Harden (1990) the description of *P. umbratica* follows Threlfall (1983) with *P. leptospermoides* (a central Queensland serpentinite endemic) included in the circumscription. The leaves of *P. leptospermoides* are alternate while those of *P. umbratica* are in fact opposite.

Table 1. A comparison of the distinguishing features between *Pimelea cremnophila* and *P. umbratica*.

Character	*P. cremnophila*	*P. umbratica*
Secondary venation	obscure	prominent
Secondary venation angle	25–35°	40–50°
Inflorescence	mostly axillary	mostly terminal
Bisexual flower hypanthium length	4–6.5 mm	5–7.5 mm
Bisexual flower sepal length	3–4 mm	2–2.5 mm
Stamens	filaments present	anthers subsessile
Anther length	1.7 mm	2–2.5 mm
Seed colour	red-brown	black

Acknowledgments

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Rediscovery of *Prostanthera staurophylla* F.Muell. and reinstatement of *P. teretifolia* Maiden & Betche (Lamiaceae)

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Abstract

A population of *Prostanthera staurophylla* was recently rediscovered in the Mt Mackenzie area near Tenterfield on the Northern Tablelands of New South Wales. A detailed morphological comparison of these plants with the previously known population occurring in the Torrington area revealed that the populations were morphologically sufficiently distinct from each other to be recognised as separate species. *Prostanthera teretifolia* is reinstated as a distinct species, separate from *P. staurophylla*. The former species occurs near Torrington, whereas, *P. staurophylla* is restricted to the Mt Mackenzie area near Tenterfield. Descriptions, botanical illustrations and comments on the conservation status of each species are provided.

Introduction

The staff of the Northern Tablelands Region of the New South Wales National Parks and Wildlife Service (Department of Environment and Conservation) have been conducting floristic and vegetation inventories of the reserves within their care since 1997. These surveys have resulted in extensions of ranges for a number of highly restricted species and the discovery of many new taxa (Hunter et al. 1996; Hunter 1997; Hunter 1998; Hunter & Copeland 2001). During a flora survey of Mt Mackenzie Nature Reserve (by one of us – JTH), specimens were collected of a *Prostanthera* growing amongst heath plants within crevices of a single granite outcrop. Although this plant was tentatively identified as *Prostanthera staurophylla* (*sensu lato* — as circumscribed by Conn 1992), an initial comparison of the morphological features of these plants, with those that occur in the Torrington area, suggested that they were distinct.

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The plant collector Charles Stuart originally made collections of *Prostanthera staurophylla* from the Tenterfield area (Northern Tablelands region, NSW) while he was a gardener on a property in that region (Orchard 1999). These collections were sent to Ferdinand von Mueller who described the taxon in *Fragmenta Phytographiae Australiae* (Mueller 1875). However, since Stuart made these original collections, definitive material conspecific with the type has not been recollected. In 1908, based on collections by Richard Cambage in the Torrington area, *Prostanthera teretifolia* was described (Maiden & Betche 1908). Using the herbarium collections available and limited field knowledge, Conn (1992) incorrectly assumed that *P. staurophylla* represented a precociously flowering juvenile growth stage of *P. teretifolia* since the juvenile leaves of this latter species are superficially similar to the adult leaves of *P. staurophylla*. Thus, the two taxa were considered synonymous and combined under *P. staurophylla*, which had nomenclatural precedence (Conn 1992). However, the rediscovery of populations conforming to the type material of *Prostanthera staurophylla* sens. str. has clarified the distinctions between these two taxa and provided evidence that *Prostanthera teretifolia* (*sensu stricto*), occurring near Torrington, should not have been reduced to the synonymy of *P. staurophylla*.

Terminology

The terminology used in this paper follows Conn (1984), with modifications to inflorescence terminology defined in Conn (1995).

Key to species

An excerpt from the Key to species of *Prostanthera* (Conn 1992, p. 647, couplet 27) is amended to incorporate the reinstatement of *P. teretifolia* as distinct from *P. staurophylla*.

27 Branches densely covered with short curled hairs; bracteoles not persistent

  27a Adult leaves grey-green, strongly revolute such that lamina appears subterete, 5–16 mm long; margin entire or deeply 2- or 3-fid, densely covered with sessile glands; branches densely covered with sessile glands; anther appendage absent or minute .... ***P. teretifolia***

  27a* Adult leaves lime- to dark green, oblong or linear, if lobed, then lobes linear, never terete-like, 2–9 mm long, deeply (2–)3(–7)-fid, with scattered glandular hairs adaxially; branches densely covered with podiate glandular hairs; anther appendage present .... ***P. staurophylla***

27* Branches glabrous between nodes or sparsely to densely covered with ± straight, spreading to appressed hairs; bracteoles persistent .... [to couplet 28]

Taxonomy

Prostanthera staurophylla F.Muell., *Fragmenta Phytographiae Australiae* 9: 73 & 74 (1875).

Lectotype (**here designated**): New South Wales: Northern Tablelands: '12 miles SW of Tenterfield', *C. Stuart* (MEL 43669); probable isolectotypes: 'New England', *C. St.* (K); 'Nova Anglia', 'Prostanthera trilobata Fv M ined.', *C. St.*, 1869 (K); 'New England', *C. Stuart* (NSW 134503) (refer 'Typification', below).

Erect to spreading shrub 1–1.8 m high. *Branches* ± terete to sub-quadrangular, densely glandular-pubescent with sub-sessile glands, tubercular hairs throughout, non-glandular hairs multicellular, curled or crisped, 0.5–1.2 mm long, white. *Leaves* lime- to dark green, strongly aromatic (when crushed); *petiole* distinct, 0.6–1.2 mm long; *lamina* elliptic to oblong or more commonly widely trullate or cross-shaped, deeply (1–) 3 (–7)-lobed, 2–9 mm long, 0.9–7 mm wide, discolorous, abaxial surface paler and densely covered with curled or crisped non-glandular hairs, particularly along mid-vein and lateral veins towards lobes where distinct and raised, margin recurved but never revolute; adaxial surface sparsely glandular when young, less dense towards petiole, sparsely scabrous particularly on margins and apices, mid-vein depressed. *Flowers* axillary, solitary. *Podium* 0.7–1.5 mm long, sparsely hairy and glandular. *Prophylls* persistent, inserted below the calyx base (propodium to anthopodium ratio 3–4), elliptic to narrowly ovate, 0.3–0.4 mm long, 0.15–0.25 mm wide, glandular. *Calyx* 3–4 mm long, lime-green, sometimes with a purple-maroon tinge; outer surface sparsely glandular; inner surface glabrous; margin fimbriate with multicellular white hairs 0.2–0.3 mm long; *abaxial lobe* broadly ovate, 1.5–2.5 mm long, 2–2.5 mm wide, apex rounded; adaxial lobe broadly ovate, 1.2–1.6 mm long, apex obtuse to rounded. *Corolla* 15–18 mm long, bluish mauve with darker markings; outer surface glabrous; inner surface sparsely hairy; *tube* 8–10 mm long; abaxial median lobes transversely broad-spathulate, 5–6 mm long, 6–7 mm wide, apex irregular, rounded and bilobed; lateral lobes elliptic, 3–4 mm long, 3–4 mm wide, apex rounded; adaxial median lobe-pair very depressed ovate, 1–2 mm long, 9–10 mm wide. *Stamens* inserted 3–5 mm above base of corolla; filaments 3–6 mm long; anthers 0.8–1.4 mm long, connective extended to form a basal appendage 1–1.4 mm long, terminating in narrowly triangular trichomes. *Pistil* 7.5–9 mm long (Fig. 1).

Selected specimens: New South Wales: Northern Tablelands: Mt Mackenzie Nature Reserve, SW of Tenterfield, *J.T. Hunter 14377–80*, 12 Mar 2001 (all NSW); *loc. cit. J.T. Hunter s.n.*, 01 Nov 2004 (NSW, spirit); *loc. cit. J.B. Williams*, 29 Sep 2004 (NE, NSW).

Notes: the discovery of the Mt Mackenzie population of *P. staurophylla* is the first record of this species (*sensu stricto*) for 130 years. The affinities of *Prostanthera staurophylla* are unclear; however it is expected that it will prove to be closely related to *P. teretifolia* from the Torrington area. This species differs from *P. teretifolia* by its adult leaves being 3–7-lobed, not terete; the lime- to dark green coloured leaves as opposed to grey-green; the presence of a distinct anther appendage (lacking or minute in *P. teretifolia*); and the habit which is taller in mature specimens and usually develops into an erect, sometimes leafless, single stem (*P. teretifolia* is an erect to spreading, multi-branched from base, leafy shrub). Since the leaves of *P. staurophylla* are not terete, the distinctly glandular abaxial leaf surface of this species is visible (abaxial leaf surface not visible in *P. teretifolia*). The flowers of *P. staurophylla* have distinct markings on the inner surface of the corolla, whereas these markings are absent in *P. teretifolia*. These and other useful distinguishing features are summarised in Table 1.

Fig. 1. *Prostanthera staurophylla* F.Muell. **a**, branchlet; **b**, entire leaf (abaxial surface); **c**, 3-lobed leaf (abaxial surface); **d**, detail of nodal area of branchlet and base of leaves; **e**, open flower showing corolla and stamens; **f**, adaxial (upper) stamen, showing dorsal surface of anther, connective and appendage; **g**, adaxial stamen showing ventral surface of anther, and connective appendage extending from behind; **h**, abaxial (lower) stamen showing dorsal surface of anther, connective and appendage; **i**, flower showing dots on corolla tube and stamens (ventral view); **j**, base of calyx, showing prophylls, with one prophyll detached (from *J.T. Hunter s.n.*, 1 Nov 2004, NSW). Scale bar: a=20 mm, b & c=6 mm, d, f, g, h & j=2.4 mm, e & i=10 mm. Illustration by Lesley Elkan.

Etymology: in reference to the cross-shaped leaves, referring to the divided nature of the leaves which in some cases resemble a cross.

Typification: the protologue of this species states 'In rupibus graniticis Novae Angliae inter vicum Tenterfield et flumen Severn; C. St.' (Mueller 1875, p. 73). The label on the single collection of *P. staurophylla* held at MEL (MEL 43669) also refers to 'Granite rocks' and summarises the locality as '12 Miles SW of Tenterfield'. Together with the morphological similarities of these collections to the protologue, this collection is here selected as the lectotype. The MEL collection does not provide the name of the collector(s); however, the label is thought to be handwritten by Charles Stuart, with identification 'Prostanthera staurophylla F.M.' (at the bottom of the label) added at some later time by Ferdinand von Mueller.

The two collections of *P. staurophylla* by Charles Stuart, held at K (as listed above), are here regarded as probable isolectotypes. Both of these collections refer to the collection locality as 'New England' or 'Nova Anglia'. The protologue refers to the locality in the Latin form 'Novae Angliae'. Both of these collections use the abbreviation 'C. St.' for the collector Charles Stuart. This abbreviation is also used in the protologue. The single collection of this species by Charles Stuart from 'New England', on 'Phytologic Museum of Melbourne' label (handwritten at some later date by Ernst Betche) (NSW 134503) is also regarded as a probable syntype. A note added by Nerida Ford (ex NSW; in her own hand) to this latter collection suggests that it is 'possibly a para-type'. However, since Mueller did not specifically designate a holotype, this collection should more correctly be regarded as a probable syntype (according to Article 9.5, Greuter et al. 2000). She also added that the 'Type locality was New England, from the vicinity of Tenterfield to the Severn River' but this information is merely a reference to the Protologue (Mueller 1875). All three collections morphologically correspond with the description provided in the protologue. The NSW collection and the two specimens held at K are here regarded as probable isolectotypes.

Distribution: scattered plants within a single diffuse population of *Prostanthera staurophylla* were found at Mt Mackenzie Nature Reserve, Northern Tablelands, New South Wales (Fig. 3).

Habitat: *Prostanthera staurophylla* grows in open and exposed situations within crevices of a granitic outcrop at an elevation of 1200 m above sea level. This species is a co-dominant with *Kunzea opposita* F.Muell. and *Leptospermum novae-angliae* Joy Thomps., with an understorey dominated by *Leucopogon neoanglicus* F.Muell. ex Benth., *Lomandra longifolia* Labill., *Lomandra filiformis* (Thunb.) Britten, *Gahnia aspera* (R.Br.) Spreng., *Themeda triandra* Forssk. and *Brachyscome stuartii* Benth.

Conservation status: *Prostanthera staurophylla* has a very restricted occurrence being only known from the Mt Mackenzie Nature Reserve. The population size is estimated to be less than 500 individuals, occurring in an area of about 200 metres long and 80 metres wide. Although fire is unlikely to have occurred in this area for over 30 years; many seedlings were noted underneath mature stands. This suggests that germination is occurring naturally without the stimulus of fire, which is typical of plants endemic to granitic outcrops (Hunter 2003). This species should be considered as endangered and warrants listing as threatened in the schedules of the *New South Wales Threatened Species Conservation Act 1995* (TSC 1995, TSC 2002, TSC 2004), the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC 1999), and as Critically Endangered (CR B1a + B2a) in the *IUCN Red List of Theatened Species* (Baillie et al. 2004).

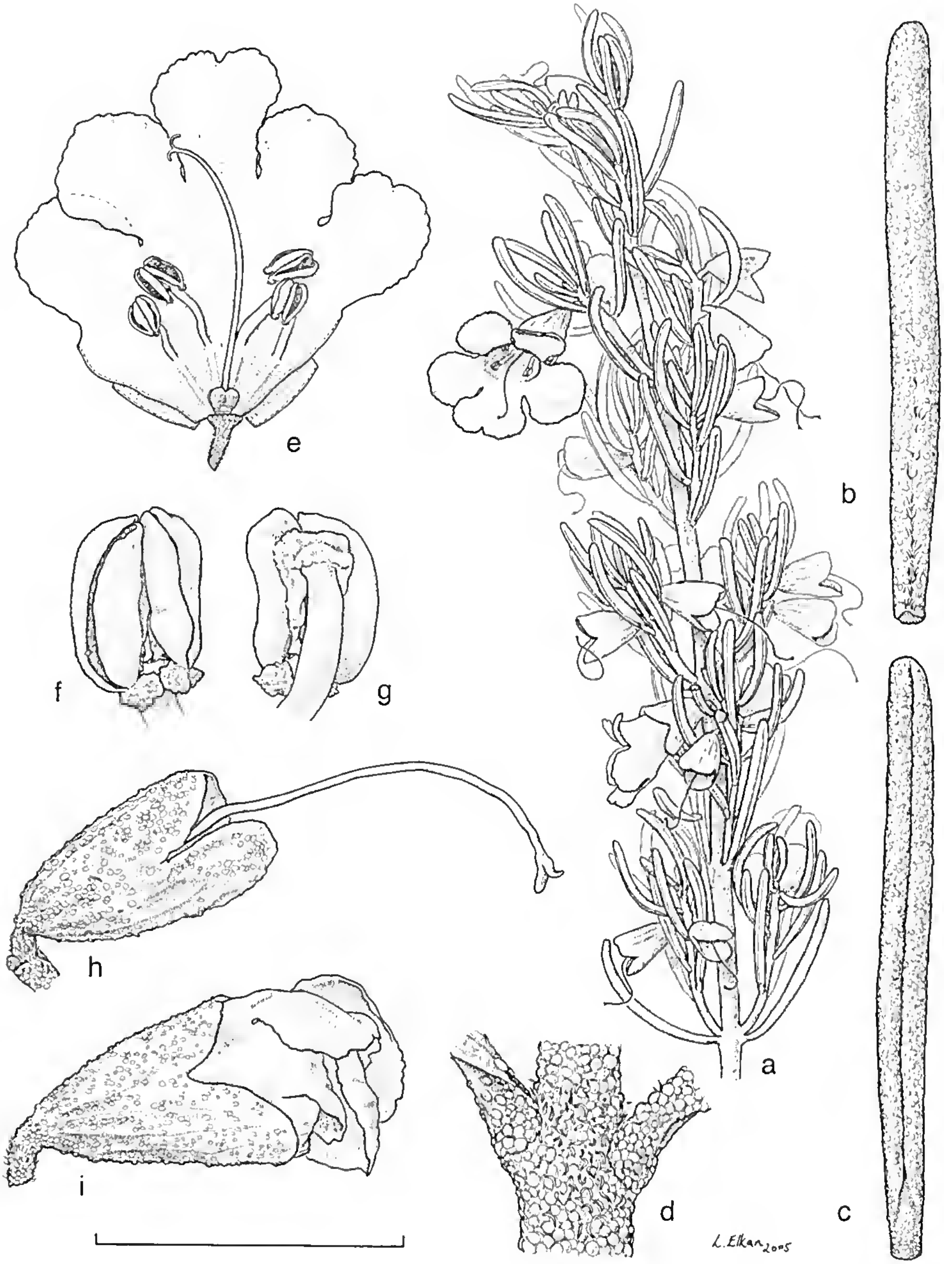

Fig. 2. *Prostanthera teretifolia* Maiden & Betche **a**, branchlet; **b**, leaf showing adaxial surface; c, leaf showing abaxial surface; **d**, detail of nodal area of branchlet and base of leaves; **e**, open flower showing corolla, stamens and gyneocium; **f**, stamen, showing ventral surface of anthers, locular appendages and minute connective appendage (visible between locules of anther); **g**, stamen showing dorsal surface of anthers, locular appendages and connective; **h**, fruiting calyx and persistent style and stigma (lateral view); **i**, flower bud (lateral view) (from *Cambage s.n.*, 29 Sep 1907, NSW 134430). Scale bar: a=20 mm, b, c, h & i=6 mm, d, f & g=2.4 mm, e=10 mm. Illustration by Lesley Elkan.

Prostanthera teretifolia Maiden & Betche, *Proc. Linn. Soc. New South Wales* 33: 313 & 314 (1908).

Holotype: New South Wales: Northern Tablelands: Torrington, *R.H. Cambage s.n.*, 29 Sep 1907 (NSW 134430).

Erect to spreading shrub 0.3–1 m high, multi-branched from near base; *branches* quadrangular, tending to become sub-terete, very densely glandular with sub-sessile, semi-hemispherical glands, densely with multicellular curled (eglandular) hairs (hairs 0.1–0.3 mm long) (refer details in 'Notes' below). *Leaves* grey-green, strongly aromatic (when crushed); *petiole* distinct or indistinct, 0.6–1.8 mm long; *lamina* dimorphic; *juvenile lamina*, rarely present, entire to deeply 3-lobed, 5–10 mm long, 1–9 mm wide. *Adult lamina* linear, subterete (refer details in 'Notes' below), entire or 2- or 3-lobed, 5–16 mm long; 0.5–0.9 mm wide, abaxial and adaxial surfaces densely glandular with sub-sessile, semi-hemispherical glands and with occasional crisped hairs (particularly on younger leaves). *Inflorescence* racemiform on leafy branches; uniflorescence monadic with flowers occurring singly in the axils of leaves. *Podium* 0.6–0.9 mm long, densely hairy and glandular. *Prophylls* not seen, soon deciduous, inserted near midpoint of podium (propodium to anthopodium ratio c. 1.3). *Calyx* 4–5 mm long, green, adaxial surface often purplish and/or with a purple-maroon tinge; outer surface densely glandular with sub-sessile, semi-hemispherical glands, sometimes with a few scattered hairs; inner surface glabrous; *lobes* depressed-ovate; *abaxial lobe* 1.5–2 mm long, apex obtuse to rounded; adaxial lobe 1–1.2 mm long (shorter than abaxial lobe), apex almost truncate. *Corolla* 8–9 mm long, bluish purple, violet or white; outer and inner surface glabrous; tube 4.5–5 mm long; abaxial median lobes broadly spathulate, c. 4 mm long, 4–4.4 mm wide, apex slightly irregular, rounded, shortly bilobed; lateral lobes elliptic, 3–4 mm long, 3–4 mm wide, apex rounded; adaxial median lobe-pair very depressed ovate, 2.2–3 mm long, 6.5–8 mm wide. *Stamens* inserted 2.2–2.5 mm above base of corolla; filaments 1.2–2.5 mm long; anthers 0.8–1.3 mm long, with base of lobes extended to form a locular appendage 0.2–0.3 mm long; connective extending to form an indistinct, minute appendage (up to 0.2 mm long) or appendage absent. Pistil c. 6 mm long (Fig. 2).

Selected specimens: New South Wales: Northern Tablelands: Torrington, *J.L. Boorman s.n.*, Jan 1911 (BM, K, NSW); *J.B. Williams s.n.*, 20 Nov 1965 (NSW); *J.B. Williams s.n.*, 29 September 2004 (NE, NSW); c. 1 km N of Torrington township, *A.J. Whalen 109 & R.G. Coveny*, 18 Oct 1993 (BRI, MEL, NSW); 4 miles NW of Torrington, *H. Wissman s.n.*, Apr 1967 (NSW). North Western Slopes: Eastern Binghi, N of Torrington, *J. Benson s.n.*, 3 Aug 1991 (NSW).

Etymology: in reference to the 'terete' (subterete) and linear foliage. The vernacular name for this species has been once recorded as 'Turpentine bush' (*J.B. Williams s.n.*, NSW 134377).

Typification: the protologue (Maiden & Betche 1908) cites the habitat as 'in glabris saxosis graniticis'. This is in agreement with the notes (in Cambage's hand) on the holotype (lower left of herbarium sheet) that describes the plant as growing 'On bare acid granite rocks'. The handwritten label (lower right) cites the locality as 'Torrington n[ea]r Deepwater'; however, this additional information is not supported by the protologue.

Distribution: found commonly on rocky granite outcrops within the Torrington area of New South Wales (Fig. 3).

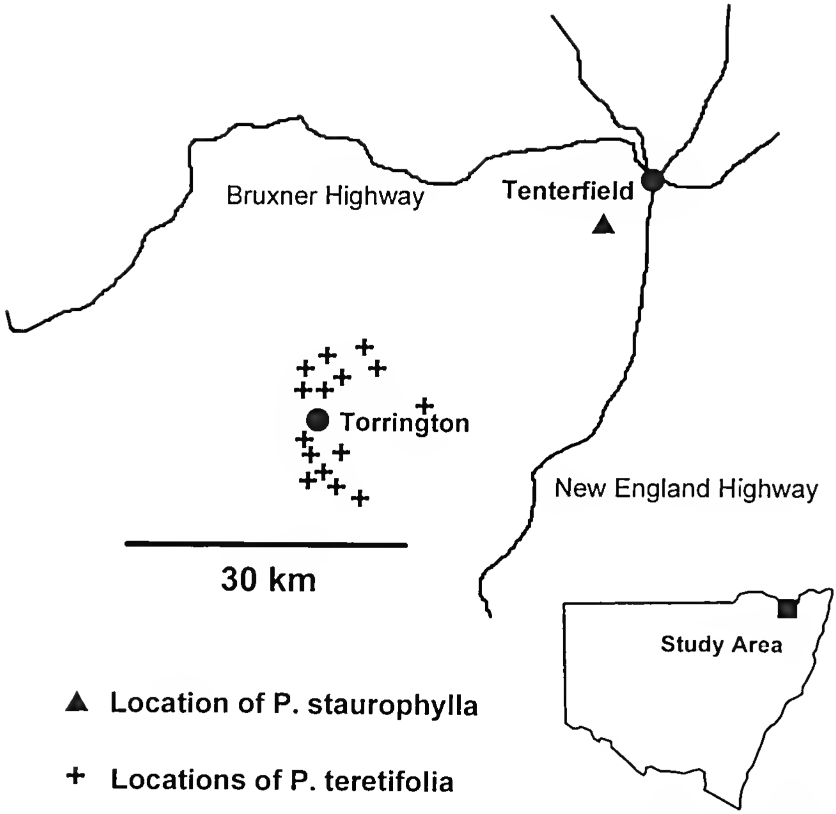

Fig. 3. Distribution map of *Prostanthera staurophylla* (▲) and *P. teretifolia* (+), Northern Tablelands region of New South Wales, Australia

Table 1. Diagnostic characters separating *Prostanthera staurophylla* from *P. teretifolia*.

Feature	***P. staurophylla***	***P. teretifolia***
Leaves dimorphic	No	Yes
Adult lamina margin	Recurved	Revolute (lamina subterete)
Adult lamina length	2–9 mm	5–15 mm
Lamina adaxially densely glandular	No	Yes
Adult lamina non-glandular indumentum	Stiff & scabrid	Weak & crisped
Adult lamina abaxial surface visibility	Visible	Obscured
Adult lamina lobes	0 or (2–)3(–7)	0 or 2–3
Leaf colour	Lime- to dark green	Grey-green
Stems branching	Intricate & very densely branched	Loosely branched
Corolla inner surface markings	Present	Absent
Corolla length	15–18 mm long	8–9 mm long
Anther appendage	1–1.4 mm long, with triangular trichomes	Absent or minute

Habitat: *Prostanthera teretifolia* is also a species endemic to granite outcrops. It is found in open and exposed situations within crevices in heathlands and shrublands from elevations of 800-1200 m above sea level (Fig. 3). It is commonly associated with *Leucopogon neoanglicus* F.Muell. ex Benth., *Kunzea bracteolata* Maiden & Betche, *Leptospermum novaeangliae* Joy Thomps., *Leucopogon melaleucoides* A.Cunn. ex DC., *Acacia viscidula* Benth., *Brachyloma saxicola* J.T.Hunter and *Micromyrtus sessilis* J.W.Green.

Notes: the curled hairs of the branchlets are especially common at the nodes and in two narrow zones on the internodes, with each zone on opposite 'sides' of the branchlets, extending from the leaf axil region to the next more distal nodal region between the opposite leaf bases.

The lamina of the leaves is not truly terete, but rather, the strongly revolute margin obscures the abaxial lamina surface, including the mid-vein, such that the lamina appears subterete.

Conservation status: *Prostanthera teretifolia* is restricted to the Torrington area. However, it is very common within the granite landscapes and has been described as a dominant species epitomizing shrublands of granitic outcrop communities of the New England Batholith (Hunter & Clarke 1998). Thousands of plants exist with many of these occurring within the Torrington State Conservation Area under the protection of the New South Wales National Parks Service. Currently the species is listed under the ROTAP (Briggs & Leigh 1996) code of 2RC-. This schedule should be changed slightly based on current information as the conservation status is considered adequate (2RCa).

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New combinations in Australasian *Zostera* (Zosteraceae)

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Abstract

The new combinations ***Zostera muelleri*** subsp. ***capricorni*** (Ascherson) S.W.L.Jacobs, ***Z. muelleri*** subsp. ***mucronata*** (Hartog) S.W.L.Jacobs and ***Z. muelleri*** subsp. ***novazelandica*** (Setchell) S.W.L.Jacobs are provided for species recently recommended to be treated as a single species.

Introduction

Les et al. (2002) provided ITS, *trnK* and *rbcL* sequences of numerous samples of the family Zosteraceae, concentrating on the Australasian taxa. These were supported by a cladogram derived from morphological data. All results indicated that:

(i) there was no support for retaining *Heterozostera* as a distinct genus unless subgenus *Zosterella* (which contains all of the other Australasian *Zostera* taxa) was raised to genus level (Tomlinson & Pozluszny 2001); and

(ii) there was no support for maintaining the species *Zostera capricorni, Z. muelleri, Z. mucronata* and *Z. novazelandica* and that these could not be reliably and consistently distinguished from each other. The recommendation was that they be treated as one species, *Z. capricorni* (though *Z. muelleri* has priority and is the name that should have been recommended).

Neither conclusion is novel (Phillips & Meñez 1988). Les et al. (2002) present the most detailed analysis of characters and the most recent review. The results provide no support for the solution suggested by Tomlinson & Pozluszny (2001) and suggest some sorting of specimens on a geographical basis. While some of these loose groups have morphological markers, they do not all have useful markers. Those markers that are discernible are not completely reliable and there is some breakdown between them, especially where two groups overlap. Nonetheless experienced practitioners can and do make distinctions most of the time, except for the indicated molecular differences within *Z. muelleri s. str.* In response to those results (Les et al. 2002) and to reduce

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the probability of losing valuable field information, we here recognise the four taxa as subspecies of *Z. muelleri*, the earliest available name for the group. Subspecies is an appropriate level of recognition as the taxa are sorted geographically and there is a considerable (?uncomfortable) degree of character overlap between them.

Zostera muelleri Irmisch ex Asch., *Linnaea* 35: 168 (1867)

Type (fide Hartog 1970:90): "Melbourne, at the mouth of the river Yarra, "Australia Felix", fl., November 1852, *F. von Mueller* (Type, MEL, P)".

Zostera muelleri subsp. ***muelleri***

Zostera muelleri subsp. ***capricorni*** (Asch.) S.W.L.Jacobs, ***comb. et stat. nov.***

Basionym: *Zostera capricorni* Ascherson, *Sitzungsber. Ges. Naturf. Freunde Berlin*: 11 (1876)

Type (fide Hartog 1970:85): "Moreton Bay, 10-10-1875, *Naumann* (Type, UC)".

Zostera muelleri subsp. ***mucronata*** (Hartog) S.W.L.Jacobs, ***comb. et stat. nov.***

Basionym: *Zostera mucronata* Hartog, *Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk. Tweede Reeks* 59 (1): 91-92 (1970)

Type citation: "Mandurah [W.A., small bay near the bridge], in sandy estuary, 16-8-1950, *G.G. Smith 274*" (holo L; iso PERTH-U!).

Zostera muelleri subsp. ***novazelandica*** (Setch.) S.W.L.Jacobs ***comb. et stat. nov.***

Basionym: *Zostera novazelandica* Setchell (1933: 816).

Type citation: "Bluff, [lower littoral zone,] N.Z., *W.A. Setchell*, Mar 11 1927 Herb U Calf 313091" (holo UC).

A discussion of lectotypes is currently in press with *Flora of Australia* (John Kuo pers. comm.).

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Two new species of *Aponogeton* (Aponogetonaceae), and a key to species from Australia

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Abstract

Two new species, ***Aponogeton cuneatus*** (removed from *A. elongatus*) and ***Aponogeton tofus*** (removed from *A. euryspermus*) are described from Australia. A key is provided for all native and naturalised *Aponogeton* species in Australia, and new descriptions are provided for *A. elongatus* and *A. euryspermus.*

Introduction

Hellquist and Jacobs (1998) revised the Australian species of *Aponogeton*, describing six new taxa. Even though there had been a substantial increase in the number of specimens available for examination since Bruggen's (1969) pioneering work, our paper stimulated further collecting and further good quality specimens have become available. While collecting DNA samples for a phylogenetic study of the family (Les et al. 2005) we observed some material that indicated to us the possibility that there may be at least one additional new species. The results of the analyses in Les et al. (2005) clearly demonstrate that there actually are two new species, one (identified previously as *A. elongatus*) that molecular data resolved as a distinct sister species to *A. queenslandicus*, and another (identified previously as *A. euryspermus*) that resolved as a distinct sister species to the *A. euryspermus*/*A. kimberleyensis* clade. Examination of morphological characters has confirmed their status by demonstrating that these species are not only well-defined by their degree of molecular divergence but also are distinctive morphologically. The two new species of *Aponogeton* are described here, with modified descriptions of the species in which they were formerly included also provided, along with a key to all Australian species.

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Key to native and naturalised species of Aponogeton in Australia

1. Proliferous offshoots formed at tip of peduncle; plants rarely flowering. .... ***A. proliferus***
1* Proliferous offshoots not formed on plants; plants regularly flowering. 2

2. Inflorescence branched with two spikes. 3
2* Inflorescence unbranched with one spike. 5

3. Flowers white (rarely pink); tepals 1, with 13 or more veins. .... ****A. distachyos***
3* Flowers yellow, yellow-green, or green; tepals 2–6, 1-veined. 4

4. Tepals 6; seeds (2.6–)5.1–6.2(–7.0) mm long; leaves all floating. .... ***A. hexatepalus***
4* Tepals 2; seeds 2.1–3.2 mm long; leaves all submersed. .... ***A. lancesmithii***

5. Leaves all submersed, slightly to strongly bullate. 6
5* Leaves submersed and/or floating, not bullate. 7

6. Spathe persistent, to 2.5 cm long; inflorescence to 5.5 cm long; peduncle about same diameter as inflorescence rachis. .... ***A. bullosus***
6* Spathe caducous, to 1.5 cm long; inflorescence to 34 cm long; peduncle much broader than inflorescence rachis. .... ***A. lancesmithii***

7. Plants mainly producing floating leaves; floating leaves mostly cordate at base; seeds with obvious double testa. .... ***A. queenslandicus***
7* Plants mainly producing submersed leaves or submersed and floating leaves; floating leaves mostly obtuse, some cuneate or truncate at base; seeds with a single testa or, if double, the second seed coat closely adhering and difficult to detect. 8

8. Submersed leaves narrow, 0.9–3 mm wide; seeds 0.7–1.4 mm long. ...... ***A. kimberleyensis***
8* Submersed leaves broad, 5–60 mm wide; seeds 1.2–4.9 mm long. 9

9. Fruit oval and thick-coated; seed coat closely adhering to embryo and difficult to detect, or tightly-fitting and very thin; floating leaves rarely formed. 10
9* Fruit elliptic and papery; seeds with a loose outer coat, easily separated from embryo; floating leaves commonly formed. 11

10. Perianth segments spathulate; south of the Tropic. .... ***A. elongatus***
10* Perianth segments cuneate; north of the Tropic. .... ***A. cuneatus***

11. Seeds with a distinct knob at one end, cylindrical to narrowly elliptic, 0.7–1.6 mm wide. .... ***A. vanbruggenii***
11* Seeds without a knob at one end, broadly elliptic to almost cylindrical, nearly oval, (1.1–)1.5–2.8 mm wide. 12

12. Seeds broadly elliptic, 2–2.8 mm wide; Kimberley Region. .... ***A. euryspermus***
12* Seeds almost cylindrical to narrow elliptical, 1.5–2 mm wide; eastern Northern Territory. .... ***A. tofus***

* = introduced species

Aponogeton cuneatus **S.W.L.Jacobs *sp. nov.***

A. elongato similis sed segmentis perianthii cuneatis, distributione geographica tropica differt.

Holotype. Queensland: Mowbray River, S of Port Douglas, 16° 33.844'S 145° 22.596'E, *S.W.L. Jacobs 9319 & C.B. Hellquist*, 15 Apr 2005 (NSW). Isotypes: BRI, NASC.

Submersed aquatic perennial. Tuber ovate to elongate, to 4 cm long, 1.5 cm wide. Leaves submersed and rarely floating; submersed blades narrow to broadly-elliptic to elongate, 10–50 cm long, 2–5 cm wide, green or dark green to maroon-green; margins sometimes slightly undulate; base tapering gradually into petiole, sometimes asymmetrical; apex blunt-cuneate or obtuse; 5–9-veined; 0–2(–4) rows of lacunae on each side of the midrib; petiole to 30 cm long. Floating leaves not seen. Peduncle to c. 90 cm long, 2–4 mm wide at base broadening to 5–6 mm wide at base of inflorescence. Spathe to 1.5 cm long, caducous. Inflorescence yellow, emergent or floating, single, tightly-flowered or spaced along the rachis; rachis 1.1–3.1 mm wide. Flowers turned in all directions. Perianth segments 2, cuneate, 1-veined, yellow, 1–1.4 mm long, 1.4–2 mm wide. Stamens 6; anthers 0.3–0.4 mm long, 0.3–0.6 mm wide; filaments 0.8–1.7(–2.7) mm long, broader at base. Carpels (2–)3(–6). Fruit rounded, thick-coated, 2.5–5.8 mm long, 1.8–5.0 mm wide; beak mostly lateral, occasionally terminal, to 1.5 mm long. Seeds 2–5 per fruit, 1.2–3.2(–4.2) mm long, 0.5–1.1(–1.6) mm wide, elliptic, with a single testa, closely adhering to embryo or very thin.

Distribution: coastal Queensland north of the tropic.

Selected specimens examined: Queensland: Portland Roads Road between Tozers Gap and the Middle Claudie Crossing, *Clarkson 2923*, 25 Feb 1980 (DNA, MEL); McIvor R., N of Hopevale–Cooktown rd, *Jacobs 8195, Hellquist & Wiersma*, 1 Aug 1997 (NSW, BRI, NASC); Stone Creek, nr Innisfail, *Jacobs 8571 & Les*, 18 Oct 1999 (NSW, CONN).

Notes: permanent creeks and rivers, often shaded.

This species is named for the cuneate perianth segments characteristic of the species.

A. cuneatus is superficially similar to *A. elongatus*, but presents a gestalt that always made us suspect that it was a different taxon. No clear distinction could be made with seed characters so it was retained in *A. elongatus*. The use of comparative DNA sequence data (Les et al. 2005) indicated that, despite its superficial resemblance, *A. cuneatus* is quite distantly related to *A. elongatus* and actually most closely related to *A. queenslandicus*. Subsequently, better spirit collections have allowed us to see that a conspicuous difference exists in the shape of the perianth segments, with *A. cuneatus* having cuneate tepals (perianth segments) and *A. elongatus* having spathulate tepals.

Aponogeton tofus S.W.L.Jacobs ***sp. nov.***

Aponogeton elongatus forma *strigosus* H. Bruggen (1969: 133). **syn. nov.**
Holotype. Northern Territory: Edith Falls Road, c. 3 miles [5 km] E of Stuart Highway, *L.G. Adams 1658* (L). Isotype NSW.

A. euryspermo et A. vanbruggenii similis,sed ab A. euryspermo seminibus angustioribus cylindricis differt: ab A. vanbruggenii seminibus extremo etoruloso differt.

Holotype. Northern Territory: Cultivated by Dave Wilson, Howard Springs, 12° 30.982'S 131° 03.239'E, *S. Jacobs 9258*, 13 Mar 2005, originally from 100 m downstream (S side) of the crossing of the Bulman to Gove rd over the Goyder River, 13° 01.68'S 134° 58.6'E (NSW).

Rooted, submersed perennial aquatic. Tuber ovate-elongate, 1–3 cm long, 1–2 cm wide. Leaves mostly submersed, sometimes floating. Submersed blades linear, linear-lanceolate, ovate, or elliptic, to 23(–35) cm long, (0.5–)1.4–2.5(–6) cm wide; margins flat or slightly undulate; base narrowly to broadly cuneate, obtuse or attenuate; apex obtuse, broadly obtuse, blunt-cuneate to acute-cuneate, truncate, or rarely retuse; (3–)7–9(–11)-veined; 1–5 rows of lacunae on each side of midvein; petiole to 23(–50) cm long. Floating leaves ovate or elliptic, to 11 cm long, green to maroon-green; margins flat; base cuneate, obtuse or attenuate; apex obtuse; midrib with 2–4 parallel veins on both sides; petiole to 64 cm long. Peduncle to 29(–107) cm long, 0.6–1.8 mm wide at base broadening to (7–)22–48 mm wide at base of infloresence. Spathe to 1.5 cm long, caducous. Inflorescence yellow, emergent or floating, single, rarely branched, to c. 17 cm long, tightly flowered or spread out along rachis; rachis 0.9–3 mm wide. Flowers turned in all directions. Perianth segments 2, spathulate, 1-veined, yellow, c. 1.5 mm long, 0.7–1.5 mm wide. Stamens 6; anthers c. 0.2–0.5 mm long, 0.4–0.5 mm wide; filaments 1.2–2.1 mm, broader at base. Carpels (2–)3. Infructescence moderately dense. Fruit 4–6 mm long, 3.3–4 mm wide, beak to 1 mm long, lateral, reflexed or straight. Seeds cylindrical, almost ovoid, 2–5 per fruit, usually 1 per small fruit, 3.5–4.5 mm long, (1.1–)1.5–2 mm wide, thick outer testa easily removed, a second, if present, tightly adhering and difficult to remove.

Distribution: northern portion of the Northern Territory and Arnhem Land.

Selected specimens examined: Northern Territory: Edith Falls rd, c. 3 miles [5 km] E of Stuart Hwy, *Adams 1658* 11 Dec 1966 (NSW); c. 7 km NE Katherine on the Katherine River, *Jacobs 3810* 3 May 1980 (NSW); Cultivated by L. Smith, Kelso, Qld, *Jacobs 8268 & Hellquist*, 18 Aug 1997, originally from the Northern Territory (NSW).

The following specimens were identified as *A. euryspermus* in Hellquist and Jacobs (1998) and almost certainly belong here, but the specimens have not been reannotated. Arnhem Land, Mt Gilruth area, 13° 03′S, 133° 01′E, *Henshall 1869*, 6 Jun 1978 (DNA, MEL); lagoon at Jabiru, 12° 40′S, 132° 53′E, *Craven 2277*, 17 Feb 1973 (DNA, MEL); Kakadu Nat. Park, 13° 32′S, 132° 29′ *Russell-Smith 8559*, 7 Jan 1992 (DNA).

Notes: grows in freshwater streams, rivers and lagoons, usually in or near sandstone country, especially the Arnhem Land Plateau. Flowering and fruiting December to February and May to July.

This species is named for the sandstone of the Arnhem Land Plateau area where most of the specimens have been collected. 'Tofus' is literally translated as 'tufa', which in modern usage is applied to a relatively porous or spongy rock composed of chemically or biologically precipitated $CaCO_3$. In older usage, and Latin, 'tufa' (or tofus) was used for a sedimentary rock deposited in layers, a definition including sandstone.

Many specimens of *Aponogeton* from the tropics originally were assigned to *A. elongatus* by Bruggen (1985) and others but can now be assigned to *A. euryspermus*, *A. vanbruggenii* or *A. tofus*. These taxa initially produce submerged leaves in flowing or clear water but later in the year plants often develop floating leaves. Species in this group can be separated by their seed shape and size; *A. euryspermus* has large broad seeds that can become very thick when mature, *A. tofus* has narrower almost cylindrical seeds, while *A. vanbruggenii* has even narrower seeds with a distinct knob at one end. All have seeds with an outer testa that is easily removed (thick in *A. euryspermus* and *A. tofus* – thin in *A. vanbruggenii*). All species are confined to the tropics with *A. euryspermus* more westerly in its distribution, *A. vanbruggenii* more easterly and *A. tofus* growing between the two but overlapping with *A. vanbruggenii*. DNA sequence data (Les et al. 2005) indicate that indeed, *A. tofus* is closely related to *A. euryspermus* (as it had been previously identified); however, it is distinct and quite divergent at the molecular level from that and other species.

Aponogeton elongatus F.Muell. ex Benth., Fl. Austr. 7: 188 (1878)

Submersed aquatic perennial. Tuber ovate to elongate, to 4 cm long, 1.5 cm wide. Leaves submersed and rarely floating (except for subsp. *fluitans*); submersed blades narrow to broadly-elliptic to elongate, 7–34(–42) cm long, 0.8–3.7(–6.7) cm wide, green or dark green to maroon-green; margins slightly undulate to undulate; base tapering gradually into petiole, broadly cuneate, obtuse, or rarely truncate, sometimes slightly asymmetrical; apex blunt-cuneate or obtuse; (5–)7–9(–11)-veined; 0–2(–4) rows of lacunae on each side of the midrib; petiole to 17(–35) cm long. Floating leaves not commonly formed, narrowly elliptic to slightly obovate, 9–19 cm long, 2.2–3.5 cm wide; base obtuse, broadly cuneate, cordate, or truncate; apex obtuse; 7–9-veined; petiole to 60(–90) cm long. Peduncle to c. 90 cm long, 6–8 mm wide at base broadening to 5–8 mm wide at base of inflorescence. Spathe to 1.5 cm long, caducous. Inflorescence yellow, emergent or floating, single, tightly-flowered or spaced along the rachis; rachis 1.1–3.1 mm wide. Flowers turned in all directions. Perianth segments 2, spathulate, 1-veined, yellow, 1.8–2.5 mm long, 0.7–1.3 mm wide. Stamens 6; anthers 0.3–0.4 mm long, 0.3–0.6 mm wide; filaments 0.8–1.7(–2.7) mm long, broader at base. Carpels (2–)3(–6). Fruit rounded, thick-coated, 2.5–5.8 mm long, 1.8–5.0 mm wide; beak mostly lateral, occasionally terminal, to 1.5 mm long. Seeds 2–5 per fruit, 1.2–3.2(–4.2) mm long, 0.5–1.1(–1.6) mm wide, elliptic, with a single testa, closely adhering to embryo or very thin.

Distribution: coastal Queensland south of the Tropic and coastal northeastern New South Wales.

1. Plants rarely or never producing floating leaves .... 10a. subsp. *elongatus*

1* Plants commonly producing floating leaves .... 10b. subsp. *fluitans*

Aponogeton euryspermus Hellq. & S.W.L.Jacobs, Telopea 8: 16 (1998)

Rooted, submersed perennial aquatic. Tuber ovate-elongate, to 1–3 cm long, 1–2 cm wide. Leaves submersed and/or floating. Submersed blades linear, linear-lanceolate, ovate, or elliptic, to 23(–35) cm long, (0.5–)1.4–2.5(–6) cm wide; margins flat or slightly undulate; base narrowly to broadly cuneate, obtuse, or attenuate; apex obtuse, broadly obtuse, blunt-cuneate to acute-cuneate, truncate, or rarely retuse; (3–)7–9(–11)-veined; 1–5 rows of lacunae on each side of midvein; petiole to 23(–50) cm long. Floating leaves ovate or elliptic, to 11 cm long, green to maroon-green; margins flat; base cuneate, obtuse, or attenuate; apex obtuse; midrib with 2–4 parallel veins on both sides; petiole to 64 cm long. Peduncle to 29(–107) cm long, 0.6–1.8 mm wide at base broadening to (7–)22–48 mm wide at base of inflorescence. Spathe to 1.5 cm long, caducous. Inflorescence yellow, emergent or floating, single, rarely branched, to c. 17 cm long, tightly flowered or spread out along rachis; rachis 0.9–3 mm wide. Flowers turned in all directions. Perianth segments 2, spathulate, 1-veined, yellow, 1.1–2 mm long, 0.7–1.5 mm wide. Stamens 6; anthers c. 0.2–0.5 mm long, 0.4–0.5 mm wide; filaments 1.2–2.1 mm, broader at base. Carpels (2–)3. Infructescence moderately dense. Fruit 3–6.2 mm long, 2.4–5 mm wide, beak to 1 mm long, terminal or lateral, reflexed or straight. Seeds broadly elliptic, almost ovoid,1–3(–4) per fruit, usually 1 per small fruit, 3.2–4.4 mm long, (1.1–)2–2.8 mm wide, thick outer testa easily removed, a second, if present, tightly adhering and difficult to remove.

Distribution: the Kimberley Region of Western Australia.

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Teucrium thieleanum (Labiatae), a new species from Victoria, Australia

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Abstract

Teucrium thieleanum is an erect subshrub that is moderately to densely glandular hairy, with simple, multicellular podiate glands, subsessile hemispherical glands, as well as long and short eglandular hairs, ovate to broadly ovate leaves with crenate to lacerated margin. This paper provides a full description of ***Teucrium thieleanum***, habitat notes, botanical illustration, and a key to distinguish this species from other named *Teucrium* species in Victoria.

Introduction

This species is only known from two localities in East Gippsland, Victoria (Australia). The earliest collection being by Neville Walsh and David Albrecht, gathered in 1988 from the Marble Gully area, with later collections by Kevin Thiele, gathered in November 2004 and January 2005, both from Little River Gorge. With the description of this new species, in this paper, there are now five known species of *Teucrium* occurring in Victoria.

Terminology follows Conn (1984). Inflorescence terminology follows Briggs and Johnson (1979), except for modifications by Conn (1995).

Teucrium thieleanum B.J.Conn, ***sp. nov.***

T. corymboso foliis latioribus (24–45 mm), margine crenato vel lacerato, prophyllis latioribus (0.6–0.8 mm), indumento glandifero longo subsessilique (vice subsessili modo) differt.

Type: Victoria: East Gippsland: Little River Gorge above 'BBC Camp', *K.R. Thiele 2992*, 24 Nov. 2004 (holo NSW 677435; iso MEL 2264890).

Erect subshrub 1–1.5 m high, branches above the base (*Thiele 2992*). *Branches* ± quadrangular, slightly ridged on angles, densely hairy; hairs simple, straight to slightly curved, multicellular, glandular, ± spreading (patent to slightly antrorse or retrorse); internodes with short and long hairs, short hairs 0.1–0.2 mm long, translucent throughout or with gland white to pale golden-coloured, long hairs 0.5–0.9 mm long; nodes with longer spreading hairs 1–1.5 mm long, moderately glandular with hemispherical, subsessile glands. *Leaves* aromatic, with petiole 7–8 mm long; *lamina* ovate to broadly ovate, less frequently elliptic, greyish green, 40–50 mm long, 24–45 mm wide, with length 1–1.7 times width, distance from base of maximum width 0.3–0.5 times total lamina length;

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abaxial surface sparsely glandular hairy (average density 8–10 hairs per mm^2), hairs ± patent, c. 0.1 mm long, with longer hairs on veins and margin (hairs 0.2–0.4 mm long), very densely covered with subsessile glands (as per branches); adaxial surface moderately glandular hairy (average density c. 12 hairs per mm^2), hairs ± patent, 0.8–1.3 mm long, densely covered with subsessile glands (as for branches); base decurrent; margin crenate to lacerate, slightly recurved, with apex of teeth rounded to subacute (when lacerate); apex subacute; venation distinct, midvein and secondary veins slightly raised on abaxial surface. *Inflorescence* frondose-bracteose, many-flowered; uniflorescence dichasial, (5–)7–15-flowered (7-flowered distally). *Podium* 2–5.5(–7) mm long, densely hairy (as for branches), hairs 0.1–0.3 mm long. *Prophylls* ± persistent, inserted near middle of podium (propodium 2–3 mm long; anthopodium 1.8–2 mm long, with propodium 1–1.5 times length of anthopodium), opposite to subopposite; lamina narrowly triangular, 1–1.5 mm long, 0.6–0.8 mm wide, slightly concave lengthwise to almost flat, densely hairy with short hairs (as for branches). *Calyx* dull green, campanulate; outer surface densely hairy with short hairs (as for branches), midveins prominent, ridged, with slightly longer glandular hairs; *tube* 1–1.5 mm long, inner surface glabrous; *lobes* equal, narrowly triangular, c. 2 mm long, 0.8–1 mm wide at base, with length 2–2.5 times width, inner surface sparsely hairy (hairs as for branches), apex subacute. *Corolla* 6–7.5 mm long, white; outer surface of lobes moderately hairy, eglandular hairs 0.1–0.2 mm long, translucent to white, simple, multicellular, spreading to antrorse, sparsely to moderately glandular with subsessile hemispherical glands; inner surface sparsely hairy in tube, with hairs simple, spreading, c. 0.1 mm long; *tube* 1.5–2 mm long; *lobes* glabrous, or with an occasional eglandular hair, inconspicuously glandular with minute, subsessile hemispherical glands; *abaxial median lobe* spathulate, slightly involute-conduplicate, 3–3.6 mm long, 2–2.5 mm long, with length c. 1.5 times width, apex rounded; *lateral lobes* and *adaxial median lobe pair* slightly elliptic to oblong, 2–3 mm long, each lobe 1–1.3 mm wide, with length 2–2.3 times width, apex obtuse. *Stamens* inserted 0.5–0.7 mm above base of corolla; filaments arching towards adaxial inner surface of corolla, 6–8 mm long, sparsely hairy near base (as for inner surface of corolla tube), abaxial filament-pair longer than adaxial filaments; anthers 0.5–0.6 mm long, c. 0.3 mm wide, connective with a line of hemispherical, white glands. *Pistil* 10–11 mm long; *ovary* cylindrical to slightly obovoid, 0.3–0.5 mm long, diameter 0.6–0.7 mm, lobes c. 0.1 mm long, moderately hairy distally, with hairs eglandular, white, ± curled, moderately glandular (glands subsessile, hemispherical); *style* c. 9 mm long, strongly curved (towards adaxial plane); *stigma lobes* 0.7–1 mm long, slightly unequal, soon becoming ± strongly reflexed. *Fruiting propodium* and anthopodium extended to c. 3 mm long. *Fruiting calyx* enlarged, 3–4 mm long, mouth 2–2.5 mm diameter (compared to c. 1 mm diameter in flower), becoming pale brown, densely glandular. *Mature mericarps* 1.5–2 mm long, surface light to dark brown, with irregular longitudinal ridges (corrugated), moderately hairy and glandular (as for ovary). Figure 1.

Other specimens examined: Victoria: East Gippsland: Little River Gorge below 'Farm Creek', *K.R. Thiele 2994*, 5 Jan 2005 (MEL *n.v.*, NSW); Marble Gully area, 200 m S of Old Hut Creek, *N.G. Walsh 2089 & D.E. Albrecht*, 30 Jun 1988 (AD, MEL, NSW)

Distribution: this species is only known from East Gippsland region of Victoria.

Habitat: this species is recorded as growing in *Eucalyptus albens* grassy woodland on loamy soils derived from Snowy River volcanics (*Thiele 2992 & 2994*) and from the margin of dense *Pomaderris* sp. aff. *oraria – Helichrysum adnatum* shrubland on marble substrate (*Walsh 2089*).

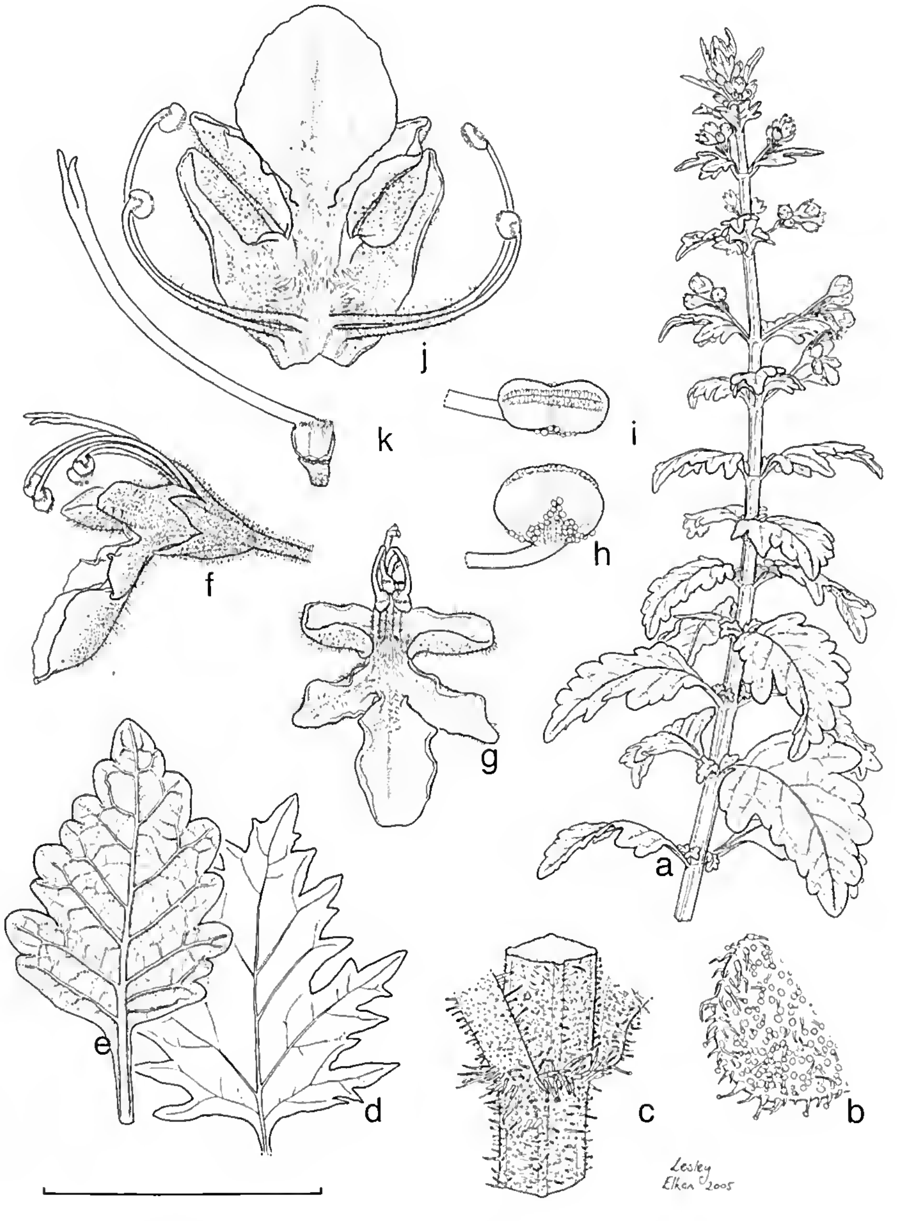

Fig. 1. ***Teucrium thieleanum*** B.J.Conn **a,** branchlet, showing flowers and flower buds; **b,** detail of adaxial leaf surface showing eglandular hairs, plus podiate and hemispherical glands; c, detail of branchlet showing indumentum with long multicellular podiate glands at node between leaf bases; **d,** leaf with margin lacerate; e, leaf, showing prominent venation of abaxial surface and margin crenate; **f,** flowers, lateral view, showing calyx, corolla, exserted style, stigma and stamens; g, corolla, ventral view, showing position of stamens and stigma; **h,** anther, dorsal view, showing line of hemispherical glands on connective; **i,** anther, ventral view; **j,** open corolla, showing hairy inner surface of tube and androecium, and comparative lengths of stamens; **k,** gynoecium, showing indumentum on distal surface of ovary, displaced alignment of style (towards adaxial inner surface of corolla), and slightly unequal stigma lobes. (a, b, e–k from living material of *Thiele 2994*; c from herbarium material of *Thiele 2994*, d from *Thiele 2992*). Scale bar: a = 50 mm; b = 2 mm; c = 4 mm; d & e = 40 mm; f & g = 10 mm; h & i = 2.5 mm; j & k = 7.5 mm.

Etymology: the specific epithet *thieleanum* recognises the significant contribution that Kevin Thiele has made to systematic botany. He is also the collector of the type material.

Notes: this species has multi-branched botryoidal superconflorescences, with all axes anthotelic, consisting of thyrsoid conflorescences. Each conflorescence usually consists of 7-flowered simple dichasia throughout much of its length, whereas 15-flowered dichasia are present towards the base. However, fewer-flowered dichasia are occasionally present, especially when the plant is beginning to flower. The inflorescence is leafy throughout much of its length, with a gradual reduction in leaf size from base to apex. However, the bracts at the distal end of the a_1 internode of the uniflorescence are slightly lacerated, like normal leaves. Ultimately, the leaves are reduced such that they are prophyll-like distally. *Teucrium thieleanum* is morphologically very similar to *T. corymbosa*. The characters that distinguish these two species are summarised in the identification key (see below).

Conservation status: although the conservation status of this species is unknown, it has been recorded as locally 'uncommon' (*Walsh 2089*) and 'infrequent' (*Thiele 2992* and *2994*).

Identification of Teucrium thieleanum from other Victorian species

The identification key provided by Conn (1999, p. 457) to the species of *Teucrium* occurring in Victoria is here modified to distinguish this new species from the other species.

1. Leaves entire, or trifoliate with linear entire leaflets; plants greyish from a very dense, short indumentum 2
1. Leaves toothed or deeply lobed almost to midrib; plants green 3

2. Leaves trifoliate (or sometimes the lowermost entire) .... ***T. albicaule***
2. Leaves simple throughout .... ***T. racemosum***

3. Leaves entire, deeply lobed; hairs mostly branched .... ***T. sessiliflorum***
3. Leaves toothed, not deeply lobed; hairs simple, never branched 4

4. Leaves with margin serrate, lamina 6–20 mm wide; corolla with abaxial median lobe (lip) 6–9 mm long; prophylls narrow (1–1.3 mm long, c. 0.2 mm wide); branches with simple, short, antrorse eglandular hairs and subsessile hemispherical glands .... ***T. corymbosum***
4. Leaves with margin crenate to slightly lacerate, lamina 24–45 mm wide; corolla with abaxial median lobe (lip) 3–3.6 mm long; prophylls broad (1–1.5 mm long, 0.6–0.8 mm wide); branches with simple, short and long eglandular hairs, straight to slightly curved, and multi-celled, podiate glands and subsessile hemispherical glands .... ***T. thieleanum***

Acknowledgments

The botanical illustration of *Teucrium thieleanum* was skillfully drawn by Lesley Elkan (NSW). Kevin Thiele (CANB) brought this taxon to my attention. Peter Wilson (NSW) kindly corrected the Latin diagnosis.

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Haloragodendron gibsonii (Haloragaceae), a new species from the Blue Mountains, New South Wales

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Abstract

A new species, ***Haloragodendron gibsonii***, is described from the Blue Mountains region of New South Wales. This taxon has always been recognised as being close to *H. lucasii*, a species restricted to the Ku-Ring-gai area of Sydney, but its rank has been uncertain. Relationships within the genus in eastern Australia have now been assessed using molecular data and these support recognition of the Blue Mountains plants as a distinct species.

Introduction

In October 1982, Sydney naturalist and bushwalker Colin Gibson collected two small pieces from a plant in the Bungleboori Creek area of the Blue Mountains National Park (Gibson 1998). Unfortunately, herbarium staff did not recognise the significance of this specimen when it was brought in and it was overlooked until late 1986 when it was identified as *Haloragodendron lucasii* (Maiden & Betche) Orchard. *H. lucasii* was originally named from a collection made in the Sydney suburb of Gordon and had been presumed extinct until its rediscovery in nearby Barra Brui, also in 1986. The Blue Mountains specimens showed some differences from those from Sydney, particularly in the unwinged fruit that sets seed (*H. lucasii* sens. str. has a winged hypanthium and does not appear to set seed). Orchard (1990), with only a single Blue Mountains specimen available for examination, said he was 'inclined to consider it as merely a variant of *H. lucasii*'. The differences between the Blue Mountains and Sydney populations, however, prompted Wilson (1991) to suggest that the former might constitute a distinct subspecies. Briggs and Leigh (1988) listed this taxon as '*Haloragodendron* sp. 1 (Wollongambe Creek)' then later (Briggs & Leigh 1996) as '*Haloragodendron lucasii* subsp. 1 (Wollongambe Ck.; Hind 5981)'. Recent molecular data (Moody 2005) in combination with the morphological differences support the recognition of this variant taxon at specific rank and it is here described as *H. gibsonii*.

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Materials and methods

In a broader study of Haloragaceae, Moody (2005) collected various species of *Haloragodendron* and generated sequences of the nuclear (ITS) and chloroplast (*trn*K intron, including *mat*K) regions. Vouchers for the eastern Australian species included in this study are shown in Table 1. Full details of techniques used, and broader, more detailed, analyses will be presented elsewhere (Moody, in prep.).

Molecular Results

A phylogenetic hypothesis derived from a parsimony analysis of the combined ITS + *trn*K–*mat*K DNA sequence dataset for the eastern Australian species of *Haloragodendron* is presented in Fig. 1. The eastern species form a monophyletic group with 100% bootstrap support and a branch length of 15. There are 4 point mutations in the *mat*K + *trn*K cpDNA region that vary between *H. lucasii* and the new species. There are 8 point mutations and 1 indel (1 bp) in ITS that vary consistently between *H. lucasii* and the new species. There is no variation between the Sydney populations in cpDNA while some autapomorphies are found between ITS sequences from the two samples derived from the Barra Brui population (Fig. 1). However, the ITS sequence data derived from one of the ex-Barra Brui plants (*Moody 482*: cultivated at Mt Annan) and the St Ives Chase population (*Moody 486*) did not vary, so the latter was omitted from the analysis. The DNA variation between *H. lucasii* and the new species is comparable to that found between *H. monospermum* and *H. baeuerlenii* (Fig. 1).

Key to species of *Haloragodendron* in eastern Australia

1. Fruits obovoid to obpyramidal, strongly angled and ribbed, or winged
    2. Leaves at least 2.5 cm long; hypanthium and fruit distinctly winged
    3. Wings conspicuously veined; anthers 2–4 mm long .... 1. ***H. baeuerlenii***
        3* Wings not conspicuously veined; anthers mostly 4–6 mm long .... 2. ***H. lucasii***
    2* Leaves usually 1–1.5 cm long; fruit angled and ribbed .... 3. ***H. monospermum***
1* Fruits ovoid, obtusely angled when dry, never strongly ribbed .... 4. ***H. gibsonii***

Haloragodendron gibsonii Peter G. Wilson & M. Moody, ***sp. nov.***

H. lucasii affinis sed floribus minoribus (petalis antheribusque brevioribus), fructibus ovoideis nunquam alatis differt.

Type: New South Wales: Cultivated, Royal Botanic Gardens, Mt Annan, Accession No. NSW498891 ex Blue Mountains National Park (*Hind 5978 & Cherry*), *Peter G. Wilson 1684*, 15 Sep 2004 (holo NSW; iso CANB, K, US distribuendi)

Straggling shrub up to 1 m tall; stems 4-angled to narrowly winged. Leaves subsessile, lanceolate, 15–25(–28) mm long and 2–5.5(–6) mm wide, serrate; teeth reddish, variable in size, (4–)7–12 each side. Flowering shoots (primary or lateral) terminating in a

Table 1. Vouchers for samples of eastern Australian species of *Haloragodendron* used in this study

Species	Voucher	Locality
Haloragodendron lucasii	Moody 481, CONN	Cultivated, Mt Annan Botanic Garden (ex Australian National Botanic Gardens— Original source: Barra Brui)
H. lucasii	Moody 482, CONN	Cultivated, Mt Annan Botanic Garden (Original source: Barra Brui)
H. lucasii	Moody 486, CONN	St Ives Chase
H. sp.	Moody 480, CONN	Cultivated, Mt Annan Botanic Garden (Original source: Bungleboori Creek area)
H. monospermum	Moody 475, CONN	NE of Braidwood
H. monospermum	Moody 491, CONN	Cultivated, Australian National Botanic Gardens (Original source: WNW of Kybean)
H. baeuerlenii	Moody 483, CONN	Cultivated, Mt Annan Botanic Garden (Original source: Deua National Park)

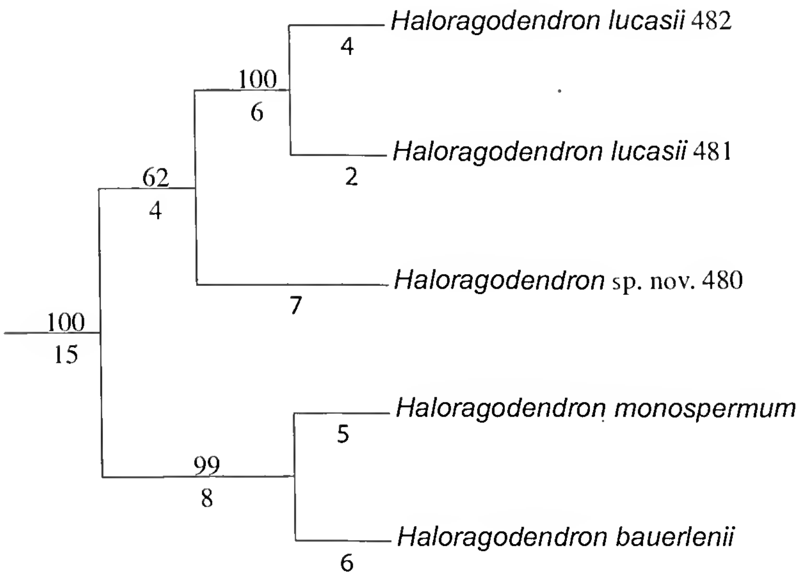

Fig. 1. Phylogenetic hypothesis of relationships among the eastern species of *Haloragodendron* based on combined *mat*K–*trn*K cpDNA and ITS nrDNA sequence data analysed using parsimony (taken from Fig. 1.3 in Moody 2005). Numbers above branches are bootstrap support; those below are branch lengths.

subsessile flower; lateral flowers with tapering bases 1–2.5 mm long. Primary bracts of the flowering shoot are somewhat reduced forms of normal foliage leaves that become smaller towards the apex, with the pair subtending the terminal flowers sometimes bract-like (lacking teeth, browning off and deciduous), 3.2–4.5 mm long, 0.7–0.9 mm wide. Bracteoles 1.8–2.3 mm long, 0.4 mm wide, inserted very close to the node. Flowers ±sessile, solitary; petals 6–9.5 mm long, 2.5–3 mm wide; stamens 8, filaments 3–3.5 mm long, anthers 2.5–4.5 mm long, apparently dimorphic, with the antesepalous 0.5–1 mm longer than the antepetalous. Ovules 4. Immature fruit ovoid, green, 5–6 mm long and 4–5 mm broad with a fleshy pericarp; mature fruit semipersistent on the plant, dry, dark brown, 4.5–5 mm long and 2.5–3.5(–4) mm broad, ± ovoid but weakly 4-angled and with a few coarse papillae in the lower half; pericarp woody, 0.8–1.0 mm thick. Seed solitary. Fig. 2.

Notes: this species is close to *H. lucasii* but differs by the ± ovoid, unwinged hypanthia and fruits, and the smaller flowers with petals 6–9.5 mm (compared with 9.5–12) mm long and anthers 2.5–4.5 mm (compared with 5.5–7 mm) long. The petals are not as markedly twisted in bud.

Etymology: the species is named for Colin P. Gibson, who made the first collection.

Distribution: seems to be confined to Bungleboori Creek and its tributaries, Blue Mountains National Park.

Habitat and ecology: in more protected sites, e.g. sheltered gullies and on creek banks, plants have been recorded in open forest of *Eucalyptus oreades* with *Ceratopetalum apetalum*, *Logania albiflora*, *Todea barbara*, *Gahnia* sp., and *Prostanthera* sp. In more exposed sites, e.g. dissected cliff-lines and pagodas, they have been found in heath associated with species such as *Allocasuarina distyla*, *Banksia ericifolia*, *B. conferta*, *Eucalyptus stricta*, *Leptospermum trinervium*, *Acacia hamiltoniana*, *Olax stricta* and *Caustis pentandra*.

Conservation status: in Briggs and Leigh (1996) this species is coded as 2RCat (i.e., rare but adequately conserved with a total known population of 1000+ plants that are all known to occur in a conservation reserve). Population numbers at individual sites are mostly high, although at one site the plants were described as 'either gregarious or cloning'. There is no evidence available to assess clonality, but the species certainly regenerates from seed: one herbarium sheet (*Keith s.n.*, 23 Feb 1999) consists of seedlings 15–35 cm high that had come up subsequent to a wildfire in 1994.

Selected specimens examined: New South Wales: Central Tablelands: Bungleboori Creek, *Gibson s.n.*, 3 Oct 1982 (NSW 284758); Bungleboori Creek, *Jones s.n.*, 26 Feb 1992 (NSW 262806); Yarramun Creek, *Lembit s.n.*, 7 Dec 1986 (NSW 171423, HO); Hole-in-the-Wall Creek, *Gibson 13*, 26 Dec 1988 (NSW); E of Mt Norris towards Bungleboori Creek, *Hind 5981 & Cherry*, 26 Feb 1990 (NSW).

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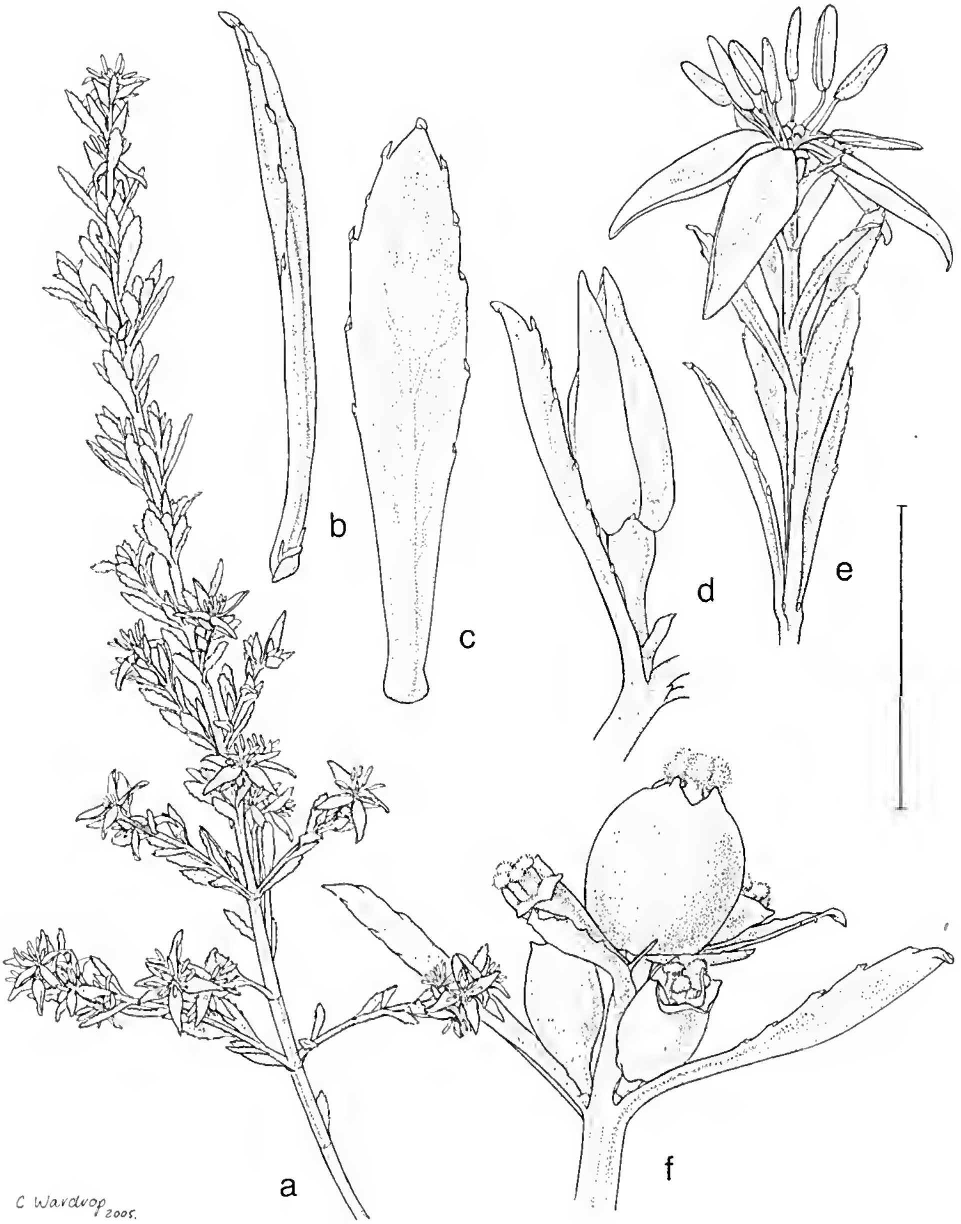

Fig. 2. *Haloragodendron gibsonii*. **a**, habit; **b**, **c**, leaf; **d**, bud (just beginning to open); **e**, flower; f, developing fruit (all from *Wilson 1684*). Scale bars: a = 75 mm; b–d = 8 mm; e, f = 10 mm.

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Lysimachia (Myrsinaceae) in New South Wales

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Abstract

This paper describes and provides a key to *Lysimachia* taxa occurring in New South Wales: *L. fortunei*, *L. japonica* and *L. vulgaris* var. *davurica*.

Introduction

Lysimachia was previously placed in the family Primulaceae, but a recent phylogenetic study analysing molecular and morphological data of primuloid families supports the transfer of the genus to Myrsinaceae (Källersjö et al. 2004). In addition to the synopsis of diagnostic morphological characters of the family provided by Källersjö et al. (2004), many *Lysimachia* species have schizogeneous secretory cavities that appear as lines or dots on vegetative and reproductive parts, which according to Anderberg and Ståhl (1995) are characteristic of Myrsinaceae.

Lysimachia is a cosmopolitan genus more common in the Northern Hemisphere. There are about 180 or possibly up to 250 species of *Lysimachia* worldwide. Some species have medical and culinary uses, particularly in Asia.

When the treatment for *Lysimachia* was first published in the *Flora of New South Wales* (Makinson 1990), two species were known to occur in New South Wales. Since then there have been changes to the known distribution of *L. japonica* (one new and one historic record from South Coast) and *L. vulgaris* var. *davurica* (extensions of range to South Coast and Southern Tablelands), as well as an additional species, *L. fortunei*, recorded for the State. In these three perennial species, the flowers are 5-merous with a deeply dissected, ± campanulate, persistent calyx and a deeply dissected, campanulate to rotate corolla.

This paper provides an updated brief treatment of the *Lysimachia* taxa occurring in New South Wales and was undertaken in order to revise the NSW FloraOnLine (http://plantnet.rbgsyd.nsw.gov.au/floraonline.htm). There is further scope for detailed taxonomic assessment of the genus in Australia.

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Key to *Lysimachia* taxa in New South Wales

1 Stems ± prostrate, to 18 cm long, pilose with septate hairs; leaves ovate or broadly ovate to ± spathulate, to 2.5 cm long; flowers solitary in leaf axils; pedicels without basal bract; corolla close to or barely exceeding length of the calyx .... 1 ***L. japonica***

1* Stems erect, to 2 m high, minutely glandular-hairy or ± glabrous; leaves elliptic to narrowly elliptic, lanceolate or oblanceolate, mostly 3–9 cm long; flowers in panicles or racemes; pedicels with basal bract; corolla distinctly exceeding calyx.

2 Leaves mostly opposite or in whorls, minutely glandular-hairy particularly along veins (on both surfaces or mainly on lower surface) and margin; pedicels 5–12 mm long, slender, distinctly longer than bract; calyx apices acuminate, margins glandular streaked; corolla yellow, 6–9 mm long .... 2 ***Lysimachia vulgaris*** var. ***davurica***

2* Leaves mostly alternate, glabrous; pedicels 1–5 mm long, stout, as long as or shorter than bract; calyx apices obtuse, margins membranous; corolla white, to 5.5 mm long .... 3 ***Lysimachia fortunei***

1. *Lysimachia japonica* Thunb., *Fl. Jap.*: 83 (1784)

Trailing, stoloniferous herb; stems ± prostrate, rooting at lower nodes, often ascending towards ends, to 18 cm long or possibly longer, with ± retrorse, often slightly crisped, hyaline, septate hairs (to c. 0.5 mm long) and scattered minute reddish glandular-papillae. Leaves mostly opposite, occasionally subopposite or alternate on some stems; lamina ovate or broadly ovate to ± spathulate, mostly 0.8–1.7 cm long and 5–15 mm wide, with scattered minute reddish glandular dots (glandular punctate) and hyaline, septate hairs; petiole 2–10 mm long, narrowly winged. Flowers solitary, axillary, usually 5–8 mm diam.; pedicel 1.5–5 mm long (reported to 10 mm long in overseas treatments), without a bract; sepals 4–7 mm long, lanceolate with acuminate to ± subulate apex and scattered septate hairs, glandular-spotted; petals not or scarcely exceeding the sepals, 3.5–5.5 mm long, yellow, apex acute or obtuse; filaments glabrous. Capsule globose or subglobose, 2–3(–4) mm diam., much shorter than persistent calyx, usually minutely pilose at apex, longitudinally dehiscing from apex by 5 valves, many-seeded. Flowering mainly November – January; also recorded flowering in April and possibly later. Fig. 1a–c. Common name: **Creeping Loosestrife.**

Habitat: moist situations, in and on margins of rainforest, on stream banks and in swamps, including swampy shallow drainage lines on flats.

Distribution: mainly north from the Williams River (Barrington area), with an historic record from Tilba Tilba (1881) and a more recent record from near Bega (1996); also Victoria where reported to be of uncertain status (see Walsh 1996) and widespread from Japan and Taiwan west to the Himalaya region, India and Sri Lanka and south through Indochina to Indonesia and Papua New Guinea. Occurrences in Queensland and perhaps eastern Victoria would not be improbable.

Conservation status: not listed as threatened or endangered in New South Wales where it is locally frequent to rare in various moist habitats.

Selected specimens: New South Wales: North Coast: near Williams River, 1802–5, *R. Brown* (MEL237010!, NSW155424!); Wiangarie State Forest, 27 Dec 1979, *R.G. Coveny 10560 & P.D. Hind* (NSW!), southern end of Gloucester Bucketts, 1 Jan 1994, *R.G. Coveny 16710* (BRI, CANB, K, MEL, MO, NSW!), Bentley, Richmond River, 1893, *A.H. Edwards* (MEL1517684!); above Shannon Creek, c. 30 km S of Grafton, 10 Apr 2002, *J. & P. Edwards* (NSW498015!), upper Bellinger River, Bishops Creek, 30 Nov 1993, *P. Gilmour 7512* (CANB, MEL, NSW!); Tooloom Range, Dec 1907, *J.H. Maiden* (NSW155422!); South Coast: Tilba Tilba, Nov 1881, *M. Bate 207* (MEL!); Jellat Flat, 5 km SE of Bega, 26 Nov 1996, *J. Miles* (NSW433736); Northern Tablelands: N of Mooraback Rest Area, Werrikimbe National Park, 5 Dec 1987, *J.R. Hosking* (NSW213496!, TARCH).

2. *Lysimachia vulgaris* var. *davurica* (Ledeb.) Knuth, *Pflanzenr.* IV 237 (Heft 22): 304 (1905)

L. davurica Ledeb., *Mém. Acad. Imp. Sci. St Pétersbourg Hist. Acad.* 5: 523 (1812)

Rhizomatous herb; aerial stems erect, simple or weakly branched, to 1.5 (–2) m high, with minute, erect, reddish brown-tipped glandular hairs (to 0.1 mm long or slightly longer) and some times with occasional longer septate hairs intermixed, becoming glabrous on lower stem. Leaves mostly opposite or in whorls of 3 or 4, elliptic to narrowly elliptic, lanceolate or oblanceolate, mostly 4–9 cm long and 10–22 (–32) mm wide (leaves becoming smaller towards stem apex), often long and narrow (to 10.5 cm long, 7–8 mm wide) on young plants, discolorous, green, paler beneath, minutely glandular-hairy, dotted with orange to blackish glands (glandular punctate), sessile or with petiole to 3 mm long. Panicles terminal and upper-axillary, many-flowered. Flowers 9–15 mm diam.; pedicel mostly 5–12 mm long, with a distinctly shorter basal bract 2–6 mm long; sepals 3–4 mm long, lanceolate-ovate with an acuminate apex and distinct orange to blackish (on drying) glandular line on the outer surface near the margins, ciliolate with gland-tipped hairs; petals clearly exceeding the sepals, 6–9 mm long, bright yellow, often with minute orange to reddish glandular lines or dots, apex broadly acute to obtuse; filaments with minute glandular hairs. Capsule globose or subglobose, 2–4 mm diam., longer than persistent calyx when mature, with minute gland-tipped hairs at apex, longitudinally dehiscing from apex by (4–)5 valves, many-seeded. Flowering December – March. Aerial stems die back after flowering and fruiting. Fig. 1d–f. Common name: **Yellow Loosestrife.**

Habitat: moist situations, including peatland swamps, stream banks and lagoons. Grows in damp soils to saturated peat, in sedgeland and wet heath communities, associated with *Phragmites australis*, *Carex* spp., *Juncus* spp., *Bolboschoenus fluviatilis*, *Lycopus australis*, *Lythrum salicaria*, *Leptospermum* spp. and *Melaleuca ericifolia*.

Distribution: rare in Australia; recorded in several wetlands in New South Wales, including Wingecarribee Swamp between Robertson and Moss Vale, a swamp/pond system in the Lower Boro – Braidwood area, and a lagoon near Bega. These populations are far disjunct from the main natural range of this taxon in NE Asia where it occurs from Japan west to Mongolia and eastern Russia. Its occurrence in Australia may provide evidence supporting long-distance dispersal; in this case the agency is likely to have been migratory waterbirds, such as Latham's (Japanese) Snipe, which visit Australian wetlands in the summer. Both var. *davurica* and var. *vulgaris* have been recorded in Victoria with uncertain status (see Walsh 1996).

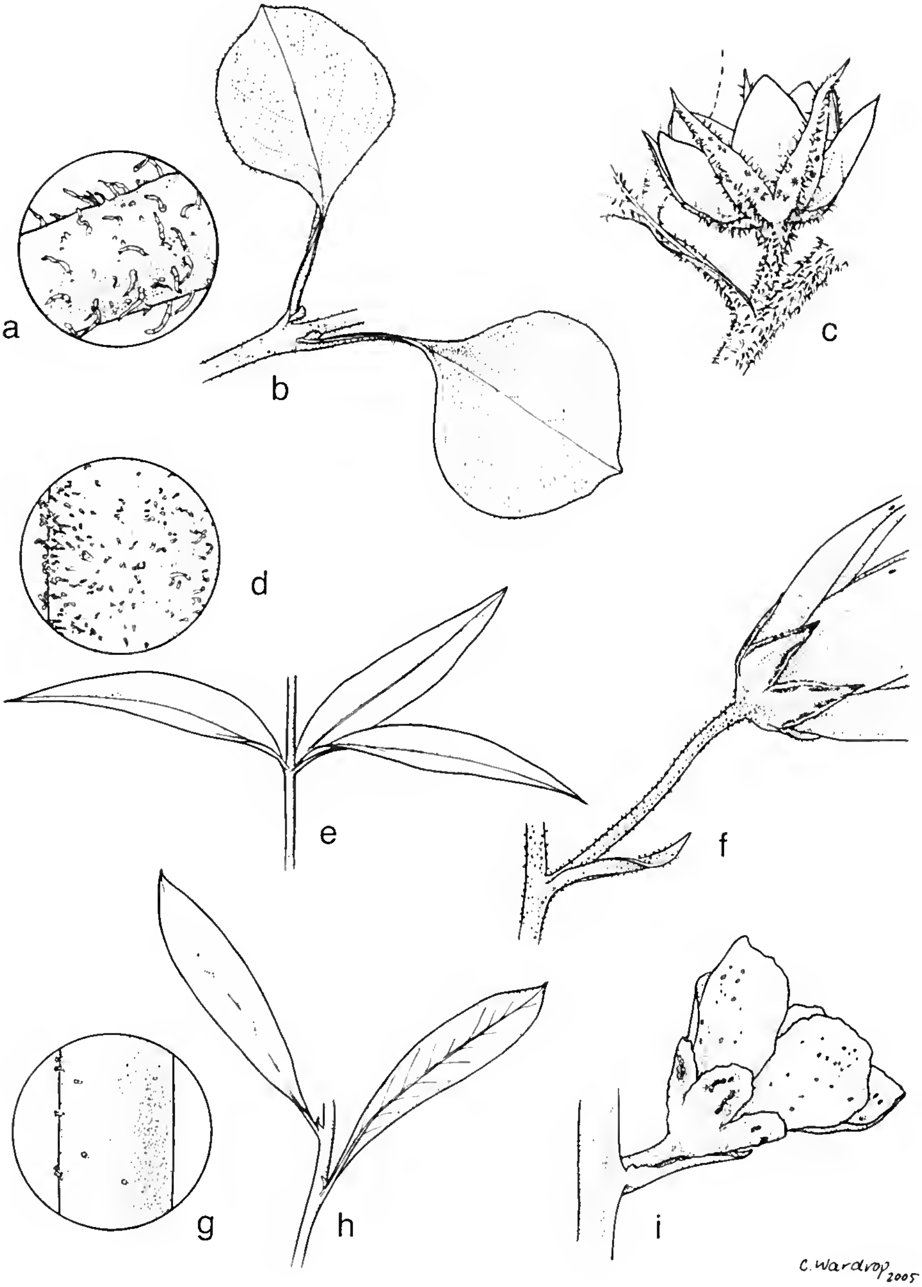

Fig. 1. *Lysimachia japonica*. **a, b**, part of stem; **c**, flower. *L. vulgaris* var. *davurica*. **d, e**, part of stem; **f**, flower. *L. fortunei*. **g, h**, part of stem; **i**, flower. **a–c**, *J. & P. Edwards* (NSW498015); **d–f**, *J. Miles* (NSW615689); **g–i**, *L.M. Copeland 3557, I.R. Telford & J. Hodgon* (NSW).
Scale bar = 0.24 cm (g), 0.3 cm (a, d), 0.75 cm (i), 1 cm (c), 2 cm (b), 6 cm (f, h) or 8 cm (e).

Conservation status: listed as Endangered under Schedule 1 of the *New South Wales Threatened Species Conservation Act 1995* and is not located in any protected reserves. The largest population in New South Wales is under threat from major disturbance of its wetland habitat since most of the Wingecarribee Swamp peatland collapsed and fragmented in August 1998.

Selected specimens: [precise localities withheld for conservation purposes] New South Wales: South Coast: SE of Bega, 18 Dec 2002, *J. Miles* (NSW615689!); ibid. 21 Feb 2003 (NSW702297!); Central Tablelands: Wingecarribee Swamp, 26 Feb 1969, *R.G. Coveny 906* (CANB, MEL, NSW!), 9 Feb 1988, *P.G. Kodela* (NSW254143!, UNSW!), 27 Feb 1997, *P.G. Kodela* (CANB!, K!, MEL!, MO!, NSW425850!, PE!, UNSW!), 28 Mar 2001, *P.G. Kodela 574 et al.* (CANB!, MEL!, MO!, NSW!), 1 Jun 2001, *P.G. Kodela 600a* (NSW!); Southern Tablelands: Lower Boro – Braidwood area, 19 Feb 2001, *R.O. Makinson 1787* (CANB).

Notes: A possible taxonomic synonym is *L. muelleri* N.P.Balakr., the replacement name for *L. salicifolia* Benth. nom. illeg. (Walsh 1996). Investigations by Bob Makinson (pers. comm.) indicate likely synonymy, which has implications for the status of *L. vulgaris* var. *davurica* as native based on historic specimens from Victoria labelled as *L. salicifolia.*

Lysimachia vulgaris L. var. *vulgaris* and var. *davurica* are some times treated as separate species (e.g. Hu & Kelso 1996). The present paper maintains the variety level, with a molecular phylogenetic study finding these taxa to be very close (Hao et al. 2004) and there being strong morphological similarities (pers. obs.).

Lysimachia vulgaris var. *vulgaris* is native mainly to Europe and is most readily distinguished from var. *davurica* by having conspicuous, long, septate hairs on the stems, leaves and other parts (pers. obs.). In var. *davurica* there may be occasional long septate hairs amongst predominantly minute glandular hairs. The leaves may also be broader in var. *vulgaris*, to 50 mm wide. There are occasional records of *L. vulgaris* (variety uncertain) from New Zealand and the species is treated as naturalised there. In parts of North America *L. vulgaris* is a problem weed of wetlands that was probably introduced from Eurasia as an ornamental.

In Chinese folk medicine flavanol glycosides have been extracted from *Lysimachia vulgaris* var. *davurica* for treatment of high blood pressure.

3. ***Lysimachia fortunei*** Maxim., *Bull. Acad. Imp. Sci. Saint-Pétersbourg* 12: 68 (1868)

Rhizomatous herb; aerial stems erect (to decumbent), simple or some times branching near apex, reddish, to c. 70 cm high, with sparse, minute, gland-tipped hairs, appearing ± glabrous. Leaves mostly alternate, narrowly elliptic or oblanceolate, mostly 3–6.5 cm long and 6–12 mm wide, glabrous, dotted with minute reddish glands (glandular punctate), ± sessile. Racemes terminal, many-flowered, to 15 cm long. Flowers 5–7 mm diam.; pedicel mostly 1–2 mm long (occasionally to 5 mm long in basal flowers), with a ± equally long or longer basal bract 2–4(–5) mm long; sepals 1.5–2.5 mm long, ovate-elliptic with obtuse apex, glandular-dotted, margins whitish-membranous; petals exceeding the sepals, to 5.5 mm long, white, often with minute purplish glandular dots and lines, apex rounded; filaments with minute glandular hairs. Fruits not seen. Flowering around February. Fig. 1g–i. Common name (Japan): **Swamp Tiger Tail**.

According to Iwatsuki et al. (1993) and Hu and Kelso (1996) the stems can reach 80 cm high, the leaves can also be lanceolate and to 11 cm long and 25 mm wide, the racemes to 20 cm long and the capsule is globose, 2–2.5 mm diam., glabrous, dehiscing by valves and many-seeded.

Habitat: moist situations; recorded in New South Wales from a broad gully swamp, growing in peaty loam over basalt, on stream bank and flat, in wetland herbfield with *Carex*, *Geum* and *Juncus*.

Distribution: recorded in Australia only from a swamp in Werrikimbe National Park where it occurs possibly as a result of long distance dispersal by a wetland bird; main natural distribution is in E Asia from China to Japan.

Specimens examined: [precise locality withheld for conservation purposes] New South Wales: Northern Tablelands: Werrikimbe National Park, 13 Feb 2003, *L.M. Copeland 3557, I.R. Telford & J. Hodgon* (BRI, CANB, MEL, NE, NSW!, TARCH) & *L.M. Copeland 3566, I.R. Telford & J. Hodgon* (CANB, MEL, NE, NSW!).

Conservation status: rare in Australia, being only recorded from one wetland which is protected in Werrikimbee National Park; status requires further investigation, but *L. fortunei* is likely to be a 'natural adventive' or 'distance-dispersed native' based on the similar distribution patterns of the other species.

Note: in addition to the more distinct differences in leaf arrangement and inflorescence features (including flower colour), *L. fortunei* can be distinguished from *L. vulgaris* var. *davurica* by the indumentum. In *L. fortunei* the stems appear ± glabrous with only a few scattered minute hairs while in *L. vulgaris* var. *davurica* the minute indumentum is usually moderately dense, at least in the upper parts, as seen with a 10x lens.

Conclusion

Three *Lysimachia* taxa are currently known to occur in New South Wales: *L. fortunei*, *L. japonica* and *L. vulgaris* var. *davurica*. In Australia they are also known from Victoria, along with the commonly cultivated species *L. nummularia* L. which has been recorded as naturalised.

Because *Lysimachia* is not widespread or common in Australia and some species are sold for cultivation as ornamentals it has often been assumed that records in the wild represent naturalised escapes in this part of the world. For example, *Lysimachia vulgaris* var. *davurica* in Wingecarribee Swamp attracted great debate in 1997 at a mining warden's inquiry on peat mining as to whether it was a rare native or introduced weed growing in the wetland. The presence of this taxon and *L. fortunei* in particular, in New South Wales, could well provide examples of chance distributions resulting from long distance dispersal, which is not uncommon for cosmopolitan wetland plants. There is no obvious garden escape pattern for the genus in New South Wales and some of the populations are in remote localities. The question of how long some of the populations have been in Australia remains unanswered. Palynological and macrofossil analyses of peat or sediments where *Lysimachia* grows might be ways of investigating pre-European occurrence. From what is known about the distribution of the genus and the history of specimen records, *Lysimachia* is likely to be an elusive cosmopolitan in Australia. It is quite possible that new localities for *Lysimachia* will be found in Australia in the future.

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Three new species of *Nymphaea* (Nymphaeaceae) in Australia

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Abstract

Nymphaea alexii (aff. *N. hastifolia*, subgenus '*Confluentes*'), ***N. carpentariae*** and ***N. georginae*** (both aff. *N. macrosperma*, subgenus *Anecphya*) are described from the Gulf Savannah region of Queensland and immediately to the south. A key is provided for the native and naturalised species of *Nymphaea* in Australia.

Introduction

As part of continuing studies in *Nymphaea* (Jacobs 1989, 1992, 1994), including sampling for an extensive DNA study, we have been able to collect good material sufficient to describe three new species.

Nymphaea alexii S.W.L.Jacobs & Hellq. ***sp. nov.***

N. hastifoliae similis sed staminibus cremiis, apice ovarii rubro, cristis seminis nonnunquam carunculatis differt.

Holotype. Queensland: c. 23 km N of Normanton, Karumba rd, 17° 31.741′S 141° 09.625′E, *S. Jacobs 9325 & C.B. Hellquist*, 17 Apr 2005 (NSW). Isotypes: NASC, BRI.

Annual or perennial with a globose rhizome c. 2 cm diam. Blade elliptic, to 15 cm long, to 10 cm wide; margins slightly sinuate; stipules fused for c. 1 cm, the apical lobe free, acute c. 1 cm long. Flowers to 30 cm above the water, pleasantly-scented, day-flowering. Sepals 4–5, to 6 cm long, green outside; tip acute. Petals (18–)20–25(–40), to 5.5 cm long, 1.5 cm wide, lanceolate, white, grading into the stamens, no gap between petals and stamens; tip acute. Stamens cream, to c. 150; filaments membranous, to 17 mm long; anthers to 10 mm long; appendage white, much reduced and only visible on outer stamens. Ovary often red at the apex, with vestigial or obsolete sterile lobes; carpels 8 to 16; fruit globose, c. 4.5 cm diam. Seeds elongated, c. 1–2 mm long, glabrous, with longitudinal ridges, parts of the ridges sometimes proliferating irregularly into linear outgrowths when mature; cells of the testa with a comparatively large lumen (as judged from surface view) and short arms of more or less equal length, with a single

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margin (as opposed to the apparent double margin in *N. hastifolia*), ends of the arms of the epidermal cells neither expanded nor raised, the cell walls covered with regularly-arranged minute papillae (visible at c. 500X on a SEM).

Selection of specimens examined: Queensland: c. 23 km N of Normanton, Karumba rd, *Jacobs 9325a & Hellquist*, 17 Apr 2005 (NSW, NASC, BRI); c. 25 km S of Normanton, Croydon rd, *Jacobs 9326 & Hellquist*, 17 Apr 2005 (NSW, NASC, BRI).

N. alexii grows in ephemeral billabongs and the shallow margins of more perennial lagoons (similar to *N. hastifolia*) during the end of the Wet and shortly after, and has often disappeared by May. It can be readily distinguished from *N. hastifolia*, or indeed from any other native *Nymphaea* sp., by its distinctive cream stamens and its small, ridged seeds. This species belongs in subgenus '*Confluentes*'[1].

The species is named after Alex James Fussell, grandson of SWLJ.

A minutely papillose seed surface, has not been observed elsewhere in subg. *Anecphya* or '*Confluentes*'. Interestingly, the seeds of this taxon are similar to those of *Ondinea purpurea*, as depicted by Schneider and Ford (1978), both in their longitudinal ridges and the granulate surface. A similar seed surface is known elsewhere in *Nymphaea* only in a group of species within subg. *Hydrocallis.*

Nymphaea carpentariae S.W.L.Jacobs & Hellq. ***sp. nov.***

N. macrospermae similis sed floribus albidis plerumque grandioribus, seminibus minoribus differt.

Holotype. Queensland: Burketown, bore drain of town bore, 17° 44.879´S 139° 32.899´E, *S. Jacobs 9329 & C.B. Hellquist*, 18 Apr 2005 (NSW). Isotypes: NASC, BRI.

Perennial with a globular to elongate rhizome to c. 4 cm long. Blade orbicular to elliptic, to 45 cm diam.; margins with regularly-spaced triangular teeth to 1.5 mm long; stipules fused for (1–)4–8 cm, terminal lobe free, acute, 0.5–1 cm long. Flowers to 40 cm above the water, lightly scented; day-flowering. Sepals 4, to 6.5 cm long, green outside with purple streaks, streaks occasionally obscuring the green; tip obtuse. Petals mostly 12–22, 4–6 cm long, 1.5–2.5 cm wide, oblanceolate to spathulate, mostly white, rarely with some blue, with a space of c. 1 cm between petals and stamens; tip obtuse; when blue, most of the petals coloured, not just the outer petals and fading only slightly with maturity. Stamens yellow, mostly 150–300; filaments membranous to cylindrical, to 25 mm long; anthers 2.5–5 mm long, appendages vestigial or obsolete. Ovary lobes vestigial or obsolete; carpels 7–19; fruit globose, c. 4 cm diam. Seeds spherical to elongate-spherical, 2–3.5 mm long, c. 2 mm wide, with more or less continuous rows of short hairs usually c. 0.1–0.15 mm long; cells of the testa with a lumen of variable width and arms of unequal length with the ends of the arms expanded but not raised.

Selection of specimens examined: Queensland: Between Normanton and Maggieville, *Clarkson 2697*, 6 Nov 1979 (NSW681541); c. 4 km N of Normanton, Karumba rd, *Jacobs 9324 & Hellquist*, 17 Apr 2005 (NSW);Boogan Lagoon, *Jacobs 1280*, 26 Apr 1974 (NSW681369); Forked Lagoon 'Wernadinga', *Jacobs1368*, 30 Apr 1974 (NSW681 368); E of Croydon, Georgetown rd, *Jacobs 8588 & Les*, 22 Oct 1999 (NSW440424); Cumberland Chimney, c. 22 km W of Croydon, Georgetown rd, *Jacobs 9320 & Hellquist*, 16 Apr 2005 (NSW).

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[1] Formal description of the subgenus *Confluentes* is waiting on the publication of the treatment of this group in the Flora of Australia series.

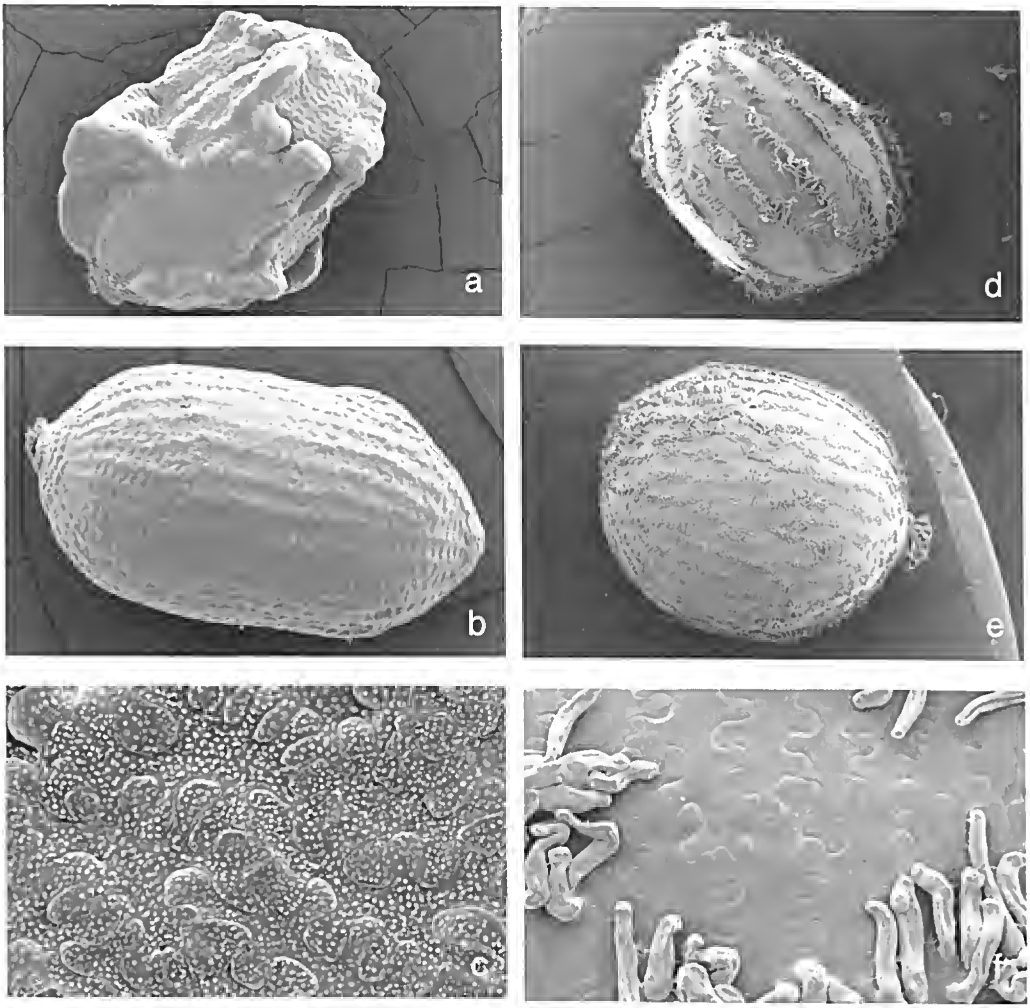

Fig. 1. *Nymphaea* seeds; the bare patches, or areas where the features are less well defined, are those areas where the seeds pack tightly next to each other. **a**, *Nymphaea alexii* (SJ9325) seed showing the ridges and the proliferation or caruncles present on most seeds (c. 35X); **b**, *N. alexii* (SJ9325) seed showing minimal proliferation, some proliferation is visible at top right; the ridges are clearly visible. This seed is from the same collection as Fig. 1a and all fruits examined have both types of seed (c. 35X); **c**, *N. alexii* (SJ9325) seed surface showing the characteristic papillae on the surface of the epidermal cells (c. 425X); **d**, *N. carpentariae* (SJ9329) whole seed showing the more or less continuous rows of hairs and a smaller seed than *N. georginae* in Fig. 1e (c. 25X); **e**, *N. georginae* (SJ9335) whole seed showing the partly disorganized and incomplete rows of hairs and a larger seed than *N. carpentariae* in Fig. 1d (c. 15X); **f**, *N. georginae* (SJ9335) seed surface showing the epidermal cells with a narrow lumen and short irregular arms (c. 225X)

N. carpentariae grows in perennial or near perennial billabongs and lagoons around the Gulf of Carpentaria. It can be distinguished from *N. macrosperma* by the usually larger white flowers, and from *N. georginae* by the smaller seeds and by the blue-flowered forms of the latter fading with age. Although the differences in shape and dimensions of the seeds in *N. carpentariae* and *N. georginae* do not seem very great, when compared side by side the differences are quite striking. This species belongs in subgenus *Anecphya*. Specimens of this species have usually been included in *N. immutabilis*.

This is the original 'Albert De L'Estang' sent to Bailey in Brisbane; there are still some of the original distinctive seeds in the Herbarium (BRI). Most of what is now grown and sold as cv. 'Albert De L'Estang' appears to be *N. immutabilis*. The cultivar 'Andre Leu' is *N. carpentariae*.

The species is named for the Gulf of Carpentaria region in which it grows.

Nymphaea georginae S.W.L.Jacobs & Hellq. ***sp. nov.***

N. macrospermae similis sed floribus in quoque loco plerumque albidis caeruleisque, floribus caeruleis decolorantibus differt. A *N. gigantea* seminibus majoribus differt.

Holotype. Queensland: Georgina River, Camooweal, 19° 55.576´S 138° 06.903´E, *S. Jacobs 9332 & C.B. Hellquist*, 19 Apr 2005 (NSW). Isotypes: NASC, BRI (blue-flowered specimen).

Perennial with a globular rhizome c. 4 cm diam. Blade orbicular to elliptic, to 60 cm diam.; margins with regularly-spaced narrow-triangular to triangular teeth to 2–4 mm long; stipules fused for 1–3 cm with free acute terminal lobes 0.3–1 cm long. Flowers to 30 cm above the water, fragrant, day-flowering Sepals 4, to 6.5 cm long, green outside with purple streaks, streaks occasionally obscuring the green; tip obtuse. Petals mostly 12–26, 4–7 cm long, 2–3.5 cm wide, oblanceolate to spathulate, white or, less commonly, blue, rarely pink, and fading with age, with a space of c. 1 cm between petals and stamens; tip obtuse; when blue, most of the petals coloured, not just the outer petals. Stamens mostly 150–250; filaments membranous to cylindrical, to 25 mm long; anthers to 6 mm long, appendages vestigial or obsolete. Ovary often red with lobes vestigial or obsolete; carpels 7–19; fruit globose, c. 4 cm diam. Seeds globose to subglobose, (1.5–)2.5–4 mm diam., with often interrupted rows of short hairs c. 0.1–0.15 mm long; cells of the testa with a comparatively long-narrow lumen and arms of unequal length with ends slightly expanded but not raised.

Selection of specimens examined: Queensland: Georgina River, Camooweal, *Jacobs 5531 & P.Wilson*, 4 May 1988 (NSW280651); *Jacobs 9332 & Hellquist*, 19 Apr 2005 (NSW); Flood channel of Thomson River, Longreach, *Jacobs 9335 & Hellquist*, 20 Apr 2005 (NSW).

N.T.: James River, nr 'Avon Downs', *Chippendale s.n.*, 20 Jun 1960 (NSW); *Jacobs 5300, 5303, 5304, 5306 & K. Wilson*, 7 Jun 2005 (NSW); *Jacobs 9331 & Hellquist*, 20 Apr 2005 (NSW).

Nymphaea georginae grows in the billabongs and flood channels of the upper parts of northern rivers flowing into the Lake Eyre system. These waterbodies may hold water for >1 year but also are frequently dry for >1 year. It can be distinguished from *N. carpentariae* by the larger seeds and from *N. macrosperma* by the larger flowers of blue-flowered plants fading with age. This species belongs in subgenus *Anecphya*. This species has the strongest scent of any in subg. *Anecphya*, but it is still considerably less scented than species of subg. '*Confluentes*'. Specimens of this species have usually been included in either *N. gigantea* or *N. immutabilis*.

The species is named for the Georgina River, one of several in which it grows and the type locality.

Key to native and naturalised species of *Nymphaea* in Australia.

1. Petals yellow, grading into stamens (with filaments to 38 mm long); leaf blade margin sinuate; horizontal stolons and vertical rhizomes both present. .... ***N. mexicana***[2]

1* Petals white, blue or pink; grading into stamens or a distinct gap present; leaf blade margins various; stolons absent; rhizomes either horizontal, or vertical and more or less tuberous. 2

2. Rhizomes horizontal or suberect, elongated and vigorous; flowers more or less floating on the water surface. .... ***N. alba, N. odorata*** and hybrids

2* Rhizomes tuberous, erect; flowers standing clear of the water surface. 3

3. Petals grading into stamens; leaf blade with entire, sinuate or dentate margins. 4

3* Distinct gap present between petals and stamens; blade with sinuate or dentate margin. .. 9

4. Filaments flattened, thickened, tough; leaf blade margin dentate; blade undersurface usually pubescent .... ***N. pubescens***

4* Filaments membranous and either cylindrical, or all flattened, or only some outer filaments flattened; leaf blade undersurface always glabrous; blade margin sinuate. 5

5. Anthers to 24.5 mm long; apical appendage to 10 mm long. .... ***N. caerulea***[3]

5* Anthers 13 mm long or less; apical appendage minute or absent. 6

6 Anthers cream; top of ovary frequently red; seeds with longitudinal ridges and these often with proliferations. .... ***N. alexii***

6* Anthers yellow; top of ovary rarely red; seeds without longitudinal ridges or proliferations. 7

7. Filaments to 25 mm long; sepals to 11.5 cm long; petals blue to mauve, white, or pink; widespread; habitats various. .... ***N. violacea***

7* Filaments to 18 mm long; sepals to 7 cm long; petals white. 8

8. Sepals usually with purple flecks, to 7 cm long; anthers to 8.5 mm long, sometimes apiculate; carpels 11–22; fruit to 2.5 cm diam.; seeds glabrous, 1.75–2.5 mm long, 1–1.5 mm wide, cells of testa without a 'double edge'; growing in more or less permanent water; Cape York Peninsula, New Guinea. .... ***N. elleniae***

8* Sepals without purple flecks, to 6 cm long; anthers to 5.5 mm long; appendage absent; carpels 8–16; fruit to 4.5 cm diam.; seeds glabrous, spherical, c. 1 mm diam., cells of testa with a 'double edge'; growing in ephemeral water on floodplains; N.T., W.A. .... ***N. hastifolia***

9. Filaments flattened and tough; petals usually <10; stamens usually <25; leaf blade margin sinuate; mature seed <1.5 mm long. .... ***N. nouchali***

9* Filaments membranous, slightly flattened to cylindrical; petals usually >10; stamens usually >50; leaf blade margin toothed; mature seeds >2.5 mm long. 10

10. Sepal margins pink; petals becoming dark pink with age; blade margin with sparse teeth to 2 mm long. .... ***N. atrans***

10* Sepal margins white or blue, rarely pink; petals not darkening with age, teeth usually more than 2 mm long. 11

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[2] The plant introduced in Australia is a hybrid involving this species, rather than pure *N. mexicana*, as in other places where this taxon is said to be introduced.

[3] The introduced plant in eastern Australia is not typical of *N. caerulea*, originally described from Egypt, but better fits what has traditionally been treated as *N. capensis*. However, further work on the interpretation of the type of this latter name is required (J. Wiersema pers. comm.).

11. Anthers to 6 mm long; sepals to 6.5 cm long; petals to 26 on fully developed flowers, white, deep blue, rarely pink; blade margin with teeth to 4 mm long. 12

11* Anthers >6 mm long; sepals to 12 cm long; petals to 34 on fully developed flowers, blue, white, or rarely pink; blade margin with teeth to 5 mm long. 14

12. Flowers mostly blue, rarely pink or white, comparatively small; petals to 5 cm long and all the same colour; sepals to c. 4.5 cm; leaves comparatively large with teeth on mature leaves cylindrical from a shallow triangular base; seeds globose to subglobose, 3–4.5 mm diam. .... ***N. macrosperma***

12* Flowers mostly white with some blue, rarely pink, larger; petals to 7 cm long and all the same colour; sepals to 6.5 cm; leaves not as large with teeth on mature leaves triangular to narrow-triangular; seeds globose to elongate-spherical, 2–4 mm diam. 13

13. Seeds spherical to elongate-spherical, 2–3.5 mm long, c. 2 mm wide, with more or less continuous rows of short hairs; flowers mostly white, rarely blue, no obvious fading with age. .... ***N. carpentariae***

13* Seeds globose to subglobose, 2.5–4 mm diam., with often interrupted rows of short hairs; flowers mostly white but blue flowers still common, the blue flowers fading with age. .... ***N. georginae***

14. Anthers to 10 mm long; rarely apiculate; when coloured the petals fading with age; carpels 12–18; seeds ovate, pubescent, the hairs arranged in more or less continuous rows of short hairs; cells of the testa with a long lumen and short arms of equal length, the ends not raised, rarely expanded. .... ***N. gigantea***

14* Anthers to 15 mm long; often apiculate; when coloured the petals usually not fading with age; carpels 9–20; seeds oblong, pubescent or rarely glabrous, with sparse to dense hairs in discontinuous or disorganised rows, sometimes almost appearing scattered; cells of the testa with a long lumen and arms of equal to unequal length, the ends sometimes slightly expanded but not raised. .... ***N. immutabilis***

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An anatomo-ecological experiment in *Austrostipa aristiglumis*, a lowland Stipoid species.

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Abstract

Leaf and sheath anatomy characteristic of an aquatic or amphibious plant is reported for *Austrostipa aristiglumis* (Gramineae). *Austrostipa* and the rest of the Stipoid grasses are normally considered to be classic xeromorphs. The degree of development of the hydromorphic characteristics appears to be related to the level of soil saturation. The ecological and phylogenetic significance of these observations is discussed.

Introduction

The Stipeae is a cosmopolitan grass tribe of c. 450 species, widely distributed and not clearly delimited (Barkworth & Everett 1987). The tribe has major centres of diversity in South and North America, Australia and Eurasia, with different genera dominating in each centre. The tribe is characterised by having florets with a single spikelet, the lemma usually being coriaceous or firmer, having comparatively large unicellular macrohairs, and a range of other epidermal features that help delimit the genera.

The species grow primarily in temperate or warm-temperate regions, and are dominant in many of the arid grasslands of southern Australia, South America, and Asia at varying elevations (0 –5000 m) and the ecological range includes arid, semiarid, semihumid and humid habitats (Barkworth & Torres 2001).

Within the tribe, there are recurring patterns of morphological and anatomical variation. Anatomy in the Stipeae has been the subject of numerous studies, with the majority on leaf anatomy being carried out for taxonomic purposes. Parodi (Parodi 1944; Parodi & Freier 1945) proposed that leaf anatomy was of value in determining generic limits in the tribe. Later studies in American species, have confirmed the importance of leaf (as well as lemma and palea) anatomical characters (Brown 1958; Matthei 1965; Reeder & Reeder 1968; Caro & Sánchez 1971,1973; Clifford & Watson

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1977; Thomasson 1978; Barkworth 1981; Scholz 1982; Watson & Dallwitz 1981, 1992; Arriaga 1982, 1983; Renvoize 1985; Roig 1964 [a & b], 1965; Torres 1993,1997 [a , b & c] ; Peñailillo 1996; Rojas 1997; Cialdella & Arriaga 1998; Arriaga & Barkworth 2000; Cialdella & Giussani 2002).

Taxa from south-west Asia were revised by Freitag (1985), and the Australasian stipoid taxa by Vickery et al. (1986), Jacobs et al. (1989) and Jacobs and Everett (1996).Vazquez (1992), Vazquez and Devesa (1996, 1997) and Vazquez and Barkworth (2004) treated the stipoids of Morocco and the Iberian peninsula, and Martinovsky (1976) those of central Europe. However, anatomical characters were not included in these studies. This study is part of a larger project being undertaken by the *International Stipeae Working Group*(1) to explore the diversity within the Stipeae with the ultimate goal of developing a strongly supported taxonomic revision of the tribe. The results could be used to predict how the distribution of stipoid species, and other grasses with similar characteristics, would be affected by changes in climate.

Stipoids are known to be species adapted to mesic and xeric environments. With the exception of *Trikeraia* (Clayton & Renvoize 1986), there is no mention of any relationship with water in the descriptions of the species habitat, nor any mention of hydromorphic characteristics, in the tribe.

In this contribution we describe the leaf and sheath structure of *Austrostipa aristiglumis* (F. Muell.) S.W.L. Jacobs & J. Everett, a species of semi-arid to sub-humid habitats that has hydromorphic characters that change with the level of soil saturation. While *Austrostipa aristiglumis* grows in a variety of habitats, it is most common on the intermittently-flooded, grey self-mulching clays or heavy alluvial soils of the westerly-flowing watercourses of the winter-dominant rainfall areas of the Murray-Darling Basin.

Methods

Six pots 190 mm internal diameter and 190 mm high were planted with diaspores of *Austrostipa aristiglumis* (RK24, voucher held at NSW) in November 2002, at Sydney, Australia as this is the time of year seedlings are found in the field. The pots were placed outside in five trays 6, 11, 44, 86, and 136 mm deep, and one pot (0 mm) retained as a control with no tray. The treatments were arranged linearly in random order from random number tables (0 mm position 4; 6 mm position 5; 11 mm position 2; 44 mm position 3; 86 mm position 6; 136 mm position 1). The pots were filled with a mixture of potting mix and clay. The trays were each maintained filled with water so that each pot had different levels of saturated soil. Each time the trays were filled the control was also watered and allowed to freely drain. The pots also received natural rainfall.

One year later, after flowering, all the surviving plants from different treatments and the control (0mm, 11 mm, 86 mm) were preserved in 70% ethyl alcohol in November 2003, and herbarium voucher specimens prepared from the 11 mm and 86 mm treatments). This date was selected for harvesting because the plants had flowered and good vouchers could be collected.

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1. For further information on this group contact Dr S. W. L. Jacobs, Royal Botanic Gardens, Sydney, New South Wales, 2000, Australia.

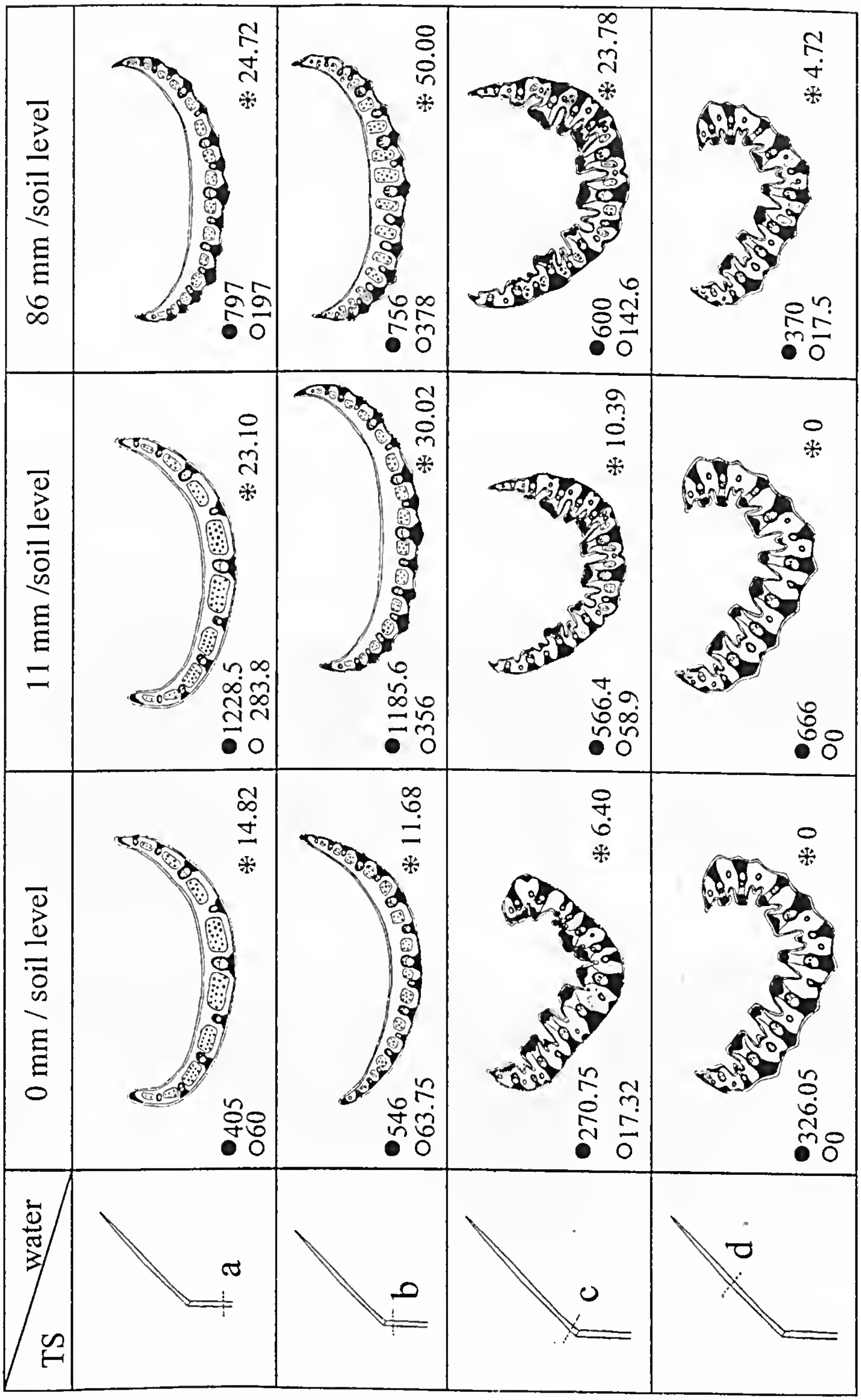

Fig. 1. Transections of leaves and sheaths of *Austrostipa aristiglumis*. Schemes representing: **a**, TS at the middle of the sheath; **b**, TS of sheath below the ligule region; **c**, TS of leaf beneath the ligule region; **d**, TS at the middle of the leaf. Legend: ● Total leaf area expresed in μm^2; O Total cavities area expresed in μm^2; ✻ relationship of air cavities to total leaf area expressed in %.

Transverse sections were made from leaves and sheaths of preserved specimens. Sections, from the middle segment of lamina and sheath and from 5 mm over and under the ligule portion, of the second or third lamina of a sterile innovation, were obtained either freehand or by embedding the material in wax and sectioning with a rotary microtome. The sections were stained with Alcian Blue/Safranin (Cutler 1978) and observed and photographied using a Leica DMLB optical microscope with a JVC digital camera. Drawings of the cross-sections were prepared using a camera lucida. Measurements of total leaf area and total cavities area were made with the IM50 Leica' software, averaged from 10 measurements each.

Results

Leaf anatomy in transection

The transection (TS) outline is U-shaped (Fig. 1). Both semilaminae may be symmetric or asymmetric (differing in one rib). The upper surface has ribs and deep (>50% of leaf thickness) and narrow furrows. Ribs alternate between large and flat-topped, and smaller and round-topped; larger ribs are coincident with one 1st or 2nd order vascular bundle (VB); smaller ribs are coincident with 3rd order vascular bundles (Figs 1, 2). The lower surface varies from flat to slightly angular.

The midrib is scarcely distinguishable with only one 1st order VB located in the centre of the transection (Figs 1, 2). Neither colourless parenchyma nor transitional parenchyma are associated with the midrib. There are subepidermal strands of sclerenchyma under both epidermes in the midrib (Fig. 1). In specimens growing in more than 10 mm of water aerenchyma is associated with the midrib, situated in channels, laterally to the VB in TS made 5mm above the ligule (Fig. 2); aerenchyma is not present in TS made in the midrib at the middle level of the leaf. When present, aerenchyma (and the corresponding lacunae in TS which contains it) represents 20 –40% of the TS.

The semi-laminae have >6 VBs, alternating 1st, 2nd and 3rd order; 1st and 2nd order are situated in the centre of the TS or towards the lower surface; all 3rd order VBs are towards the lower surface (Figs 1, 2). No colourless parenchyma is present in the semilaminae. Sclerenchyma is present under both epidermes, fragmented, in girders; sub-epidermal transitional parenchyma is also present adaxially. Sclerenchyma and transitional parenchyma produced over all types of VBs, heavily over 1st and 2nd order (Figs 1, 2). Aerenchyma in the basal portions of the semi-laminae is present in leaves of specimens growing with >10 mm of water in the tray, channels between VBs are present in 60% of the semi-laminae.The channels with aerenchyma occupy 20 –40% of the depth of the TS. The 1st order VBs in the semilaminae are elliptic to ovate, with a strand of phloem adjacent to the xylem. First order VBs have an outer vascular bundle sheath, and are abaxially and adaxially interrupted by transitional parenchyma or sclerenchyma girders; and have an inner sheath complete around the VBs (Fig. 2). Walls of cells of the inner sheath in contact with phloem are more thickened than the other sheath cell walls, the thickening in "U" or "O" form. Second order vascular bundles are elliptic, with the outer sheath complete around the VBs or abaxially interrupted only by sclerenchyma; the inner sheath is complete. Third order VBs are circular, with complete outer and inner sheaths. No extensions of the bundle sheath were seen.

Leaf margins are acute in TS, with sclerenchyma or transitional parenchyma in the margins (Figs 1, 2).

The epidermal cells in TS are smaller and thicker-walled over the VBs. Bulliform cells occur between all VBs, at the same level or slightly above the level of the other epidermal cells (Fig. 2). Epidermal hairs are absent.

Sheath anatomy in transection

The outline of the transection is permanently folded. The upper surface is flat; the lower surface is flat or ribs and furrows are slightly developed. There are more than 6 VBs in TS, alternating 1^{st}, 2^{nd} and 3^{rd} order, all located at the same level, in the centre of the TS or towards the lower surface (Figs 1, 2). No colourless parenchyma is present in the TS. Abaxially there is fragmented sclerenchyma below the epidermis, exceptionally also adaxially. Sclerenchyma or transitional parenchyma is associated with all types of VBs. Aerenchyma is present between all VBs, in lacunae, situated in the centre of TS, or closer to the abaxial surface occupying 40 –70% of the depth of TS, sometimes >70%.

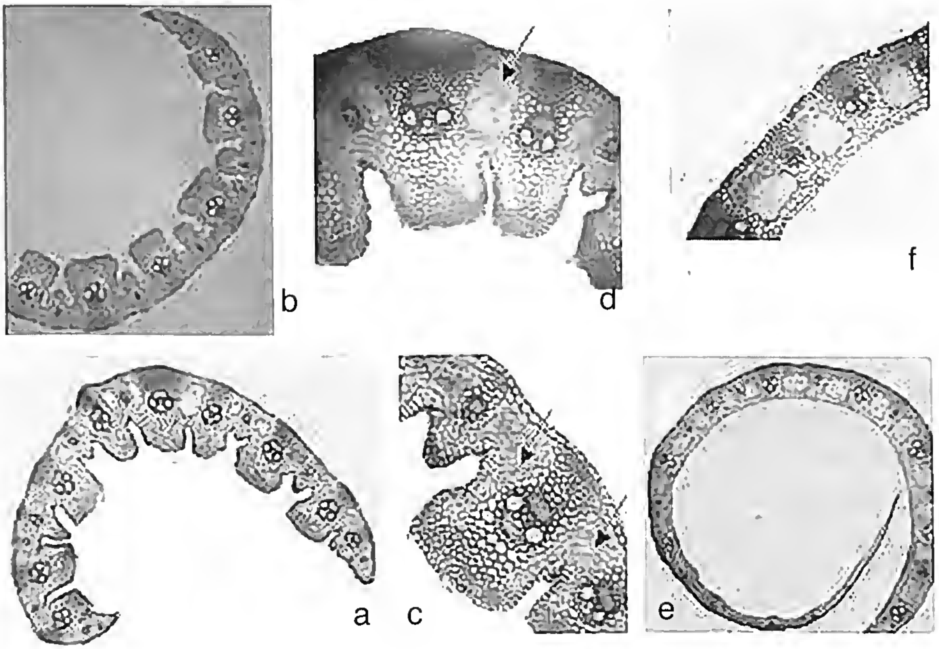

Fig. 2. Photomicrographs of *Austrostipa aristiglumis*. **a**, TS below the ligule region, showing air cavities developed on a leaf under 11 mm saturated soil treatment (35×); **b**, half of a TS below the ligule region, with no air cavities developed on a leaf under 0 mm saturated soil treatment (35×); **c**, TS of leaf showing bigger inter-cellular air spaces (arrows) in the first stage development of an air space cavity (70×); **d**, TS of leaf showing remains of cell walls from cells that have disintegrated to form an air cavity (100×); **e**, TS of sheath beneath the ligule region of a leaf under 86 mm saturated soil treatment (35×); **f**, detail of previous transection (70×).

First order VBs are ovate, with a strand of phloem adjacent to the xylem; the outer vascular bundle sheath abaxially is interrupted by sclerenchyma girders; inner vascular bundle sheaths are complete around the bundle. Second order VBs are elliptical, with an outer VB sheath abaxially interrupted by sclerenchyma girders, the inner sheath complete around the VB. Third order VBs are circular, with an outer sheath abaxially interrupted by sclerenchyma girders, and the inner sheath complete around the VBs.

No extensions of the bundle sheaths were seen (Fig. 2). Walls of the outer sheath cells are not thickened, walls of the inner sheath cells are "O" thickened, cells in contact with the phloem have thicker walls. Margins are acute in TS, with sclerenchyma or transitional parenchyma only in the margin.

Epidermal cells over the VBs are smaller and thicker in transverse section than the epidermal cells between. Epidermal hairs are absent.Tangential external walls of epidermal cells are thicker than internal walls. Stomata are in both epidermes or only in the adaxial epidermis.

The air canals have a lysigenous origin in both the leaf and the sheath. Close to the growing points, some cells separate from adjacents cells, developing larger spaces. Afterwards some cell walls begin to disintegrate and form cavities resulting in the building of big air channels along the sheath and up to the middle of the leaf. Remains of the cell walls can always be seen inside the air channels.

Discussion

Renvoize (1985) described the outstanding feature of the tribe Stipeae as the adaptation by many genera to dry habitats, reflected in the often xeromorphic nature of the leaf blade morphology and anatomy. Among the species listed at the end of his work is *Trikeraia hookeri* (Stapf) Bor but there is no mention of hydromorphic characters, despite *Trikeraia* being described as living by water (Clayton & Renvoize 1986), often on hummocks in bogs or swamps.

Austrostipa aristiglumis, on the other hand, is a species mostly growing on intermittently-flooded inland floodplains in semi-arid and sub-humid zones. These soils are dry most of the time.

Sculthorpe (1967) and Font-Quer (1970) described as amphibious those species that may live in dry soils flooded during a period of the year. One theory suggests that different groups or clades of angiosperms have retained different levels of vegetative plasticity that is manifiest in varying abilities to adapt to aquatic habitats (Arber1920; Sainty & Jacobs 1982; Jacobs & Wilson 1996). Amphibious species provide, in a structural and an ecological sense, a gradual transition between truly terrestrial and truly aquatic species (Sculthorpe, l.c.).

One characteristic of hydrophytous or amphibious species is the presence of air cavities that develop early in the different organs of the plant, while their number and size varies with the age and nature of the organ (Sculthorpe, l.c.).

The hydromorphic characters, stimulated by increasing soil saturation, presumably are an adaptation that allows *A. aristiglumis* to maximise its growth when water is available, even in "excess".

Aliscioni (2000) and Fabbri et al. (2006 in press) in their studies of the anatomy of the genus *Paspalum*, concluded that, under wet substrate conditions, species developed air cavities and aerenchyma and that this ability to develop air cavities represents a constant character. Aliscioni (2002) considered that this plasticity should be considered in systematic and phylogenetic analysis. We agree with that assessment, especially as *A. aristiglumis* represents the only known Stipoid species with hydromorphic plasticity, a characteristic that may have value in phylogenetic considerations.

Representatives of the *Stipeae* have been included in numerous molecular phylogenetic studies of grasses (Hsiao et al. 1999; Jacobs et al. 2000; Jacobs et al. 2006 in press); all show it to be a basal lineage within the *Pooideae*. Studies of the *Stipeae* molecular phylogeny (Jacobs et al. 2006 in press) support recognition of *Austrostipa* as a well-differentiated clade that includes *A. aristiglumis*. All the other species in that clade are adapted to live in xeric and semi-mesic habitats. Only *A. aristiglumis* has been observed to have the genetic adaptability and vegetative plasticity to capitalise on the intermittently-flooded habitat.

Conclusions

1) In *Austrostipa aristiglumis* the sheath structure in all cases (soil with normal water content or saturated soils) always has channels with aerenchyma; the channels increase in size with increasing saturation of the soil.

2) In *Austrostipa aristiglumis* the leaves show channels and aerenchyma in the lower part of the laminae, near the meristem and only in those samples living on the more saturated soils.

In any case, the channels and aerenchyma decreaeses and are completely lost towards the middle of the lamina.

3) In *Austrostipa aristiglumis* leaf and sheath air cavities have a lysigenous origin.

4) Most stipoid grasses have morphological and anatomical adaptations to mesic and xeric environments but *Austrostipa aristiglumis* is an unusual case of a stipoid grass adapted to intermittent flooding in inland south-eastern Australia, representing an amphibious plant.

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New taxa and combinations for *Oedogonium* and *Bulbochaete* (Oedogoniales, Chlorophyceae) in Australia

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Abstract

Fifteen new taxa in the Oedogoniaceae, the species ***Bulbochaete kakaduensis*** [for *B. elatior* sensu Scott & Prescott (1958)] ***B. rodwayi, Oedogonium bancroftii, Oe. capricornicum, Oe.cerasinum, Oe. cribbianum***, ***Oe. hardyi*** [for *Oe. monile* var. *victoriense* G.S.West] ***Oe. moebiusii*** [for *Oe. undulatum* var. *möbiusii* Schmidle] ***Oe. pilbaranum*** and ***Oe. utrarium***, and the varieties ***B. calospora*** var. ***murrayana, B. gigantea*** var. ***glabra, B. wuhanensis*** var. ***spechtii, Oe. kwangsiense*** var. ***playfairii*** and ***Oe. starmachii*** var ***weetalibahense*** are described. Two other taxa are new combinations: ***Oe. undulatum*** var. ***wissmanii*** for ***Oe. wissmanii*** Stephen Skinner and ***Oe. uleanum*** var. ***continuum*** for ***Oe. platygynum*** var. ***continuum*** Nordstedt ex Hirn.

Introduction

Seventeen taxa (8 species and 4 varieties of *Oedogonium*, 2 species and 3 varieties of *Bulbochaete*) require taxonomic review in preparation for an account of the Oedogoniales (Chlorophyta) for the Algae of Australia series. Most are new taxa and require formal taxonomic recognition. A few require revision of status, although previously described. The taxa are arranged in systematic order following Mrozińska (1991, 2000).

The earliest mention of *Oedogonium* from Australia in the literature is Sonder (1852) but without description or illustration. Next comes Berkeley and Harvey's (1860) enthusiastic description of *Oe. monile.* It was Baron von Mueller who laid the Australian foundation for freshwater phycology generally and whose enthusiasm sparked the first local interest in the Oedogoniales. Mueller encouraged people in all parts of the continent to send him curious and unexpected plants, and so received quite a few freshwater algal samples including numerous Oedogoniales. F.M. Bailey in Brisbane made a major contribution in the late 19th and early 20th Century. All three Bailey papers (1893, 1895, 1898) include *Oedogonium* and *Bulbochaete* species.

Hirn's (1900) world monograph of the Oedogoniales, the starting point for nomenclatural priority in this order, used collections from the herbaria of Mueller and Bailey, sent to V.B. Wittrock, M. Möbius, W. Schmidle and C.F.O. Nordstedt. Although Hirn did not designate types as such, there are ten taxa based solely on Australian

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collections. Four of these (and also numerous new desmid taxa) come from a single collection by T. Gulliver made 'between the Norman and Gilbert Rivers' in 1874. We have been able to find and view this collection, and some others from Australia, in LD, but not all Hirn 'types' could located. In the absence of voucher material, we have relied on protologues and subsequent monographs and floras to define existing taxa.

Further records of Oedogoniales from parts of Australia can be found in Scott and Prescott (1958) for Arnhem Land, Skinner (1980) for the New England Tableland of New South Wales, and the many contributions of Cribb to the Queensland Naturalist (see Day et al. 1995 for a list). Cribb (1956) provides the only report of *Oedocladium* in Australia.

This paper uses material from historical collections in AD, MEL and BRI, as well as recent collections forwarded to us from collectors across the continent and our own recent collections.

Methods

Recent collections were fixed in either 4% formaldehyde or 70% ethanol in the field, and sent to the National Herbarium of New South Wales where part of each sample was mounted in 40% Karo as semi-permanent slides, while the remainder of the specimen was stored in 70% ethanol and 5% glycerine. Slides were examined with a Leitz Dialux compound microscope and drawings made with a drawing tube. Collections from MEL, AD and BRI were also examined. Data sheets for each collection are also retained at NSW.

Oedogonium Link

Mrozińska (1991) defined 20 informal groups for *Oedogonium*, based on phylogenetic analysis. Later she (Mrozińska 1999) presented a new subgeneric classification and allocated her informal groups to this new infrageneric system, which we follow here. Mrozińska (pers. comm.) kindly provided us with a list of how she has allocated taxa within this new system.

Subgenus ***Archaeoedogonium*** Mrozińska (1999)

Cell walls, possibly excepting antheridia, helically striped with finely granulate or punctate outer surface; basal cell globose or depressed globose, vertically plicate. Antheridia either intercalary with single spermatozoids or in globose, single-celled dwarf males.

Group A

Macrandrous taxa.

Oedogonium cribbianum Stephen Skinner & Entwisle ***sp. nov.***

Oe. punctato-striatum sensu Cribb, *Lake Broadwater. The Natural History of an Inland Lake and its Environs*: 39 (1988)

Diagnosis: *Oedogonio fasciculato* simile, sed macrandro et oosporis globosis depressis dense verrucosisque.

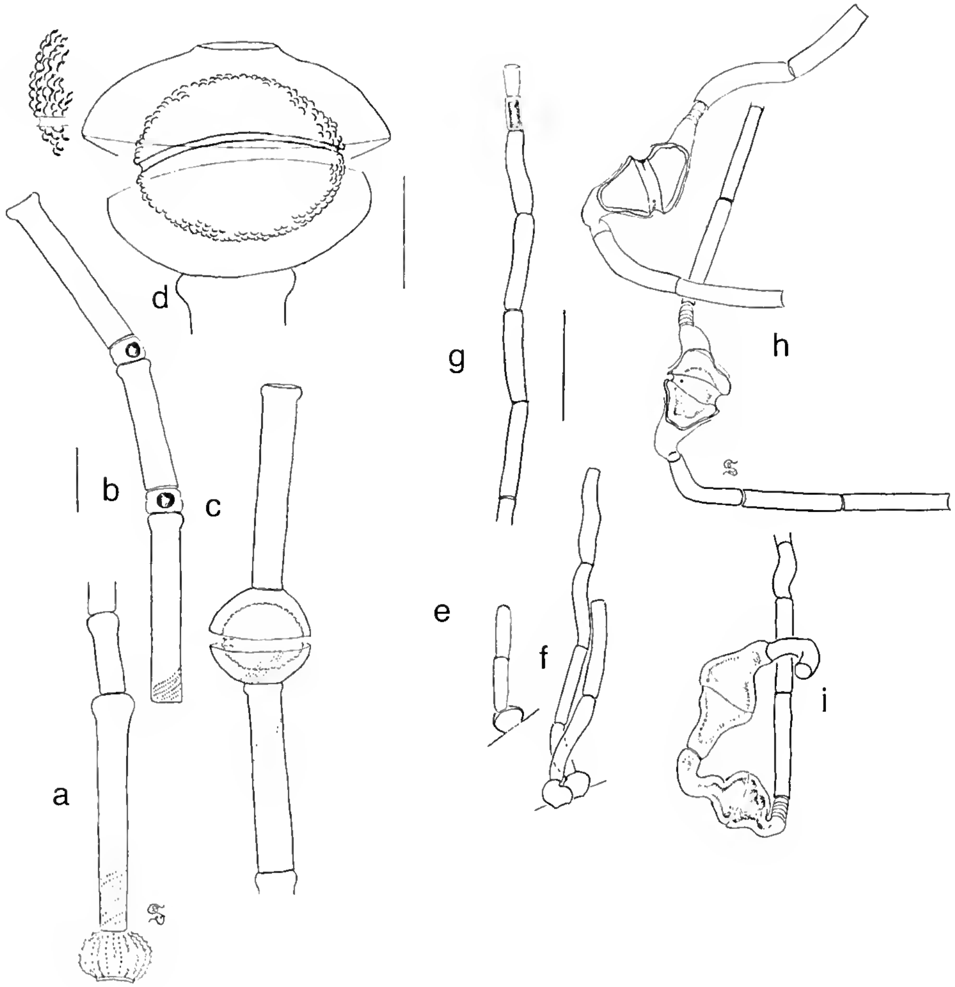

Fig. 1. *Oedogonium cribbianum*: a, basal cell; **b**, intercalary antheridia; **c**, oogonium with oospore; **d**, enlargement of oospore, with sketch of sculpturing (*Cribb 1090.4*); *Oe. utrarium*: **e,f**, basal cells; g, antheridia; **h**, solitary oogonia, with oospores; **i**, pair of developing oogonia (*Towler 283c & Wilson s.n.*). (Scales = 20 μm)

Type: Queensland: Surveyors Gully, Lake Broadwater (27° 21'S; 151° 06'E), *Cribb 1090.4*, 21 Feb 1987 (holo BRI).

Illustration: Fig. 1, a–d.

Macrandrous, monoecious or dioecious. *Vegetative cells* capitellate, finely helically punctate, L/D (3–)5–10, (14–)16–18 μm diam., chloroplast reticulate, few pyrenoids; *basal cell* hemispherical, vertically plicate, 12–15 μm long, 22–23 μm diam.; *terminal cell* shallowly domed. *Oogonium* solitary, globose to depressed globose, punctate, intercalary or occasionally terminal (and then with a domed top), circumcision median, wide at one side, 34–41 μm long, 40–44(–46) μm diam.; *oospore* depressed globose, not filling oogonium, golden to reddish golden, exospore banded verrucose, 29–32 μm long, 35–38 μm diam.; *suffultory cell* as vegetative cells, frequently L/D 3–4. *Antheridia* solitary to triple, short (L/D c.1.5) same width as surrounding vegetative cells, top opening, in groups with vegetative cells between, either several cells above or below an oogonium or on separate filaments, with one spermatozoid.

Etymology: named in honour of Professor Alan B. Cribb who has done so much to alert people to the fascination of freshwater algae.

Distribution: known from type locality in Queensland, on *Vallisneria* sp. and northern New South Wales on *Myriophyllum* sp.

Very similar to *Oe. fasciculum* Zhu (1964) from China but differs in not being nannandrous, and in having slightly more depressed oospores with more regular and dense cover of verrucae. Cribb's (1988) determination of *Oe. punctato-striatum* de Bary ex Hirn is superficially similar to the type, but that taxon has smooth oospores.

Specimens examined: Queensland: Surveyors Gully, Lake Broadwater, *Cribb 1090* subsamples, 21 Feb 1987 (BRI). New South Wales: North Western Slopes: quarry, 1 km W of township, Howell Rd, Tingha, *Skinner 0801, McPherson & Towler*, 13 Oct 2004 (NSW).

Subgenus ***Prooedogonium*** Mrozińska (1999)

Cell walls smooth; basal cells globose to depressed globose, hemispherical or if vase-like then a short goblet, L/D no more than 3. Antheridia with single spermatozoid, macrandrous or nannandrous, and then internal.

Section C

Macrandrous; basal cell hemispherical, occasionally short vase-like; oogonium usually depressed globose, oospore smooth walled.

Oedogonium utrarium Stephen Skinner & Entwisle ***sp. nov.***

Diagnosis: species bene distincta, cellula suffultoria reflexa, oogonio asymmetrico gleboso utriculoide, oospora quoque biconica sulcoque medio.

Type: Western Australia: pool in bed of tributary of Hammersley R., Fitzgerald River Nat. Pk (33° 46'S; 119° 43'E), *Towler 283c & Wilson,* 10 Aug 2003 (holo NSW).

Illustration: Fig. 1, e–i.

Macrandrous, dioecious. *Vegetative cells* narrow cylindrical, L/D 4–6, 2.5–3.5 µm diam.; *basal cell* irregular depressed globose, 4–5.5 µm high, 5–5.5 µm diam.; *terminal cell* truncated. *Oogonium* solitary or paired, irregularly saccate, , 23–28 µm long, 10–12 µm diam., circumcision median, wide; *oospore* irregular bi-conical, with median furrow, wall smooth but lumpy, not filling the chamber but forcing the circumcision open, 14–19 µm long, 10–12 µm diam.; *suffultory cell* as vegetative cell but reflexed, so that the filament is curled through 90–180°. *Antheridia* solitary or paired, terminal on separate filament, 5.5 µm long, 2–3 µm diam., single spermatozoid.

Etymology: from *utrarius* (Latin) a water-bag carrier in the Roman army. These water-bags were frequently made from whole goat or other animal skins, like wineskins, and the oogonia of this taxon are similar in shape.

Distribution: known only from the type locality, Western Australia, in a deep riverine pool on granite with aquatic grass, apparently forming a greenish layer close to the gravel.

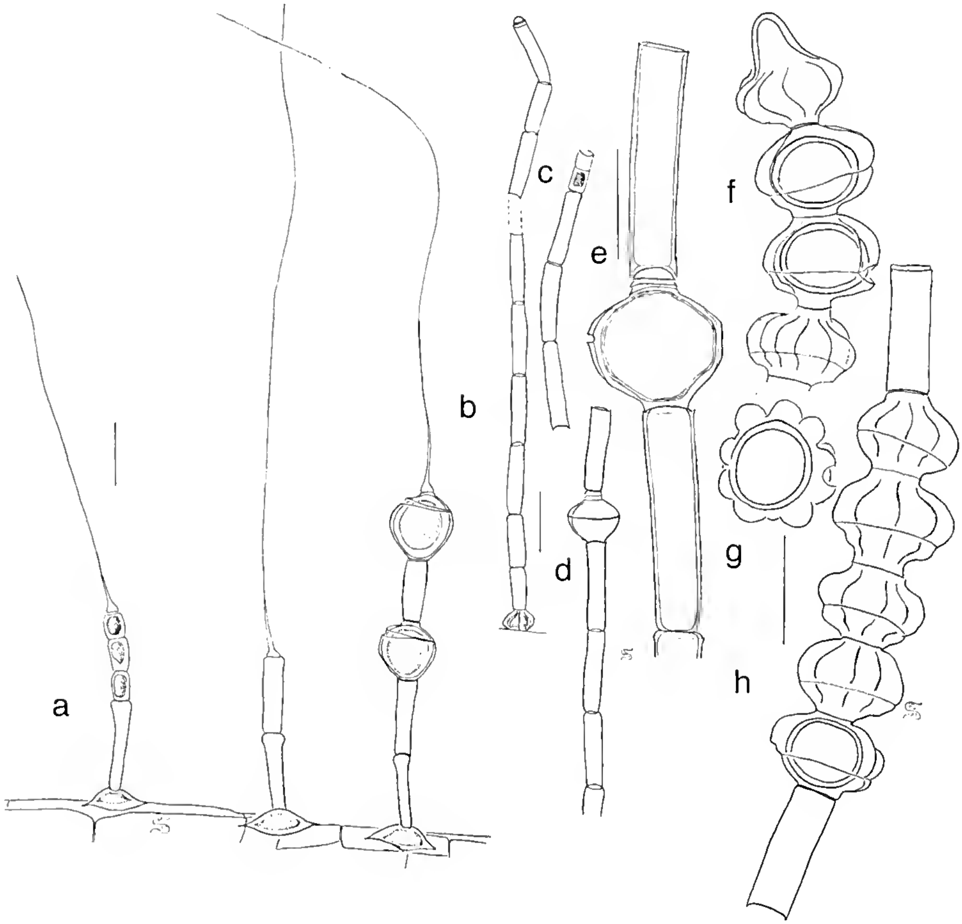

Fig. 2. *Oedogonium cerasinum*. **a**, individual antheridial, vegetative and oogonial thalli (*Cherry 446*); *Oe. pilbaranum*. **b**, vegetative filament; **c**, antheridia; **d**, oogonium; **e**, oogonium with mature oospore (*Edinger 3516*); *Oe. uleanum* var. *continuum*: **f**, terminal series of oogonia; **g**, top view of oogonium; **h**, intercalary series of oogonia (*Cribb 496.9*). (Scales = 20 µm)

While sharing vegetative characters with the rest of Group C, this taxon is distinctive in possessing the bent suffultory cell and the lumpy, irregular, wineskin-shaped oogonium as well as the bi-conical oospore with a median furrow. There are no other taxa with similar oogonia.

Oedogonium cerasinum Stephen Skinner & Entwisle ***sp. nov.***

Diagnosis: *Oedogonio fremyi* simile sed oogonio pyriformi angulari et cellularibus vegetativis capitellatibus celluloque basi hemispherico.

Type: Western Australia: Brixton Street wetland, Kenwick, Perth (32° 22'S; 115° 56'E), *Cherry 446*, 9 Sept 2002 (holo NSW).

Illustration: Fig. 2, a.

Dioecious, macrandrous. *Vegetative cells* capitellate, 15–23(–26) µm long, (3–)6–6.5 µm diam., three to seven or eight in a whole plant; *basal cell* shallow hemispherical, 3–5 µm high, 35–50 µm diam.; both male and female plants terminate in a very long, (up to three or four times the length of the rest of the thallus) fine seta. *Oogonium* pyriform to angular pyriform, 15–21 µm long, 17–20 µm diam., often acropetal, opening by a supreme hinged pore (or partial circumcision); *oospore* closefitting oogonium, pyriform to angular pyriform, wall smooth, thick, laminated, mesospore yellowish to cherry red, 14–20.5 µm long, c.17–20 µm diam. *Antheridia* paired, below seta on male plant, chambers 6–8.5 µm long, 6 µm diam, single spermatozoid.

Etymology: as the oogonia are cherry-shaped, the mesospore cherry red in colour and the collector was Wayne Cherry, *cerasinum* (Latin) for cherry-like seems appropriate.

Distribution: known only from the type locality, Western Australia, where it is epiphytic on fine, terete stems of water plants in both still and moving water.

Oedigonium cerasinum is one of a number of species with few-celled filaments, including *Oe. mirpurense* Islam, *Oe. fremyi* Gauth.-Lièvre, *Oe. nanum* Wittr. ex Hirn, *Oe. capitellatum* Wittr. ex Hirn, *Oe. sphaerandrium* Wittr. & Lundell ex Hirn, and *Oe. longipilum* Jao. *Oe. cerasinum* is distinctive in the following combination of characters: dioecious, distinctly angular pyriform oogonia, and a shallowly hemispherical basal cell. It is closest to *Oe. longipilum* and *Oe. fremyi*. It shares a terminal seta and supreme circumcision with *Oe. longipilum*, but that species has a short, vase-shaped basal cell, and ovoid oogonia, sometimes in pairs. *Oe. fremyi* has a supramedian circumcision, the oogonium is globose, the basal cell is diffuse and the vegetative cells are less consistently capitellate than *Oe. cerasinum*.

Group G

Macrandrous; basal cell shortly vase-like; oogonium opening through a median to superior pore, or pore and slit; oospore smooth.

Oedogonium pilbaranum Stephen Skinner & Entwisle ***sp. nov.***

Diagnosis: *Oedogonio rufescente* simile sed in dimensiones minore atque circumcissione oogonii rostrato.

Type: Western Australia: 28 km SSW of Turee Creek Station (23° 52'S; 118° 32'E), *Edinger 3516*, 9 May 2003 (holo NSW).

Illustration: Fig. 2, b–e.

Macrandrous, dioecious. *Vegetative cells* cylindrical or slightly capitellate, L/D 3–10, 7–8 µm diam.; *basal cell* depressed globose, slightly undulate, c.10 µm tall, 13–14 µm diam.; terminal cell ending in a shallow cap. *Oogonium* solitary or paired, depressed globose to spindle-like, 20–26 µm long, 20–23 (–25) µm diam., opening a supramedian pore or short slit; *oospore* depressed globose, smooth walled, filling chamber, mesospore brown, 18–19 µm long, 20 µm diam.; *suffultory cell* as vegetative cells. Antheridia intercalary or acropetal, in pairs, 7–10 µm long, c.7 µm diam.; single spermatozoid.

Etymology: from Pilbara, the region of Western Australia from which the sole collection was made.

Distribution: known only from the type locality, Western Australia, in a permanent seepage.

Although very close to the cosmopolitan *Oe. rufescens* Wittr. ex Hirn, this specimen shows a globose basal cell, more similar to those of *Oe. inversum* Wittr. ex Hirn and *Oe. infirmum* Tiffany, and the oospore is more nearly globose, not tending to be laterally ovoid/elliptical. The oospore fills the chamber and conforms to its shape to some extent, exhibiting a slight dome below the terminal dome of the oogonial chamber.

Subgenus ***Oedogonium*** Mrozińska (1999)

Cell walls smooth; basal cell short to elongate vase-shaped, usually with a basal disc which may be clawed.

Supersection *Monospermatozoidiae*

Antheridia with single spermatozoid; in nannandrous species either internal in goblet-like dwarf male, or extruded from the body cell, with diffuse antheridial walls.

Group E

Macrandrous or nannandrous; dwarf males with internal antheridia; basal cell shortly vaselike; oogonia with median whorl of projections or ribs.

Oedogonium uleanum Hirn, *Acta Soc. Sci. Fenn.* 27: 311 (1900).var. ***continuum*** (Nordstedt) Stephen Skinner & Entwisle ***comb.nov.***

Oedogonium platygynum var. *continuum* Nordstedt, *Bot. Not.*: 153 (1887).

Oe. platygynum var. *continuum* Nordstedt ex Hirn (1900).

Type: New Zealand: Ohaeawai, (35° 21'S; 173° 53'E), *Berggren(64)*: Herb Nordstedt, (LD n.v.).

Illustration: Nordstedt op cit: Pl. 1, figs 16, 17; hic Fig. 2, f–h.

Dioecious, macrandrous. *Vegetative cells* cylindrical to slightly capitellate, L/D 2.5–3.5, 7–8 µm diam.; *basal cell* not seen; *terminal cell* obtusely capped. *Oogonia* solitary, in pairs, threes, fours (common) or fives, depressed globose, 13.5–23 µm long, 18–25 µm diam., flanges prominent rounded mamillate, circumcision submedian; *oospore* depressed globose to spherical, not filling the chamber, 14–18 µm diam.; *suffultory cells* similar to vegetative cells. *Androsporangia*, dwarf males or antheridia not observed.

Distribution: Queensland in seepage on upper shelf near entrance of cave, and in New Zealand.

The Queensland and New Zealand collections are of the same taxon. Nordstedt (1887, 1888) described the New Zealand taxon as a variety of *Oe. platygynum* Wittr. ex Hirn. However *Oe. platygynum* var. *platygynum* is described as nannandrous and figured with dwarf males, and the flanges are rounded. Nordstedt (1887) contains the six word protologue for *Oe. platygynum* var. *continuum* Nordstedt, while the illustrations, including the antheridia/androsporangia, are in Nordstedt (1888).This taxon is clearly a macrandrous taxon, and the flanges are often slightly truncated. Although the oogonia and oospores are rather smaller than *Oe. uleanum* as described in Hirn (1900) (oogonia 28–32 µm diam., 21–26 µm long) the Queensland and New Zealand collections have oogonia in series and otherwise fit closer to *Oe. uleanum* than *Oe. platygynum*. Interestingly Hirn (1900, p. 279) queried the position of *Oe platygynum* var. *continuum* and expressed the desire for more information. “Für die Var. *continuum*, die leider noch wenig bekannt ist, sind die reihenständigen Oogonien und die abgestutzte Form der Oogoniumvorsprünge hervortretende Merkmale.” [As for the var. *continuum*, unfortunately we do not know as yet if having oogonia in series and truncated oogonial wall flanges are characteristic enough to make it distinct.] This record from Queensland was not included in Cribb (1965).

Specimens examined: Queensland: Paradise Cave, Noosa Heads, *Cribb 496.9*, 13 Oct 1962 (BRI).

Group P

Nannandrous; dwarf males with a basal cell and internal antheridia later extruded; vegetative cells may have undulate walls; oogonia with inframedian to supramedian circumcision; oospore smooth or variously sculptured.

When establishing this group Mrozińska (1991) allowed only *Oe. undulatum* and *Oe. croasdaleae* Jao as examples, and later listed *Oe. undulatum* var. *undulatum* f. *undulatum* and f. *senegalense*, *Oe. undulatum* var. *americanum* Transeau f. *americanum* and f. *serriatum* (Prescott) Mrozińska, *Oe. mirificum* Zhu and var. *minus* Jao, *Oe. croasdaleae* and f. *goczalkowicensis* Mroz. Webb in the group (Mrozińska, pers. comm.). We have adopted a much wider definition here, based on comparison of the dwarf male structures in *Oe. undulatum* with those in *Oe. hians* Nordstedt & Hirn in Hirn, *Oe. monile* and similar taxa, where the antheridial cell appears to be extruded from the body cell and to contain only a single spermatozoid at a time. The fine structure of dwarf males of members of this group requires examination similar to Leonardi et al. (1998) for *Oe. pluviale* Nordst. ex Hirn.

Oedogonium moebiusii Stephen Skinner & Entwisle ***sp. nov.***

Oedogonium undulatum var *möbiusii* Schmidle, *Flora* 82: 297, fig.1 (1896). Type: Burpengary, *Bancroft*; 1894?: Herb. Schmidle (B probably lost, n.v.).

Diagnosis: a *Oedogonio undulato* parietium tholis concavis in ambobus cellulibus vegetabilis androsporangiisque differt.

Type: Queensland: Peregian Beach (26 30’S; 153° 06’E), *Peberdy s.n.*, Sept 1973: (holo BRI).

Illustration: Fig. 3, a–d.

Nannandrous, gyn- or more frequently idioandrosporous. *Vegetative cells* undulate with 4 invaginations, 3 complete, 2 short, flat to concave vaults, L/D 3–4(–5), 15–22 µm diam.; *basal cell* vase-shaped, smooth walled; *terminal cell* with domed cap (sometimes as terminal oogonium). *Oogonium* spherical, inframedian hinged pore becoming circumcision, solitary, paired or up to 6 in a row, 46–75(–87) µm long, 44–64(–75) µm diam.; *oospore* spherical, 44–58(–67) µm diam., thick walled, lamellate and occasionally with faint denticulations below outer wall, chinese-red mesospore, almost filling oogonium,; *suffultory cell* similar to vegetative cells, but at the broad end

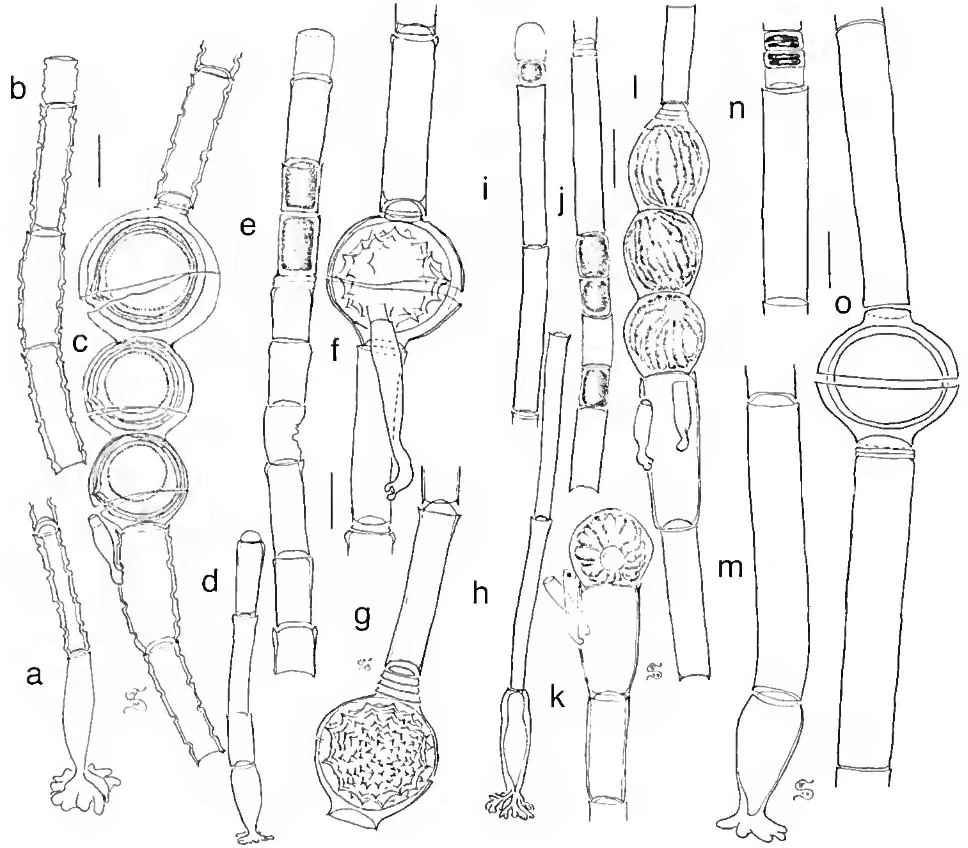

Fig. 3. *Oedogonium moebiusii*: **a**, basal cell; **b**, androsporangium; **c**, series of oogonia with oospores and dwarf male (*Peberdy s.n.* BRI704656); *Oe. hardyi*: **d**, new thallus with basal cell and terminal cap; **e**, intercalary androsporangia; **f**, oogonium with oospore and dwarf male; **g**, mature oospore (*Towler 283a & Wilson*); *Oe. kwangsiense* var *playfairii*: **h**, basal cell; **i,j**, androsporangia; **k**, terminal oogonium; **l**, series of oogonia with oospores (*Cherry 447*); *Oe. capriconicum*: **m**, basal cell; **n**, intercalary antheridia; **o**, oogonium with oospore (*Reid 270103.04*). (Scales = 20 µm)

of sizes, 19–23 µm diam.. *Androsporangia* undulate walled, 1–3(–4), often below the groups of oogonia, c. 15 µm long, c. 12 µm diam.; dwarf male on suffultory cell, curved vase-shaped body cell, 28–44 µm long, 8–12 µm diam., upper internal antheridium, 6–9 µm long, 6 µm diam. (body cell as lower antheridium), single spermatozoid.

Distribution: fertile material from Western Australia, South Australia, New South Wales and Queensland, with vegetative material noted for Victoria, in still or slow flowing habitats; Argentina, probably widespread (sometimes reported as f. *incisum* Hansg. or f. *senegalense* Nordst.).

Schmidle's iconotype is of a poorly sketched vegetative fragment, and Bancroft's specimen appears to have been lost. We have used the Schmidle epithet to describe a new species rather than make a new combination based on inadequate material.

Peberdy s.n. has all reproductive structures, and is from coastal south-eastern Queensland like the Bancroft collection. Hirn (1900), in a long and strongly worded discussion of the variation in *Oe. undulatum* sens. lat., insists that he found no consistency in the vaulting of undulations of cells even within the same filament. There is no distinction made between '*integris*' and '*repandis*' cell kinds in the Hirn (1900) protologue until you get to the various forms: 'integris' referring to those forms with the evenly undulate wall outline, and 'repandis (= bent back)' to those with the concave wavetops. Formae δ and ε of *Oe. undulatum* and the subforma below *Oe. undulatum* f. *senegalense* (Nordstedt) Hirn all show what Hirn called repand waves. Hirn (1900) quotes Hansgirg as being of the same opinion, even though forma β *incisum* Hansg. is Hansgirg's (1886) published interpretation, and he was confident enough to distribute exsiccatae under that name. Herring (1914) illustrated reproductive material of forma ε and contended that it was the common forma in Schleswig-Holstein. A clear illustration of both wall forms is given in Fig. 5c in Velez (1995).

Hirn's observation has not been the experience with Australian material examined for this study. Communities of filaments with either smoothly undulate cells or with concave vaulting have been the norm, all cells in any filament being similar in wall form. Intergrading forms, if present at all, are extremely rare. There are three known sites (Brixton St wetland, Ham Common, and Collector) where both forms of filaments may be found in the same sample, but the cells are consistent within each filament. Vélez (1995) pointed out that culture studies of filaments of various forms of *Oe. undulatum* sensu lato should clear up this problem once and for all, a sentiment with which we concur. Preliminary results indicate that culture strains are morphologically consistent (Vélez, pers. comm.). Culture studies may also demonstrate the worth of Hirn's other subgeneric character in *Oedogonium undulatum*, number of oogonia in sequence, which in Australian material of both *Oe. moebiusii* and *Oe. undulatum* varies widely within any one sample. With significant vegetative and reproductive differences, there is strong support for the distinction between these two varieties of *Oe. undulatum*. Collections of sterile filaments fitting *Oe. moebiusii* in Australia can be separated readily from filaments of *Oe. undulatum* (4 inflexions and 3 domes with 2 half-domes).

Specimens examined: Queensland: Peregian Beach, *Peberdy s.n.*, Sep 1973 (BRI). New South Wales: Southern Tablelands: Collector Ck, Collector, *Skinner 0543*, 4 Jan 2002 (NSW). Central Coast: Centennial Park, *Lucas s.n.*, – Sep 1915 (NSW); Lake Nadumgamba, Mt Annan Bot. Gdn, *Ling s.n.*, 22 Oct 2001, and *Coveny 18980*, 22 Nov 2001 (NSW). Northern Tablelands: Barleyfields Lagoon, TSR paddock, near Uralla, *Brock s.n.*, 6 Feb 2002 (NSW). North Western Slopes: quarry, Howell Rd 1km W of Tingha, *Skinner 0801, McPherson & Towler*, 13 Oct 2004 (NSW). South Australia: 6 km NW Beachport, towards Robe, *Skinner 0556*, 14 Nov 1978 (NSW); transient pool, main pond, Piccaninnie Ponds Cons. P., *Skinner 0446, Arnold & Towler*, 1 Oct 2001 (NSW). Western Australia: Fernbrook Falls, Deep R., Mt Franklin N.P., *Entwisle 2392*, 5 Jan 1994 (MEL); Brixton St wetland, Kenwick, *Cherry 447*, 9 Sep 2002 (NSW); Lake Gillon, Gillon St, Karawarra, *Skinner 0577, Casanova, Garcia & Novis*, 3 Oct 2002 (NSW).

Oedogonium undulatum (Bréb.) A.Braun ex Hirn, *Acta Soc. Sci. Fenn* 27: 257 (1900) var. ***wissmanii*** (Stephen Skinner) Stephen Skinner & Entwisle ***comb. et stat. nov.***

Oedogonium wissmanii Stephen Skinner, *Proc. Linn. Soc. N.S.W.* 104: 261 (1980).

Type: New South Wales: Northern Tablelands: Bullock Ck (30° 07'S; 152° 15'E), *Skinner s.n.*, Dec 1974 (NSW!).

Illustration: Skinner, op.cit.: fig. 3.3a–c.

Nannandrous, idioandrosporous. *Vegetative cells* evenly undulate with four grooves and five domes, L/D 2.5–4, 15–27(–30) µm diam., few large pyrenoids; *basal cell* tall, waisted vase shaped with digitoid holdfast,: *terminal cell* (sometimes oogonium) with domed cap. *Oogonium* solitary or in series 2–6, globose, 57–88 µm long, 45–72 µm diam., inframedian hinged circumcision; *oospore* globose, 56–67 µm diam., outer wall thick, opaque, often with a pinch opposite the opening of the circumcision, mesospore chinese-red; *suffultory cell* variable, from as vegetative cells to tumid, 18–28 µm diam. *Androsporangia* solitary or in series 3–5, two undulations, 16–23 µm long, 11–16 µm diam.; dwarf male narrow clavate, 45–54 µm long, 9–11 µm diam., antheridia internal, single spermatozoid.

Distribution: Western Australia, Northern Territory, New South Wales and Queensland, in both still and running water.

We have submerged the Skinner (1980) taxon in *Oe. undulatum* as var. *wissmanii*, for Australian material, because the undulate androsporangia which distinguish this variety from *Oe. undulatum* var. *undulatum*, were previously mistakenly described as antheridia in Skinner (1980). The type slides of *Oe. wissmanii* show 1) *Oe. undulatum* var. *undulatum*-like vegetative cells, 2) androsporangia with the undulate walls, and 3) no dwarf males on the oogonium. More recent collections confirm the presence of dwarf males similar to those of the type variety. The width of cells in the same filament in wild populations may vary by a factor of two in a distance of ten or fewer cells.

Novis (2003) appears to have a similar taxon, cited as *Oedogonium* sp. aff. *Oe. wissmanii*, from Chatham Island, New Zealand.

Specimens examined: Queensland: Sir John Chandler Park, Brisbane, *Peberty s.n.*, 17 Jul 1964 (BRI). New South Wales: Northern Tableland: Bullock Ck, *Skinner s.n.*, Dec 1974 (NSW). Central Coast: Nepean R., Yarramundi Bridge, Agnes Banks, *Skinner 0335 & McPherson*, 9 Aug 2001 (NSW); The Driftway, Richmond, watermeadow, *Skinner 0337 & McPherson*, 9 Aug 2001 (NSW); Ham Common, Richmond, watermeadow, *Skinner 0338 & McPherson*, 9 Aug 2001 (NSW). Northern Territory: Douglas R., u/s Douglas Hot Springs, *Padovan & Mecalfe A129*, 20 Aug 2003 (NSW). Western Australia: Brixton Street wetland, Kenwick, *Cherry 447*, 9 Sep 2002 (NSW).

Oedogonium hardyi Stephen Skinner & Entwisle *sp. nov.*

Oe. monile Berkeley & Harvey ex Hirn f. *victoriense* G.S.West, *J. Linn. Soc.* 39: 45 (1909). Type: Victoria: Yan Yean Reservoir, macrophytic benthos, *A.D. Hardy s.n.*, 2 Dec 1905 (BM, reported dried out 2004).

Diagnosis: Aut grande aut grandiore *Oedogonio monile* var. *eminente*, sed circumcisione oogonii medio, strato medio exosporae stellato spiraleque, stipa nannandrii longissima et gracile.

Type: Western Australia: tributary Hammersley R., Fitzgerald River Nat. Pk (33° 46'S; 119° 42'E), *Towler 283a & Wilson* 10 Aug 2003 (holo NSW).

Illustration: Fig. 3, e–g.

Nannandrous, gyn- or more often idioandrosporous. *Vegetative cells* regular cylindrical, L/D 4–7(–8), 11–15(–20) µm diam., ♂ usually finer; *basal cell* tall vase-like, 70–75 µm long, 15–16 µm diam.; *terminal cell* with domed cap. *Oogonium* solitary or paired (the upper one slightly larger than the lower one), globose, 58–81 µm long, 52–61 µm diam., circumcision median or submedian; *oospore* globose, 38–45(–51) µm diam., outer exospore smooth, inner exospore tightly spiraled serrations, mesospore red; *suffultory cell* slightly tumid, to 20 µm diam. *Androsporangia* intercalary, solitary or paired, if gynandrosporous then well above oogonia, 23–25 µm long, 18 µm diam.; dwarf males long narrow clavate, 91–104(–113) µm long, 8–11 µm diam., two spermatozoids formed one above the other in tip, faintly septate.

Etymology: commemorates Alfred Douglas Hardy, the Victorian botanist who sent numerous specimens to G.S. West in the 1900's and 1910's and continued to study phytoplankton in Victorian reservoirs until the 1950's (Entwisle 1990). The name *Oe. victoriense* West has been used for a different taxon.

Distribution: Western Australia and Victoria, in ponds and river pools.

The description in West (1909) is extremely brief, highlighting the length of the dwarf males, but the iconotype shows the spore wall with evenly spaced teeth. As the inner exospore wall of *Oe. monile* has longitudinal serrated ribs, and that of *Oe. hardyi* has a tight spiral of teeth, West's (1909) figure 6a–b appears to fit the latter more closely.

The suffultory cell develops first, upon which dwarf males mature before the oogonia are initiated. The form of the dwarf males with internal antheridia, the morphology of the oospore, with a wide exospore sculptured below the outer layer, and general aspect similar to *Oe. undulatum* and *Oe. monile* suggest a position in Group P. The presence of a few short rhizoids on the base of the dwarf males may also indicate affinities with Group Q.

Specimens examined: Victoria: pond opposite Phillip Island Information Centre, New Haven, *Entwisle 3133*, 29 Dec 2001 (NSW). Western Australia: tributary of Hammersley R., pool in river bed, Fitzgerald River Nat. Pk, *Towler 283a & Wilson*, 10 Aug 2003 (NSW); Brixton Street wetland, Kenwick, *Cherry 448*, 9 Sep 2002 (NSW).

Oedogonium kwangsiense Jao, Bot. Bull. Acad. Sin. 1: 85 (1947) var. ***playfairii*** Stephen Skinner & Entwisle ***var. nov.***

Diagnosis: *Oedogonio kwangsiensi* var. *kwangsiensi* simile sed costis undulatis levigatisque in oospora.

Type: Western Australia: Brixton Street wetland, Kenwick (32° 01'S; 115° 58'E), *Cherry 447*, 9 Sep 2002, (holo NSW).

Illustration: Fig. 3, i–l.

Nannandrous, idioandrosporous. *Vegetative cells* regular cylindrical, L/D 5–8, 40–74 µm long, (7–)10–19 µm diam., ♂ frequently narrow, 6–8 quite large pyrenoids; *basal cell* tall, narrow vase-like, 50–55 µm long, 10–12 µm diam., sometimes flattened on one side, holdfast digitoid; *terminal cell* (often oogonium) with rounded or shallowly peaked cap. *Oogonium* solitary to 3 in series, globose to ovoid, 32–44(–50) µm long, 32–36(–41) µm diam., (pore and) circumcision superior; *oospore* globose to barrel-shaped, top and bottom inset, oblique in the chamber, 35–39 µm long, 33–35 µm diam., inner exospore with broad, deep, undulate costae, mesospore ruby red; *suffultory* *cell* 48–70 µm long, 25–29 µm diam. *Androsporangium* intercalary, single or paired, in groups, 11–16 µm long, 10–13 µm diam.; dwarf males clavate, on suffultory cell, body cell 29–35 µm long, 4.5–6 µm diam., antheridium with single spermatozoid extruded at maturity.

Etymology: commemorates George Israel Playfair, the honorary freshwater phycologist associated with the National Herbarium of New South Wales from 1902 to 1923. In the draft manuscript of his Census (Playfair 1917) Playfair notes '*Oedogonium* sp. long corrugate spore' from Broughton Island, but did not complete the determination or include this collection (*Bottle 29*) in the Census or any other publication.

Distribution: Western Australia and New South Wales, in coastal wetlands.

The Brixton Street wetland sample contains numerous filaments with terminal solitary oogonia and the general aspect of the cosmopolitan *Oe. acrosporum* de Bary, but the equally common occurrence of intercalary series of oogonia and the pronounced depth of the costae favour inclusion in *Oe. kwangsiense* from China. The Australian material comes close to the type form of *Oe. kwangsiense* but has cylindrical cells, the costae are broad and smooth, and the basal cells are tall vase-shaped with a digitoid holdfast. This taxon is idioandrosporous, and the antheridium, while the fragile wall is persistent, appears to be extruded from the body cell of the dwarf male, rather than being a separate cell of a small plant as in both *Oe. acrosporum* de Bary ex Hirn and *Oe. tentoriale* Nordstedt & Hirn in Hirn.

Specimens examined: New South Wales: North Coast: Broughton Island, *Dr E. Stokes (Playfair 29, 30)*, –1903? (NSW). Western Australia: Brixton Street wetland, Kenwick, *Cherry 447*, 9 Sep 2002 (NSW).

Supersection *Dispermatozoidiae*

Antheridia with paired spermatozoids. In macrandrous species the spermatozoids may be horizontal, that is lying in the antheridium one on top of the other, or vertical, where the spermatozoids are found side by side. In nannandrous species the dwarf male plantlet consists of a persistent body cell, sometimes a narrow vegetative cell, and above one or a series of discrete, external antheridia, each with two spermatozoids.

Group L

Macrandrous; spermatozoids one above the other in intercalary antheridia; oogonium opening a circumcision.

Oedogonium capricornicum Stephen Skinner & Entwisle ***sp. nov.***

Diagnosis: *Oedogonium* oogonio collari cylindrico aut terminale aut basale, circumcisione oogonii medio.

Type: Queensland: Burdekin River, downstream from Highway crossing, near Ayr (19° 37'S; 147° 24'E), *Reid 270103.04*, 27 Jan 2003 (holo NSW).

Illustration: Fig. 3, m–o.

Dioecious, macrandrous. *Vegetative cells* cylindrical, chloroplast reticulate, many small pyrenoids, slight sexual dimorphism, L/D (5–)8–12, (20 ♂–)23–32 µm diam.; *basal cell* elongate goblet-shaped, ridged disc, c. 80 µm long, c. 32 µm diam.; *terminal cell* domed.

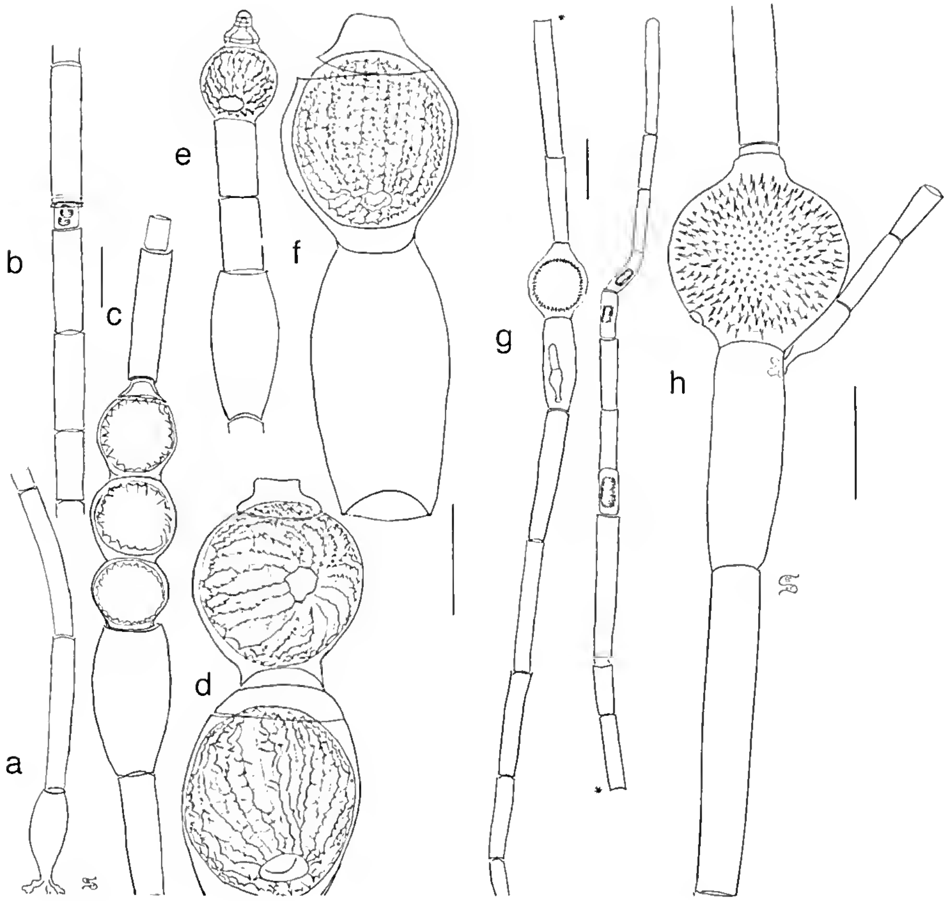

Fig. 4. *Oedogonium bancroftii*: **a**, basal cell; **b**, intercalary antheridium; c, empty antheridium above series of oogonia and suffultory cell; **d**, oospores in intercalary oogonia; **e**, terminal oogonium at a distance from suffultory cell; **f**, oospore in terminal oogonium (*Cribb 587.1*); *Oe. starmachii* var. *weetalibahense*: **g**, oogonium with dwarf male and suffultory cell, and androsporangia above, in same filament; **h**, oogonium with mature oospore, and multicellular dwarf male (*Dingley 050603.4a/b*). (Scales = 20 µm)

Oogonium globose to slightly depressed globose, (63–)68–82 µm long, (68–)77–84 µm diam., with collar top and/or bottom, stained with tannin, median circumcision, narrowly open, internal pore; *oospore* globose to depressed globose, 59–61 µm long, 59–65 µm diam., smooth exospore, red mesospore; suffultory cell as vegetative cells. *Antheridia* solitary to groups of 4–8, 8–14 µm long, 16–20 µm diam., with a short supporting cell at least in initial stages, spermatozoids paired, horizontally separated.

Etymology: from the Tropic of Capricorn which covers the northern third of Australia, where this taxon is encountered.

Distribution: Tropical Australia.

A distinctive taxon and difficult to place. It has a lantern-shaped oogonium with a well defined median circumcision and thickened wall, which would place it close to *Oe. pratense* Transeau (1914) in subgenus *Prooedogonium*, or the nannandrous *Oe. confertum* Hirn and *Oe. perspicum* Hirn in Supersection *Monospermatozoidiae*. Paired spermatozoids in antheridia in small belts, a vase-shaped basal cell and dimensions and general vegetative form that agree with larger members of the subgenus *Oedogonium*, suggest its placement there, in Group L.

Specimens examined: Queensland: Type and Burdekin R., downstream from highway crossing, near Ayr, *Reid 270103.05*, 27 Jan 2003 (NSW). Western Australia: Camp Ck, Mitchell Plateau, *Kenneally 11765a*, 18 Jun 2002 (NSW);

Oedogonium bancroftii Stephen Skinner & Entwisle ***sp. nov.***

Diagnosis: *Oedogonio areolato-costato* simile sed oosporibus globosis vel subglobosis et proportionibus minoribus.

Type: Queensland: Lake Weyba, near Noosa (26° 27'S; 153° 05'E), *Cribb 587.1*, 26 Jul 1964 (holo BRI 704657).

Illustration: Fig. 4, a–f.

Monoecious/dioecious macrandrous. *Vegetative cells* narrow cylindrical, at first slightly capitellate near basal cell, L/D (5–)6–9(–10), (8–)9–11 µm diam.; *basal cell* elongate vase-like, basal pad deeply costate; *terminal cell* usually with blunt peaked cap. *Oogonium* spherical to ovoid, (27–)34–45 µm long, (29–)34–36 µm diam., circumcision superior, solitary, paired, triples and fours common, five in a row occasional; *oospore* spherical to subglobose, top and bottom inset, 31–34 µm diam., smooth on very outside, longitudinally denticulate-costate from basal and apical rings, some forking and anastomosis, inside, mesospore red?; *suffultory cell* terminally widely tumid, 27–32 µm upper diam. *Antheridium* solitary, either subepigynous or intercalary, 12–14 µm long, c. 9 µm diam.; spermatozoids 2, horizontally displaced.

Etymology: commemorated Dr Thomas Lane Bancroft, prominent epidemiologist and assiduous collector of natural history specimens throughout Queensland from the late 19th Century to WWI.

Distribution: known only from Queensland, associated with *Oe. varians* among stoneworts in coastal tidal lake (Cribb's notes state 'highly saline').

As the oogonia appear to develop sequentially, one or two short cylindrical cells may be found between the tumid suffultory cell and the developed oogonia above. It is close to the description of North African specimens attributed to *Oe. paloense* Britton in Gauthier-Lièvre (1964), but Britton's (1949) protologue based on Philippine material has solitary ovoid to ellipsoid oospores in similar shaped oogonia, a suffultory cell similar to vegetative cells, and antheridia in long series. *Oe. bancroftii* also resembles *Oe. areolato-costatum* Jao in Mrozińska (1985), but the dimensions of the Australian specimen are all half the size of the Chinese taxon, and the oospores are spherical rather than ovoid.

Group T

Nannandrous; dwarf males multicellular, antheridia external; oogonia opening through a pore.

Oedogonium starmachii Mrozińska, *Frag. Flor. Geobot.* 4:252 (1958) var. ***weetalibahense*** Stephen Skinner & Entwisle ***var. nov.***

Diagnosis: *Oedogonio starmarchio* var. *starmarchio* simile sed cellulo suffultorio inflate.

Type: New South Wales: North Western Plains: Weetalibah Waterholes (29°19'S, 147°50'E) *Dingley 050603.4*, 5 Jun 2003 (holo NSW).

Illustration: Fig. 4, g, h.

Nannandrous, gynandrosporous. *Vegetative cells* regular cylindrical, 40–120 µm long, 7–9 µm diam.; *basal cell* short vase, 20–23 µm long, c. 8 µm diam.; *terminal cell* truncated. *Oogonium* intercalary, solitary, obpyriform, 32–34 µm long, 24–30 µm diam., pore inframedian to inferior; *oospore* globose, filling chamber, covered in fine spines, mesospore red, 23–25 µm without spines (spines add c. 1 µm to radius); suffultory cell usually inflated, 39–50 µm long, 9–12 µm diam. *Androsporangia* intercalary, in upper filament, 23–27 µm long, 8 µm diam.; dwarf males on *suffultory cell*, with slightly inflated body cell (18–20 µm long, 8–9 µm diam.), one or two vegetative cells (18–20 µm long, 4.5 µm diam.) and one or more antheridial cells (7 µm long, 4.5–5 µm diam.), solitary? spermatozoid.

Etymology: for Weetalibah Waterholes in north-western New South Wales, from where the taxon was first recognized.

Distribution: known from South Australia, in a transient roadside swamp in limestone country, and New South Wales, on *Najas tenuifolia* in caustic (pH 9.5) artesian spring, and on *Chara* sp. in coastal creek.

There are a number of closely similar taxa with spiniferous spores and inferior pores to the oogonium. The Weetalibah specimen shows some characters in common with both *Oe. inframediale* Jao and *Oe. starmachii* Mroz., both of which occur in China (Jao 1979). While *Oe. inframediale* has an inflated suffultory cell, it has regular dwarf males, and the cells are 13–21 µm in diameter. *Oe. starmachii* as described by Mrozińska (1958) and Jao (1979) lacks the inflated suffultory cell but does have the multicellular dwarf males, and vegetative cells 9–14 µm in diameter. *Oe. excentriporum* (Jao) Tiffany is similar in dimensions, and has an inflated suffultory cell, but has a distinctly superior pore. Australian collections are the same as *Oe. starmachii* as described by Mrozińska (1985) in all aspects except the suffultory cell. We therefore recognize this taxon as a new variety of *Oe. starmachii.*

Specimens examined: New South Wales: North Western Plains: Weetalibah Waterholes, between Lightning Ridge and New Angledool, *Dingley 050603.4 a & b*, 5 Jun 2003 (NSW). South Coast: Stony Ck, 3 km S of Bodalla, *Skinner 0497*, 27 Dec 2001 (NSW). South Australia: Beachport–Robe road, *Skinner 556*, 14 Nov 1978 (NSW).

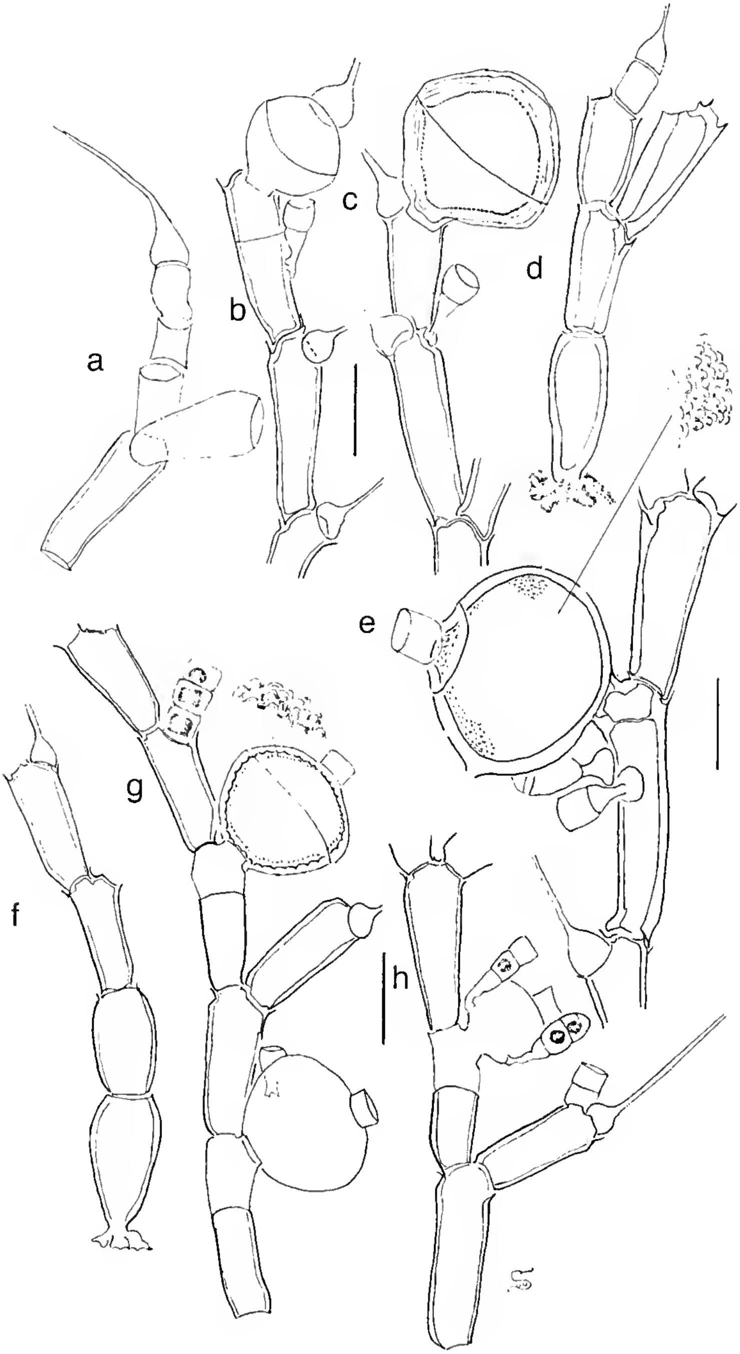

Fig. 5. *Bulbochaete rodwayi*: **a**, androsporangia and zooidangium; **b**, immature oogonium and dwarf male; **c**, mature oospore in oogonium; **d**, basal cell (*Entwisle 2497*); *B. wuhanense* var. *spechtii*: **e**, oogonium with androsporangium, dwarf males and oospore, with sketch of sculpturing (*Specht A30*); *B. calospora* var. *murrayana*: **f**, basal cell; **g**, branch with androsporangia and mature oospore, with sketch of sculpturing; **h**, immature oogonium with two dwarf males (*Skinner 0401, Arnold & Towler*).(Scales = 20 μm)

Bulbochaete C. Agardh

Bulbochaete rodwayi Stephen Skinner & Entwisle ***sp. nov.***

Diagnosis: *Bulbochaete* nannandriata oosporis quadriglobosis et glabris, nannandriis camelliformibus antheridiisque interne.

Type: Tasmania: pool in Melaleuca Ck, below Alexandra Ck junction, Port Davey Track, South West National Park (43° 25'S; 146° 08'E), *Entwisle 2497*, 3 May 1996 (holo MEL).

Illustration: Fig. 5, a–d.

Nannandrous, idioandrosporous? Thallus a densely intertwined cushion, visible to the naked eye. *Vegetative cells* subcylindrical, 48–56 µm long, 16–18 µm diam.: *basal cell* vase shaped, 18–20 µm diam. *Oogonium* squared globose, c.52 µm long and diam., median circumcision; *oospore* filling chamber, smooth, laminated thick exospore, mesospore red; suture in *suffultory cell* median, faint. *Androsporangia* in short lateral or terminal series, subtending a seta, c.16 µm long, 10–12 µm diam.; dwarf male goblet shaped, 23–25 µm long, c.10 µm diam., upper half antheridium, lower half rhizoidal, on suffultory cell.

Etymology: commemorates Leonard Rodway, botanist and natural history collector in Tasmania in the first half of the 20th Century.

Distribution: Tasmania, known only from the type locality, as free living cushions among mosses and leafy liverworts in high latitude stream.

A distinctive nannandrous *Bulbochaete* with squared globose smooth-walled oospores, and goblet-shaped dwarf males with internal antheridia. Unlike any reported *Bulbochaete* species both *B. rodwayi* and at least one population of *B. wuhanensis* var. *wuhanensis*, from Litchfield National Park in the Northern Territory, form dense masses of filaments and appear to be free living rather than epiphytes.

Bulbochaete wuhanensis Jao, *Monograpica Oedogoniales Sinicae*: 377 (1979) var. ***spechtii*** Stephen Skinner & Entwisle ***var. nov.***

Diagnosis: *Bulbochaetae wuhanense* var. *wuhanense* similis, sed gynandrospora, antheridiis epigynis atque lateralibus, oosporis verrucosis.

Type: Northern Territory: freshwater pool, South Bay, Bickerton Island (13° 46'S; 136° 13'E), *Specht A30*, 7 Jun 1948 (holo AD).

Illustration: Fig. 5, e.

Gynandrosporous. *Oogonium* 48–56 µm long, 59–88 µm diam.; *oospore* sculpturing very fine warts. *Androsporangia* epigynous or lateral, 11–14 µm long, 12–14 µm diam.

Etymology: commemorates Raymond Louis Specht, Australian ecologist and member of the American-Australian Expedition to Arnhem Land in 1948.

Distribution: Northern Territory, on aquatic vegetation in tropical seasonal waterways.

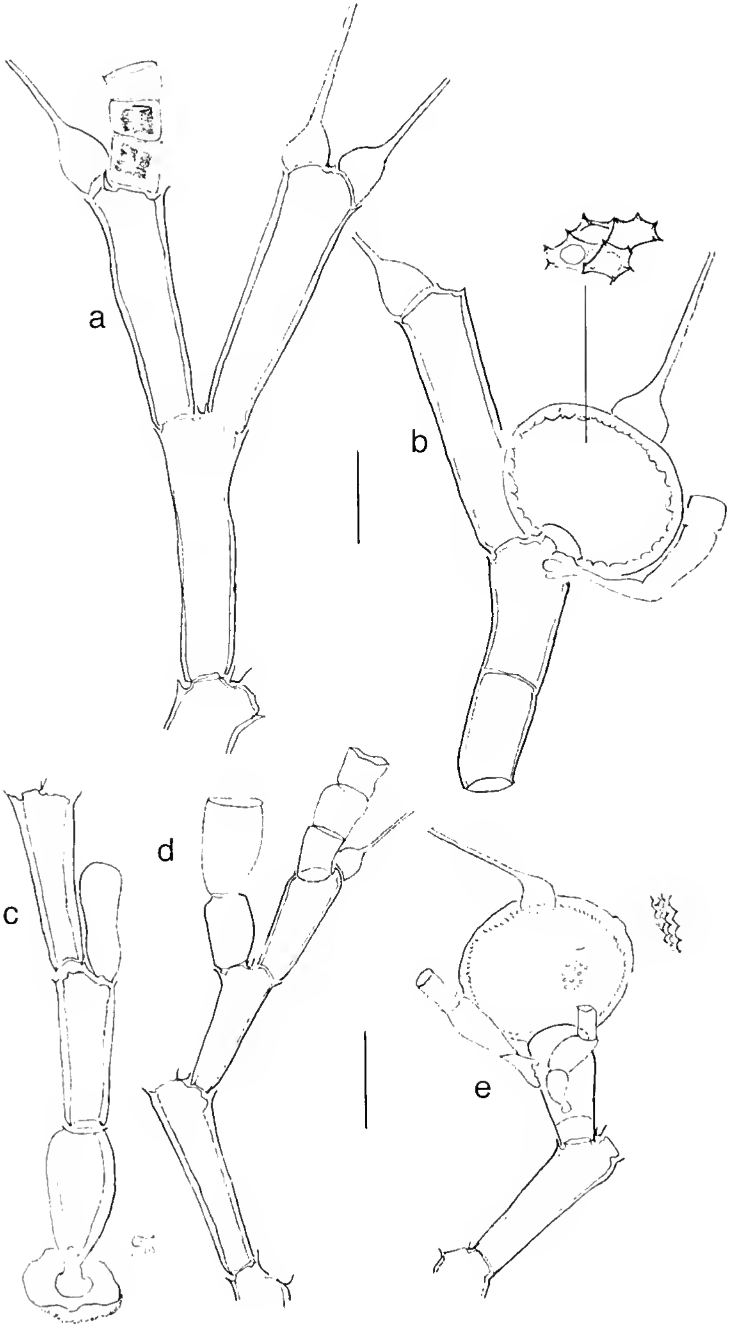

Fig. 6. *Bulbochaete Gigantea* var. *glabra*: **a**, androsporangia; **b**, oogonium with dwarf male, sketch of sculpturing (*Divola s.n.*(*Skinner 0039*)); *B. kakaduensis*: **c**, basal cell; **d**, androsporangia and zooidandium; **e**, mature oogonium with dwarf males, oospore, and sketch of sculpturing (*Dostine, Metcalfe & Padovan A104*).(Scales = 20 µm)

Differs from *B. wuhanensis* var. *wuhanensis* from China in being gynandrosporous, and the sculpturing of the oospore being very finely warty.

Specimens examined: Northern Territory: freshwater pool, South Bay, Bickerton Island, *Specht A30*, 7 Jun 1948 (AD); East Charlotte R., *Dingley 110903.2*, 11 Sept 2003 (NSW).

Bulbochaete calospora Jao, *Sinensia* 10: 147 (1939) var. ***murrayana*** Stephen Skinner & Entwisle ***var. nov.***

Diagnosis: *Bulbochaetae calosporae* var. *calosporae* similis sed in dimensionibus brevior.

Type: New South Wales: South West Slopes: Corowa–Mulwala road (36° 00'S; 146° 16'E), *Skinner 0401, Arnold & Towler*, 27 Sep 2001 (holo NSW).

Illustration: Fig. 5, f–h.

Dioecious gynandrosporous. Thallus moderately large, open but infrequently branching. *Vegetative cells* subcylindrical, 36–45(–48) μm long, 11–14(–18) μm diam., finely spirally spinose; basal cell vase-like, 48 μm long, 20 μm diam., base ridged, spreading. *Oogonium* depressed globo-pyriform, 36–39 μm long, 43–45 μm diam., cingulum, opening supramedian (closed at maturity); *oospore* filling chamber, exospore with large, sharp edged scrobiculae, mesospore yellow; suture in *suffultory cell* supramedian to superior. *Androsporangia* epigynous or lateral, solitary or in series 2–4, 9–11 μm long, c. 9 μm diam.; dwarf males shortly clavate, 25–27 μm long, 7–9 μm diam., antheridia internal, two chambers, single spermatozoid each.

Etymology: named for the Murray River valley, in which floodplain the collection was made.

Distribution: New South Wales/Victoria Border: riverine system, on filamentous algae and stoneworts.

This taxon is close to cosmopolitan *B. intermedia* de Bary in size of features and has similar position of suffultory suture, but, with the finely spinose cells, and large scrobiculae, appears to be a small variety of *B. calospora* from China.

Bulbochaete gigantea Pringsh. ex Hirn, *Acta Soc. Sci. Fenn* 27: 347 (1900) var. ***glabra*** Stephen Skinner & Entwisle ***var. nov.***

Diagnosis: *Bulbochaetae giganteae* var. *giganteae* similis sed parietibus glabris, oosporis areolatis scrobiculis.

Type: New South Wales: Northern Tablelands: Barleyfields Lagoon, near Uralla (30° 37'S; 151° 30'E), *Divola s.n.* [*Skinner 0039*], 30 May 1996 (holo NSW).

Illustration: Fig. 6, a, b.

Vegetative cells, 60–75(–80) μm long, 19–25 μm diam., smooth walled; *basal cell* vase like. *Oogonium* depressed globose, 43–45(–48) μm long, 58–68 μm diam.; *oospore* sculpturing of large, areolate scrobiculae, mesospore yellow; suture in suffultory cell median to supramedian. *Androsporangia* in series 1–4, c. 12 µm long, c. 14 µm diam., subtending seta; dwarf males clavate to vermiform, 57–60 µm long, c. 12 µm diam., antheridia internal.

Etymology: from *glaber, ra, rum* (Latin) smooth.

Distribution: New South Wales: transient swamp and creek pondages.

Differs from the widespread type variety in having cell walls smooth rather than finely helically spinose, and large open areolate scrobiculations on oospores. The report of *B. gigantea* in Skinner (1980) may refer to this taxon, as spinose cell walls were not reported. The specimen is missing, although other slides from the collection (Bullock Ck, *Skinner NED002*, Dec 1974(NE)) contain sterile fragments of a large *Bulbochaete* with smooth cell walls.

Specimen examined: New South Wales: Northern Tablelands: on stoneworts, Barleyfields Lagoon, near Uralla, *Skinner 0036, Cooper & Divola*, 29 Feb 1996, and *Divola (Skinner 0039)*, 30 May 1996 (NSW); Central Coast: on rushes in pond of Porters Ck, Wyong, *Gartenstein s.n.*, 7 Dec 2001 (NSW).

Bulbochaete kakaduensis Stephen Skinner & Entwisle ***sp. nov.***

Bulbochaete elatior sensu Scott & Prescott, *Record of the American–Australian expedition to Arnhem Land*, 3: 19 (1958).

Diagnosis: *Bulbochaetae scrobiculatae* similis sed idioandrospora nannandriisque clavatis, stipa 22–23 µm, antheridio 9–16 µm longo.

Type: Northern Territory: Howard R., upstream of Pioneer Dr. (12° 33'S; 131° 08'E), *Dostine, Metcalfe & Padovan A104*, 30 May 2003 (holo NSW).

Illustration: Fig. 6, c–e.

Dioecious, idioandrosporous. Thallus moderate, open branching. *Vegetative cells* subcylindrical, L/D 3.5–6, 12.5–14 µm diam.; *basal cell* short vase-like, 16–18 µm diam., rhizoidal base. *Oogonium* depressed globose, 37–42 µm long, 42–50 µm diam., cingulum, pore superior; *oospore* filling chamber, exospore very finely scrobiculate, mesospore yellow; suture in suffultory cell basal. *Androsporangia* lateral in series 1–4, 9–14 µm long, 11 µm diam.; dwarf male body cell stalked goblet, 22–23 µm long, 10 µm diam., antheridium single, 9–16 µm long, 7–8 µm diam.

Etymology: named for the Kakadu region of the Northern Territory over which the American–Australian expedition to Arnhem Land travelled and collected.

Distribution: Northern Territory, in still and flowing water.

Scott and Prescott (1958) described and figured the Bickerton Island specimen as *Bulbochaete elatior* Prings., illustrating clearly the fine scrobiculae. *B. elatior*, a cosmopolitan species, has smooth exospores. Scott and Prescott failed to mention if androsporangia were present. The Arnhem Land collections, and the Howard R. collection are idioandrosporous, and have dwarf males with almost clavate rather than goblet shaped body cells (as in *B. elatior*), and along with the fine scrobiculae on the oospore, make this a distinctive species.

Specimens examined: Northern Territory: freshwater pool, South Bay, Bickerton Is., *Specht A30*, 7 Jun 1948 (AD); freshwater marsh, behind dunes, Yirrkalla, *Specht A80*, 27 Aug 1948 (AD); Howard R., upstream of Pioneer Dr., *Dostine, Metcalfe & Padovan A104*, 30 May 2003 (NSW).

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A review of the taxonomy and relationships of the *Dendrobium speciosum* complex (Orchidaceae), and recognition of two new taxa

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Abstract

Dendrobium speciosum is one of Australia's most prominent orchids. Two hundred years after the type description, there are several contrasting taxonomic treatments of the *D. speciosum* complex. We review the taxonomy from first descriptions and incorporate recent numerical approaches. Our explorations extend the plant range to an almost continuous distribution along the east coast of Australia, with disjunct populations along the Tropic of Capricorn. Data from field observations, and studies of 453 plants over the entire distribution range were analysed using morphological and multivariate techniques. Results indicate a species complex forming a continuum of variation. Within the continuum from north to south the varieties *boreale, pedunculatum, curvicaule, capricornicum, grandiflorum, hillii* and *speciosum* occupy geographical areas which are defined approximately, and they exhibit significant infra-varietal variation. At interfaces of described varieties, populations show intermediate characteristics. There are no distinct qualitative differences in characters between any of the varieties or groups. We describe two new varieties, var. ***blackdownense*** and var. ***carnarvonense*** from central Queensland and propose that var. *capricornicum* Clemesha be retained for plants of east Capricorn.

Introduction

Dendrobium speciosum Sm. is one of Australia's most outstanding, widespread, and variable orchids. The complexity of variation has been highlighted by Burke (1998) and Burke and Adams (2002) using numerical analytical methods. They interpreted the complex as consisting of intergrading varieties, with some forms that could not be ascribed to any distinct groups. Nonetheless, taxa can be identified and treated as varieties. In very confusing populations along the Tropic of Capricorn, a detailed study of north Queensland plants resulted in the description of a new variety, var. *boreale*, and establishment of a neotype (and narrowed re-circumscription) for plants of var. *curvicaule*, which occurs between St Lawrence and Mt Dryander (Adams et al. 2006a).

Detailed field work from eastern Victoria to far north Queensland and west to Carnarvon Gorge has led to a reappraisal of the species and its taxonomy, defining the limits of taxa in relation to habitat and latitude. In this study we analyse a data set from all areas,

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including plants from recently explored remote areas not previously known to contain *D. speciosum*. We review taxonomic approaches and the currently defined varieties and geographically defined groups, which are compared in relation to the complex.

Historical review

Dendrobium speciosum was described by Smith (1804), and the type specimen is held in the Linnaean herbarium at the Linnaean Society in London (LINN). 'Port Jackson New South Wales' is written on the type sheet and the following is a transcription of the original description.

"*DENDROBIUM speciosum* Great Dendrobium

GYNANDRIA Diandria

"*Nectary a lip without a spur. Petals 5; the 2 lower external ones forming a pouch with their base. Lid vertical.*

"*Flowers often reversed. Cluster solitary, many-flowered. Lip three-lobed. Leaves radical, coriaceous.*

Dendrobium speciosum var. *hillii* was described by Masters in 1877 (having been described previously at species rank as *D. hillii* by Sir William Hooker in 1861), followed by var. *curvicaule* and var. *grandiflorum* (Bailey 1896). The original descriptions are not sufficiently diagnostic to distinguish the varieties in question from other members of this complex. The varieties established in the nineteenth century were based on a few specimens, and as new areas of distribution were examined the range of morphological variation was found to be far greater than initially appreciated, blurring distinctions between some varieties. This has led to questions about the taxonomic rank of these variants (Clemesha 1982). Since Dockrill's first book in 1969 there have been reviews by several authors (Clemesha 1981a, 1981b, 1986, Clements 1989, Banks & Clemesha 1990, Adams 1991), with limited new evidence offered.

Dockrill (1969) initially recognised five varieties: var. *speciosum*, var. *hillii* Mast., var. *grandiflorum* F.M.Bailey, var. *curvicaule* F.M.Bailey and var. *nitidum* F.M.Bailey. Clemesha (1981a, 1986) reviewed the described varieties, reproduced original descriptions, photographs of type specimens, photocopies of plants typical of varieties, and commented on atypical forms and variation in central Queensland, without making categorical statements about taxonomic rank. He also described a new variety, var. *pedunculatum*, from the Atherton area of north Queensland (Clemesha 1981a). He regarded the central Queensland plants, and plants at Byfield and west at Carnarvon Gorge, as dwarf races of var. *grandiflorum*. In 1982, Clemesha described a new variety, var. *capricornicum*, from the volcanic plug of Mt Jim Crow, near Rockhampton in Central Queensland, and considered that plants at Blackdown Tableland and Carnarvon Gorge represented different colour forms of this variety. Plants from different habitats close to the plugs were noted to differ from typical var. *capricornicum* in some characters.

The six varieties of *D. speciosum* recognised by Dockrill (1992) were *D. speciosum* var. *speciosum* (Smith 1804), *D. speciosum* var. *hillii* (Masters 1877), *D. speciosum* var. *grandiflorum* (Bailey 1896), *D. speciosum* var. *curvicaule* (Bailey 1896), *D. speciosum* var. *pedunculatum* (Clemesha 1981), and *D. speciosum* var. *capricornicum* (Clemesha 1982). *Dendrobium speciosum* var. *nitidum* F.M.Bailey, *D.* x *nitidum* (F.M.Bailey)

M.A.Clem. & D.L.Jones, *D. speciosum* var. *bancroftianum* Rchb.f., and *D. jonesii* Rendle subsp. *bancroftianum* (Rchb.f.) M.A.Clem. & D.L.Jones are now considered to represent *D.* x *gracillimum*, a natural hybrid between *D. speciosum* and *D. gracilicaule* (Clemesha 1981a, Banks & Clemesha 1990).

Jones (1988) treated *D. speciosum* as having six varieties. Upton (1989) recognised 'an extremely variable species' of six varieties: var. *speciosum*, var. *hillii*, var. *grandiflorum*, var. *capricornicum*, var. *curvicaule* and var. *pedunculatum*. Clements (1989) raised these varieties to species rank, with the exception of var. *capricornicum*, which was subsumed under *D. curvicaule*. Clements defined his species concept as one or more significant and consistent differences in characters, and described differences for each proposed species that have not been supported by any published studies. The changes have not been accepted by subsequent taxonomic reviewers (Banks & Clemesha 1990; Grundon et al. 1990; Adams 1991; Lavarack 1991; Dockrill 1992, 1995).

Banks and Clemesha (1990), in rejecting Clements' taxonomic treatment, regarded var. *speciosum*, var. *hillii*, var. *grandiflorum*, var. *curvicaule*, var. *pedunculatum* and var. *capricornicum* as subspecies, noting that some shared the same habitat, and intermediate forms were present. Reasons for proposing the rank of subspecies were not offered. In his revised Australian Indigenous Orchids in 1992, Dockrill recognised six varieties, and a degree of overlap, stating that his attempt at developing a key could not separate all plants into distinct varieties. Lavarack and Gray (1985) also accorded the taxa varietal rank. Adams (1991) provided a review of variation, pollination and breeding systems in *D. speciosum*, and recommended the retention of six varieties that were not completely distinct, with overlapping habitat, and variable, inconsistent features.

All reviews suggested separate distributions for the varieties, with large gaps, especially in dry areas between Rockhampton and Mackay, and around Townsville. Since then the range of known forms, localities and distribution has progressively extended. The following deficiencies are evident in past treatments: insufficient sampling of regions using living material, errors in distributions, assumptions of gaps in distribution in dry and inaccessible habitat, lack of published data to support conclusions and taxonomic proposals, and a strong tendency to place all plants into distinct taxonomic groups, whether at species, subspecies or varietal rank, even when their characteristics do not correspond with the circumscription of taxa. Clements (1989) used character differences including aerial roots, pseudobulb shape, floral segments, labellar notches, and breeding biology to propose separate species. The use of these characters for diagnosis has been refuted (Banks & Clemesha 1990, Adams 1991, Dockrill 1992, Burke & Adams 2002). In view of the large distribution range and variability, these problems are understandable, but have led to considerable confusion.

Subsequent numerical approaches (Burke 1998, Burke & Adams 2002) have supported the concept of a species complex, which required further survey and analysis. We have published new distributional data, undertaken numerical analyses in all regions, and described a new variety, var. *boreale* which applies to rainforest plants north of Townsville that had previously been included in var. *curvicaule*. We have also respecified the range of occurrence of neotypified var. *curvicaule* (Adams et al. 2006a) (Table 1).

Table 1. Recent classifications of *Dendrobium speciosum*.

Clements 1989	Banks and Clemesha 1990	Adams 1991	Dockrill 1992	Adams et al. 2006a
D. speciosum	subsp. *speciosum*	var. *speciosum*	var. *speciosum*	var. *speciosum*
D. tarberi	subsp. *hillii*	var. *hillii*	var. *hillii*	var. *hillii*
D. rex	subsp. *grandiflorum*	var. *grandiflorum*	var. *grandiflorum*	var. *grandiflorum*
D. curvicaule	subsp. *capricornicum*	var. *capricornicum*	var. *capricornicum*	var. *capricornicum*
D. curvicaule	subsp. *curvicaule*	var. *curvicaule*	var. *curvicaule*	var. *curvicaule*, var. *boreale*
D. pedunculatum	subsp. *pedunculatum*	var. *pedunculatum*	var. *pedunculatum*	var. *pedunculatum*

We have now analysed our entire data set for *D. speciosum* to extend our understanding of the species and to test previous taxonomic recommendations (Burke & Adams 2002).

Materials and methods

Sampling

Specimens were collected during field trips conducted in all regions during the flowering season (May to September) between 1981 and 2005. Populations studied represented the variation throughout each geographic area. In each study population, 6–12 plants were sampled to encompass the major variation in plant and floral characteristics. The following numbers of individuals were used in the analyses for the regions depicted in Fig. 1: Region 1a–39 plants, Region 1b–37 plants, Region 2–35 plants, Region 3–13 plants, Region 4–25 plants, Region 5–43 plants, Region 6–46 plants, Regions 7 and 8–52 plants. Wherever possible measurements were made in the field, otherwise samples were taken by removing a small number of pseudobulbs, together with roots, from the side of the plant to minimise damage and prevent local depletion. All plants were then grown in aged pine park in raised beds or pots under greenhouse conditions.

A reference collection of the sampled plants, photographic library and pressed floral parts have been maintained, as fully representative herbarium specimens of such large plants are not practical. Four hundred and fifty three plants were measured. Voucher details (including locations) of these plants can be obtained by contacting the Queensland Herbarium and the National Herbarium of Victoria. *Dendrobium speciosum* is under heavy pressure from illegal collecting, and thus no specific locality information is provided here.

Seventy-two characters were used to assess variation in the *D. speciosum* complex. Thirty-three characters were subsequently considered to be of taxonomic value (Table 2) and used in univariate and multivariate analyses.

Table 2. Morphological characters used in analyses for variation within and between populations of *Dendrobium speciosum*.

Vegetative characters

1. Pseudobulb length (cm)
2. Pseudobulb width at base (cm)
3. Pseudobulb width at midpoint (cm)
4. Pseudobulb width at top (cm)
5. Number of internodes in pseudobulb
6. Collum (narrowing of pseudobulb above swollen base) 0 = absent, 1 = 0.5– < 1.0 cm long, 2 = 1.0 –2.0 cm long, 3 = > 2.0 cm long
7. Number of leaves
8. Leaf length (cm)
9. Leaf width (cm)
10. Leaf thickness (mm)
11. Aerial roots 0 = nil, 1 = 1–3 per 10 pseudobulbs, 2 = 4–25 per 10 pseudobulbs (roots usually > 10 cm in height), 3 = > 25 per 10 pseudobulbs (roots usually erect and > 30 cm in height)

Floral characters

12. Number of flowers
13. Rachis length (cm)
14. Peduncle length (cm)
15. Peduncle width (mm)
16. Flower length (dorsal sepal tip–lateral sepal tips) (cm)
17. Flower length (dorsal sepal tip–mentum) (cm)
18. Flower width across petals (flattened) (cm)
19. Flower width at mentum (flattened) (cm)
20. Dorsal sepal length (cm)
21. Dorsal sepal width at base (cm)
22. Petal length (cm)
23. Petal width at base (mm)
24. Individual lateral sepal width at base (cm)
25. Width of lateral sepals at widest point (flattened) (cm)
26. Distance between lateral sepal tips (flattened) (cm)
27. Inner width of lateral sepals at widest point (flattened) (cm)
28. Distance from base of lateral sepals to their tips (cm)
29. Pedicel length (cm)
30. Midlobe length (cm)
31. Midlobe width (cm)
32. Forelobe [A] length (cm)
33. Forelobe width (cm)

[A] Forelobe = lateral lobes plus lamina

Morphological data were collected from the 453 specimens. Specimens were coded according to their region (Fig. 1) to facilitate discussion and the formation of hypotheses. Individuals were allocated into regions on the basis of latitude, distribution ranges of taxa previously circumscribed, and additional distribution from recent exploration. A total of 281 individuals were used for the multivariate analyses in this study using random sampling from the larger data set of 453 plants, so that all regions were adequately represented in relation to their geography and extent of variation.

An attempt was made to use pickled and prepared specimens already available or prepared from our initial surveys. This method was abandoned as the material did not preserve well and many of the characters of Table 2 could not be accurately assessed.

Therefore fresh living material was used for all measurements. For each specimen, measurements were made on three representative organs where possible, and the mean value used for analyses. The first leaf from the base of the pseudobulb was used for all leaf measurements. In the few cases where it was not possible to obtain three measurements, due to damaged or missing parts, mean values were calculated from the available material.

Phenetic analysis

Morphological data were range standardised, and a Manhattan Metric (MM) distance matrix (Sneath and Sokal 1973, Milligan and Cooper 1988) was calculated. The data set was subjected to numerical pattern analysis using the PATN package (Belbin 1988). For cluster analysis, the unweighted pair-group arithmetic averaging (UPGMA) was used. A cluster intensity co-efficient (β=-0.25) was chosen because this setting is space-dilating, and affords maximum opportunity to separate subgroups. It sharpens any discontinuities in the system so that clustering is intensified (Williams 1975a). It is particularly useful when it is suspected that no sharp discontinuities exist in the data, and it may reveal unsuspected groupings. Cramer values were calculated as previously (Burke & Adams 2002) to determine which characters best discriminated the final groups identified.

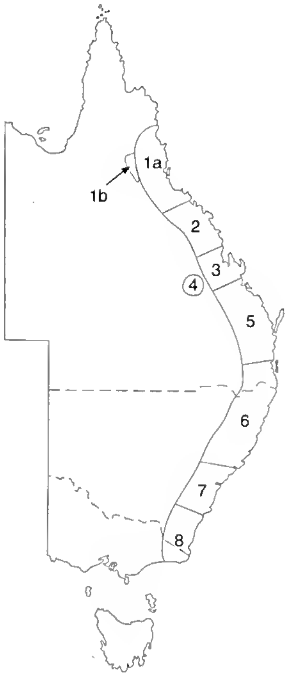


Fig. 1. Distribution range of *D. speciosum* species complex showing regions defined for this study.

The distance matrix was used for ordination by principal coordinates analysis (PCoA) (Gower 1966). Ordination techniques are considered more appropriate for analysis at the population level because, unlike cluster analysis, they do not assume a hierarchical pattern of relationships, which may not be present at the infra-specific level (Gould & Johnston 1972, Crisp & Weston 1993). Character vectors and their correlation coefficients were determined to allow examination of trends of characters across the ordination space (Williams 1975b, Belbin 1988).

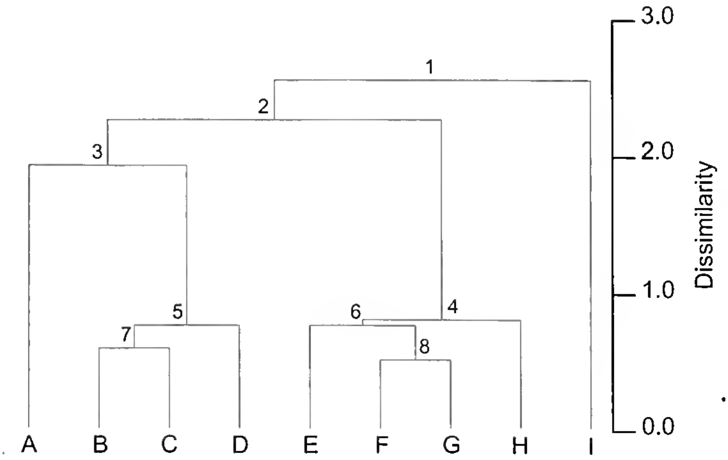
Variation of characters within and between taxa

Maximum, minimum and mean values, and first to third interquartile ranges were calculated for pseudobulb, leaf and flower length for plants in Regions 1–8 of Fig. 1.

Results

Cluster analysis combining vegetative and floral characters

Nine groups were identified in the UPGMA classification, seven containing a mix of plants from different regions or representing different varieties (Fig. 2, Table 3).



Group	Regional Composition
A	1a
B	1a (Paluma, Tinaroo, Tully), 1b, 3, 4
C	1b, 1a (Tinaroo), 4
D	1P, 2, 3, 4, 5, 6, 7, 8
E	5
F	2, 4, 5, 7, 8
G	2, 4, 7, 8
H	2, 3, 5, 7, 8
I	6

Fig. 2. Classification (UPGMA, β = -0.25) of *D. speciosum* individuals throughout the distribution range using vegetative and floral morphological characters truncated at nine groups.

Table 3. Cramer values for the most important characters of each dichotomy in the classification of *D. speciosum* individuals from throughout the distribution range based on vegetative and floral morphological characters (UPGMA β=-0.25).

Dichotomy	Character Number and Character	Cramer Value
1	33. Forelobe width	0.6926
	31. Midlobe width	0.6694
2	18. Flower width across petals (flattened)	0.7793
	16. Flower length (dorsal sepal tip–lateral sepal tips)	0.7666
	20. Dorsal sepal length	0.7658
	22. Petal length	0.7600
	28. Distance from base of lateral sepals to their tips	0.6961
3	6. Collum	0.8331
	1. Pseudobulb length	0.6746
	9. Leaf width	0.6584
4	24. Individual lateral sepal width at base	0.7591
	25. Width of the lateral sepals at widest point (flattened)	0.7328
	21. Dorsal sepal width at base	0.7132
	25. Width of lateral sepals at widest point (flattened)	0.6702
5	28. Distance from base of lateral sepals to their tips	0.7621
	14. Peduncle length	0.7393
	5. Number internodes in pseudobulb	0.6841
	15. Peduncle width	0.6713
	8. Leaf length	0.6501
6	1. Pseudobulb length	0.7801
	12. Number of flowers	0.7514
	7. Number of leaves	0.6601
7	22. Petal length	0.8327
	24. Individual lateral sepal width at base	0.8134
	28. Distance from base of lateral sepals to their tips	0.7935
	21. Dorsal sepal width at base	0.7628
	23. Petal width at base	0.7429
8	18. Flower width across petals (flattened)	0.8744
	16. Flower length (dorsal sepal tip-lateral sepal tips)	0.8720
	22. Petal length	0.8612
	20. Dorsal sepal length	0.8665

The first dichotomy separated Group I, representing most, but not all, plants of var. *hillii* (or plants from Region 6). The second dichotomy separated the mixed Groups E, F, G, and H from mixed Groups B, C, D, and Group A, which represents rainforest plants north of Townsville. Some north Queensland plants of shorter stature were clustered in Groups B and C. While Cramer values for most floral and the collum characters were moderately high (>0.8), their values indicate that there is still considerable overlap between the groups formed at the eighth dichotomy. The remaining characters had low to moderate Cramer values, indicating considerable overlap in character values between the groups formed at this level.

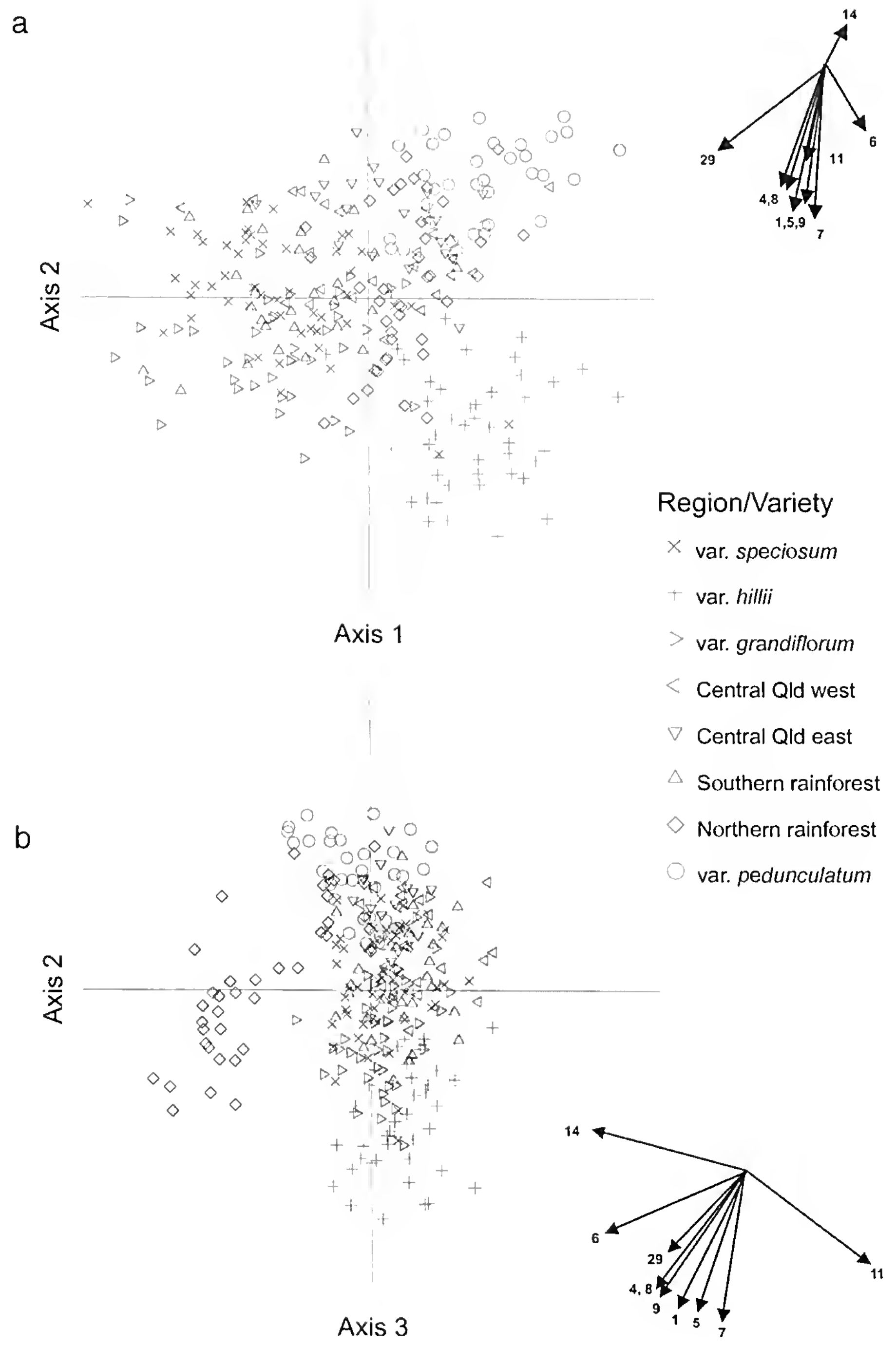


Fig. 3. Ordination from PCoA in three dimensions of *D. speciosum* individuals throughout the distribution range using vegetative and floral morphological characters. (a) Axis 1 v. 2. (b) Axis 2 v. 3. Character vectors (correlations > 0.7) showing angles in ordination space are shown. See Table 2 for character codes.

Cluster analysis using vegetative or floral characters alone

These analyses produced seven sub groups that were mixtures of plants from several different regions, similar to that produced by using all morphological characters.

Principal coordinates analysis combining vegetative and floral morphological characters

Rainforest plants north of Townsville partially separated from the main complex with minimal overlap. These plants form a group largely abutting the main complex in ordination space (Fig. 3). They partially separate on the basis of the presence of a collum, longer pedicels, and larger width at the top of the pseudobulbs. There are no absolute differences in characters of this group when compared to others. Presence of a collum also contributed to partial separation of var. *hillii* plants of rainforest in northern New South Wales and southern Queensland. Compared with all other *D. speciosum*, these plants had some of the longest pseudobulbs, which were wider at the top, with more internodes and longer leaves.

Plants of the dry country north of Townsville, typical habitat for var. *pedunculatum*, separate from var. *curvicaule* on the basis of longer peduncles. Longer peduncles are also found in some plants of var. *boreale* and not in all var. *pedunculatum* so the character is not diagnostic for var. *pedunculatum*. In the total analysis the other varieties all overlap without significant separation.

Regional principal coordinates analysis

The ordination of all 281 plants (Fig. 3) indicates a species complex. An analysis of regional subsets of plants was required to examine further for putative geographic varieties.

Regions 1 and 2: The northern rainforest group (var. *boreale*) has minimal overlap in ordination space with the southern rainforest group (var. *curvicaule*) of Region 2 (Fig. 4). There is considerable overlap between plants of var. *pedunculatum* in open forested dry country on and west of the divide, and var. *boreale*, and little overlap between var. *pedunculatum* and var. *curvicaule*.

Regions 3 and 4: The analysis indicates three groupings along the Tropic of Capricorn. The Carnarvon area group and Blackdown Tableland group abut one another with minimal overlap in the ordination space, and var. *capricornicum* of east Capricorn overlaps with the Blackdown Tableland group to some extent (Fig. 5). Variation in these regions is very extensive, especially at Blackdown Tableland, on the volcanic plugs near Rockhampton, and at Byfield and Shoalwater Bay. In the ordination space, plants from Mt Jim Crow, the type locality for var. *capricornicum*, lie at a considerable distance from those of other volcanic plugs.

Blackdown Tableland and Carnarvon Gorge plants are separated due to the higher character values in Carnarvon Gorge plants for forelobe length, flower length, dorsal sepal length, forelobe width, petal length and individual lateral sepal width. Plants on the plugs are separated from Blackdown Tableland and Carnarvon Gorge plants by lower values for pseudobulb length and leaf length.

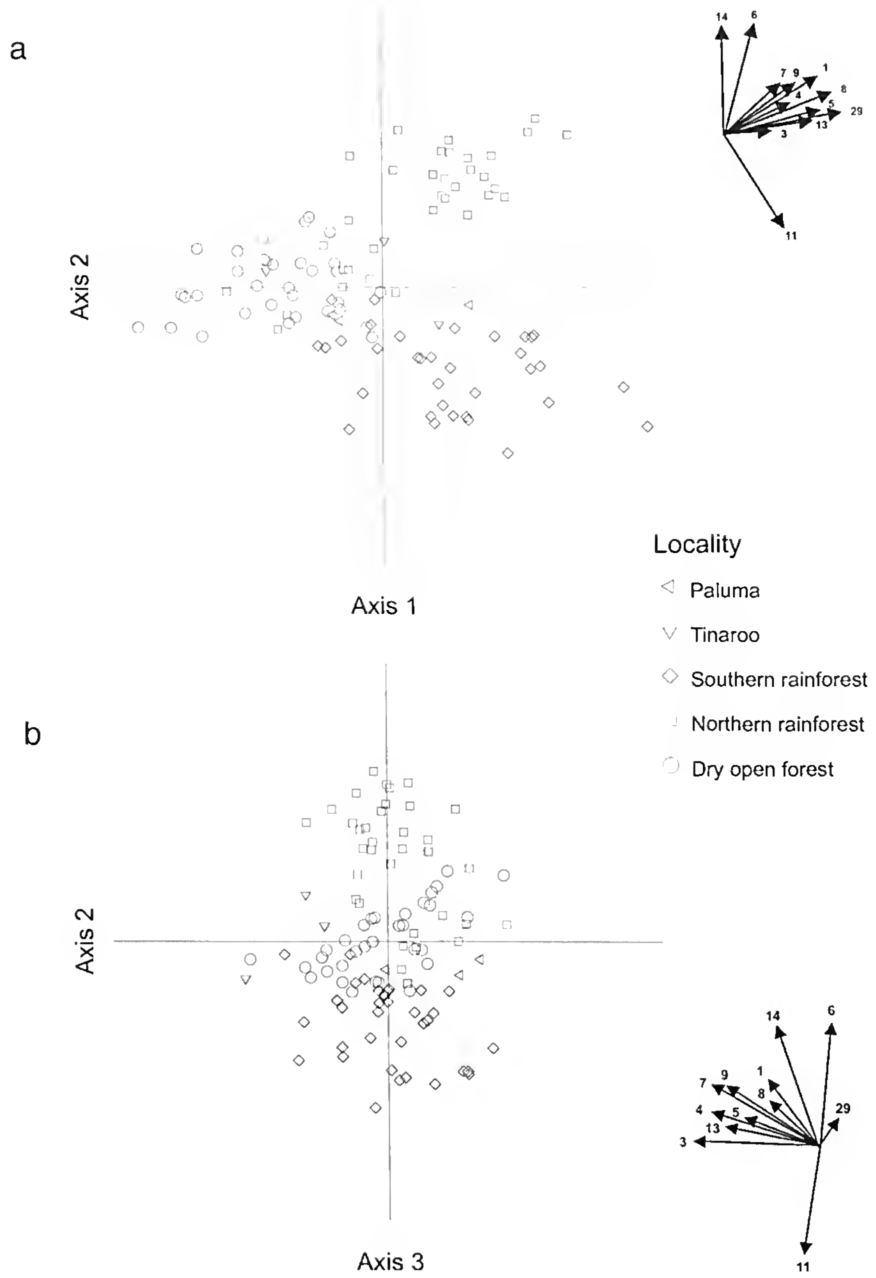


Fig. 4. Ordination from PCoA in three dimensions of *D. speciosum* individuals from north Queensland using vegetative and floral morphological characters. (a) Axis 1 v. 2. (b) Axis 2 v. 3. Character vectors (correlations > 0.7) showing angles in ordination space are shown. See Table 2 for character codes.

Regions 5 and 6: Ordination of Region 5 plants (var. *grandiflorum*) and plants along the Tropic of Capricorn (Fig. 6) indicate a small degree of overlap between Region 5 and plants of Blackdown Tableland and Carnarvon Gorge. Shorter plants from isolated populations of the southern part of Region 2 (Sarina, Clairview), and northern part of Region 5 (Mt Morgan area) (Fig. 6), overlap in ordination space with the three groups of Regions 3 and 4. There is no overlap between plants of Region 5 and east Capricorn. Ordination of Regions 5 and 6 indicated no significant sub groupings in each of these areas (Figs 7, 8). Intermediates are found at the junction between Regions 5 and 6, where the distribution of *D. speciosum* is continuous.

Regions 7 and 8: In the habitat of var. *speciosum*, there is a cohesive group with no significant sub groupings (Fig. 9).

Two new taxa from central Queensland

On the basis of field studies, regional ordination and cluster analysis, we consider that var. *capricornicum* Clemesha does not encompass the variation seen in west Capricorn, at Blackdown Tableland and the Carnarvon area, and recommend it be used only for plants from the volcanic plugs and forests of east Capricorn near Rockhampton, Yeppoon and Byfield.

Field observations and the numerical analyses are used to describe two new taxa. For all taxa, in the descriptions that follow, the dimensions used for flower vertical height and horizontal width refer to flowers pressed flat, as presentation dimensions have been shown to vary widely under different environmental conditions and at different times during the day (Burke 1998).

Dendrobium speciosum Sm. var. ***blackdownense*** P. B.Adams ***var. nov.***

Plantae variabiles sed saepe urceolatae; axes breves vel mediocres (9–28 cm longi) e basi saepe divergentes; folia ovata vel subelliptica; racemi mediocres vel longi ex comparatione altitudinis plantae (23–58 cm longi) pauciflori vel multiflori; flores subdistantes vel aggregati (14–113 per racemum), parvi vel mediocres (3.5–5.4 cm alti) late aperientes; tepala albida vel ochroleuca.

Type: Queensland, Leichhardt District, Blackdown Tableland, *P. B. Adams & S.D. Lawson*, 4 Sep1994 (holo: QRS; iso: BRI, MEL).

Plants very variable in size and shape, occasional plants showing a tendency to produce aerial roots; axes and leaves exhibiting purple pigmentation in parts exposed to direct light. Leaf bearing axes 9–28 cm long, 2.1–3.8 cm wide at mid point, round to oval in cross section, variably erect or curved, 1.9–4.6 cm wide at base, 1.5–3.2 cm wide at apex. *Leaves* terminal, 2–4, rigid, concave, 9–20 cm long, 4.3–7 cm wide, mainly ovate to sub-elliptic, broadly ovate on small plants, with a sheathing base, variably sub-elliptic or sub-oblong, concave, rigid, 1–2 mm thick. *Racemes* 1–3, 23–58 cm long; peduncle 8–15.5 cm long, 4–6 mm wide, with 1–4 medium sized bracts; rachis 15–42 cm long, 14–113-flowered: flower density varying from openly spaced to densely clustered, forming a brush. Pedicel including ovary 2.3–3.7 cm long. *Flowers* usually opening widely, variable in size and substance, vertical height 3.5–5.4 cm, horizontal width 3.9–5.4 cm, off white to deep gold, the labellum variously and diffusely marked with purple spots or short bars over forelobe and midlobe. *Dorsal sepal* 1.8–3 cm long,

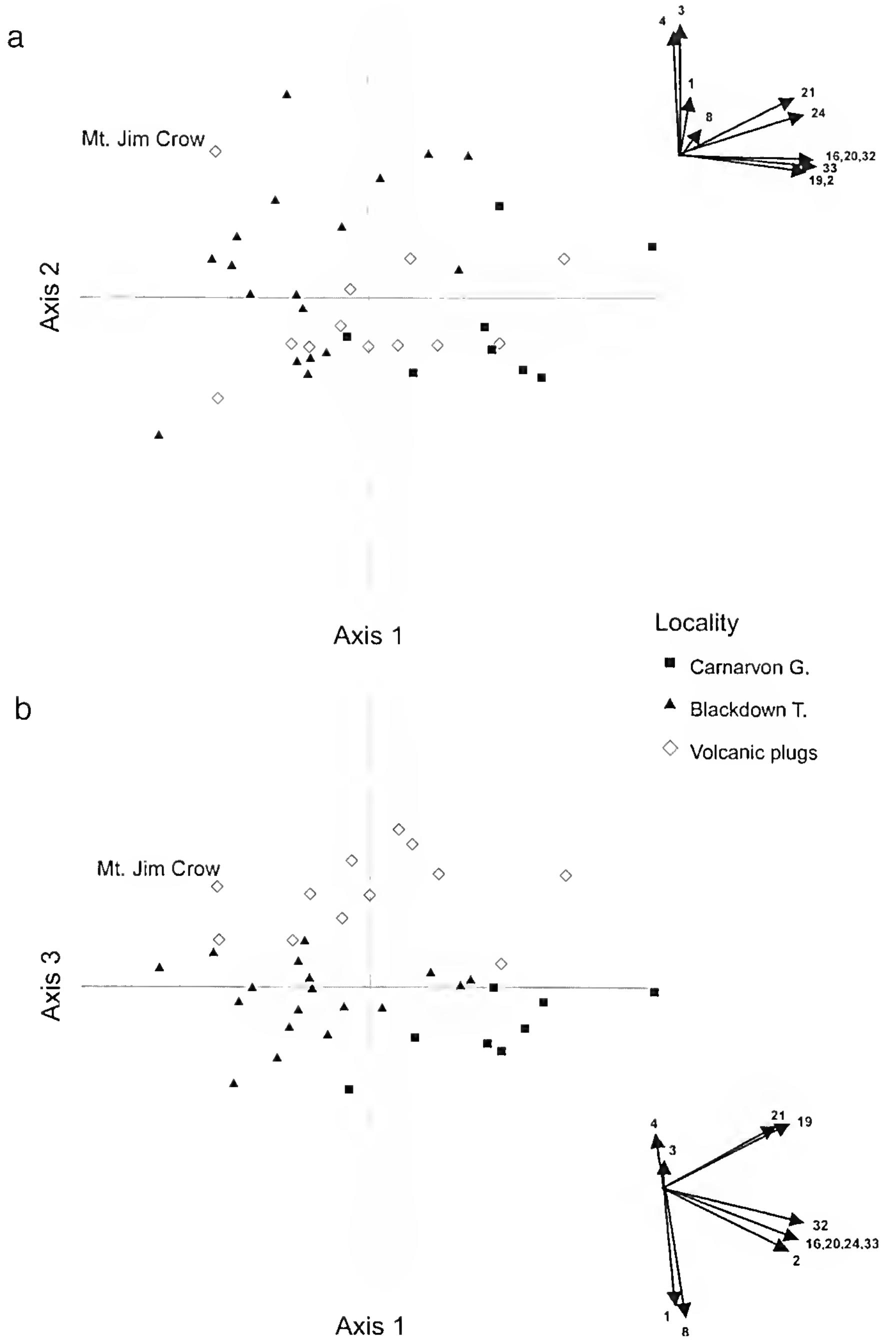


Fig. 5. Ordination from PCoA in three dimensions of *D. speciosum* individuals from central Queensland with vegetative and floral morphological characters. (a) Axis 1 v. 2. (b) Axis 1 v. 3. Character vectors (correlations > 0.8) showing angles in ordination space are shown. See Table 2 for character codes.

0.5–0.8 cm wide at the base, tapering to an obtuse-rounded apex. *Lateral sepals* 1.6–2.4 cm long, 0.7–1 cm wide at base, falcate-oblong, obtuse at apex. Petals 1.8–2.7 cm long, 3–4 mm wide, slightly falcate, with an acute apex. *Labellum* 0.8–1.3 cm long, 0.9–1.2 cm wide; forelobe 0.5–0.7 cm long, 0.9–1.2 cm wide when flattened, incurved, subtriangular; midlobe shortly clawed, 0.3–0.6 cm long, 0.7–1.0 cm wide when flattened, presenting as a curved channel with a short acute apex; callus slightly raised, 2-ridged, yellow to orange. *Column* c. 5 mm long with a foot c. 6 mm long at right angles to it. Mentum bifid, rounded, c. 7 mm from ovary to apex.

Variation: the most variable in vegetative and floral form of all the described varieties, with flowers densely or openly spaced, flowers white to deep gold, and plant height and shape varying greatly over the wide range of habitats in this region.

Flowering time: August–September.

Distribution: from the northern limit of Blackdown Tableland southwards along the Expedition Range, southern limit not determined.

Etymology: the epithet refers to Blackdown Tableland.

Illustration: see Fig. 10.

Notes: the population is geographically separated from plants of the Great Dividing Range on the east coast and Carnarvon Gorge to the west, by flood plains that are unsuitable habitat for *D. speciosum*. Plants of *D. speciosum* var. *blackdownense* are usually lithophytic, urn or basket shaped, occasionally epiphytic in sclerophyll forests, dry rainforest and exposed rocky cliff faces, often forming dense populations with *Drynaria* (Bory) J.Sm. fern on huge boulders out of reach of fire. Larger plants may have a few aerial roots, which are not usually well developed. Some plants are extremely short and compact at maturity. Although very variable, they can usually be distinguished from var. *carnarvonense*, which tend to be more robust, with large flowers of very heavy substance. There is some overlap in floral and vegetative characters with plants of var. *capricornicum*, which can usually be distinguished by vegetative features of shorter axes and leaves, more upright plant shape, and an earlier flowering time (May–June).

Dendrobium speciosum Sm. var. ***carnarvonense*** P. B.Adams ***var. nov.***

Planta robusta, plerumque urceolata vel crateriforma; axes breves vel mediocres (15–33 cm longi) e basi divergentes, basi lati, apicem versus contracti; racemi breves vel mediocres (21–47 cm longi); flores 25–87 per racemum, subdistantes, grandes (5.1–6.6 cm alti), cupulati; segmenta lata crassiuscula; lobus frontalis 1–1.4 cm latus et c. 0.7 cm longus; tepala cremea vel aurea.

Type: Queensland Leichhardt District. Carnarvon Gorge, *P.B. Adams & S.D. Lawson*, 11 Sep 1994 (holo: QRS; iso: BRI, MEL).

Plants robust, urn or basked shaped, with wide based, tapering pseudobulbs. Occasional plants produce aerial roots; axes and leaves may exhibit purple pigment in areas exposed to direct light. Leaf bearing axes 15–33 cm long, 2.1–3.1 cm wide at mid point, round to oval in cross section, variably curved, 2–5.2 cm wide at base, 1.3–3.2 cm wide at apex. *Leaves* terminal, 2–3, rigid to very rigid, concave, sub-elliptic to oblanceolate or ovate, with a sheathing base, 14.8–24 cm long, 4.6–7.4 cm wide, concave, rigid, 1.2–2.0 mm thick. *Racemes* stout, 1–2, 21–47 cm long; peduncle 7–14.8 cm long,

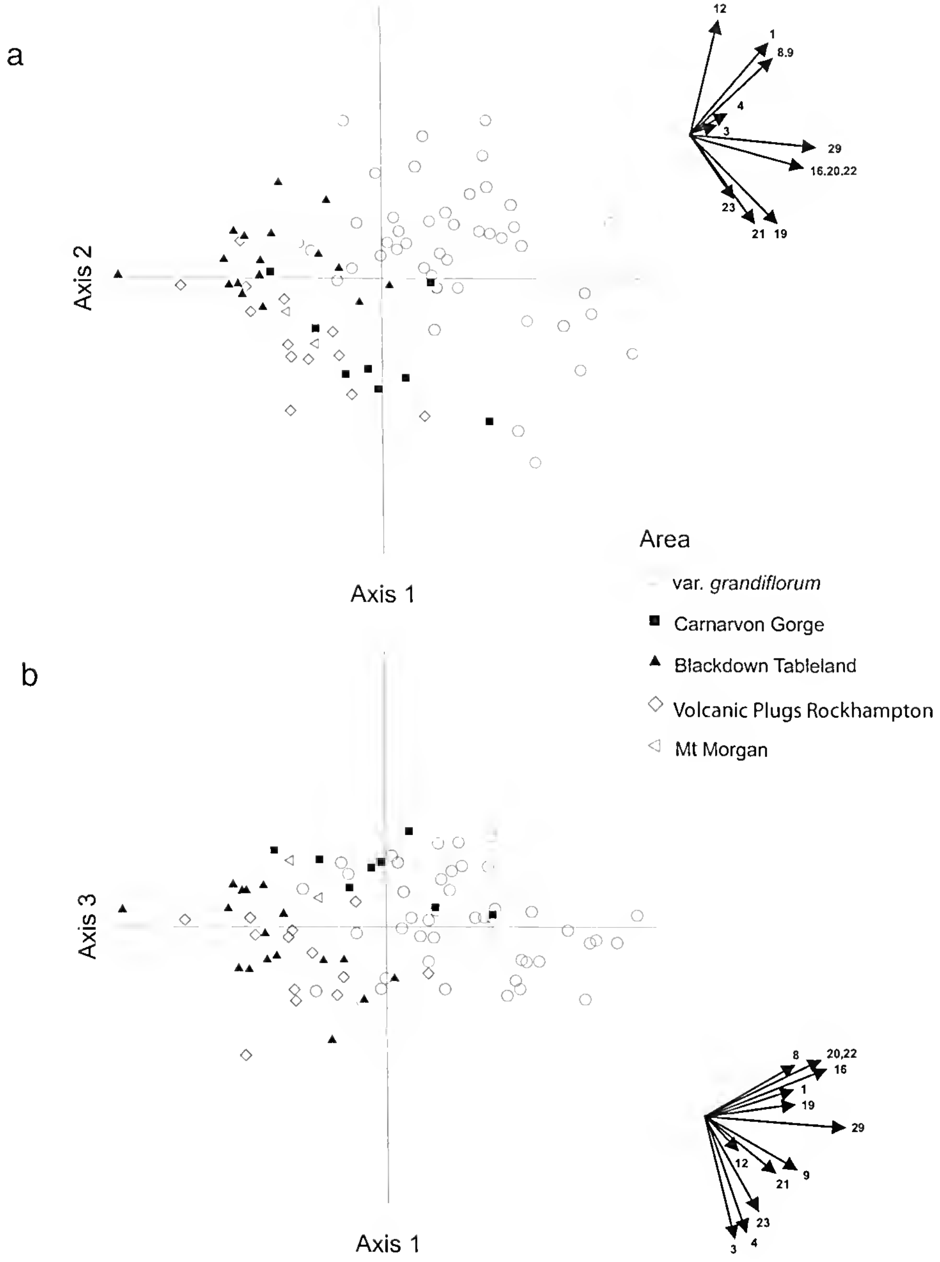


Fig. 6. Ordination from PCoA in three dimensions of *D. speciosum* var. *grandiflorum* individuals and individuals from along the Tropic of Capricorn using vegetative and floral morphological characters. (a) Axis 1 v. 2. (b) Axis 1 v. 3. Character vectors (correlations>0.8) showing angles in ordination space are shown. See Table 2 for character codes.

4.5–7 mm wide, with 1–4 medium bracts; rachis 14.5–31.5 cm long, 25–87-flowered: flowers well spaced. Pedicel including ovary 2.7–4.5 cm long. *Flowers* usually cupped and of heavy substance, medium to large flowered, vertical height 5.1–6.6 cm, horizontal width 5.5–6.3 cm, cream to gold, the labellum variously purple barred or spotted over forelobe and midlobe, markings diffuse and variable. *Dorsal sepal* 2.8–3.9 cm long, 0.5–0.8 cm wide at base, tapering to an obtuse-rounded apex. *Lateral sepals* 2.1–2.5 cm long, 0.8–1.1 cm wide at base, falcate-oblong, obtuse at apex. Petals 2.4–3.4 cm long, 2.8–4 mm wide, almost linear with an acute apex. *Labellum* 1.1–1.4 cm long, 1–1.3 cm wide when flattened; forelobe 0.7–0.8 cm long, 1.1–1.4 cm wide, incurved, subtriangular; midlobe shortly clawed, 0.4–0.6 cm long, 0.9–1.0 cm wide when flattened, presenting as a curved channel with a short acute apex; callus raised, 2-ridged, low profiled, yellow to orange. *Column* c. 5 mm long with a foot c. 6 mm long at right angles to it. Mentum bifid, rounded, c. 7 mm long from ovary to apex.

Flowering time: August–September.

Distribution: gorges of the Carnarvon region; geographically separate from other varieties.

Etymology: the epithet refers to the Carnarvon Region.

Illustration: see Fig. 11.

Notes: plants of *D. speciosum* var. *carnarvonense* are usually lithophytic, in protected sites along escarpments and rocky creeks. They are usually distinguishable from var. *blackdownense* by more robust, tapering pseudobulbs and large flowers of heavier substance. They are larger and more robust plants compared to var. *capricornicum*, and their flowers, which open later, usually have wider segments. They most closely resemble var. *speciosum* in plant form, flower shape and substance, as also indicated in numerical analyses. Like var. *capricornicum* and var. *blackdownense*, new growths show a strong development of purple anthocyanin pigment, which is not usually evident in the mature leaves.

Descriptions of other varieties

These are based on measurements of 453 plants combined with field observations. Occasional plants may be encountered with measurements outside of the ranges of values presented here. Details of the type collection for recently described var. *boreale* and neotypified var. *curvicaule* are provided.

Dendrobium speciosum Sm. var. ***speciosum***, *Exotic Bot.* 1:17, t.10 (1804)

Plants variable, basket or urn shaped, with curved axes or more erect if axes less curved. Usually lacking aerial roots, but occasional plants produce them; axes and leaves exhibiting purple pigmentation in parts exposed to direct light. Leaf bearing axes usually wide based and tapering towards the apex, 13–51 cm long, 2.1–4.5 cm wide at mid point, round to oval in cross section, variably erect or curved, 2.8–6.0 cm wide at base, 1.4–3.2 cm wide at apex. *Leaves* terminal, 2–5, rigid to very rigid, concave, sub-elliptic to ovate, occasionally oblanceolate, relatively broad at the sheathing base, 9–20 cm long and 4–12 cm wide, 1–2 mm thick. *Racemes* 1–4, 14.5–57 cm long; peduncle 5–16 cm long, 4.6–9.5 mm wide, with 1–4 medium sized bracts; rachis

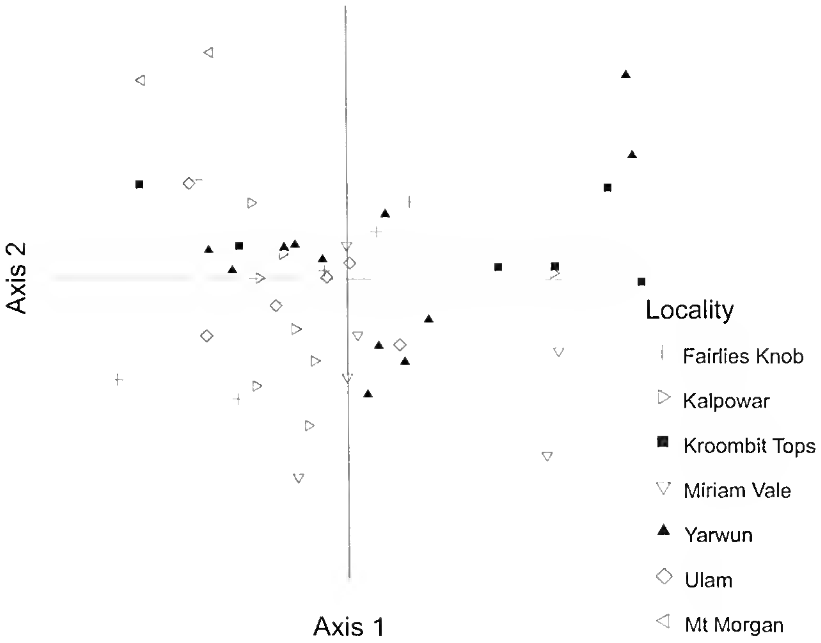


Fig. 7. Ordination from PCoA of *D. speciosum* var. *grandiflorum* individuals using vegetative and floral morphological characters. Axis 1 v. 2.

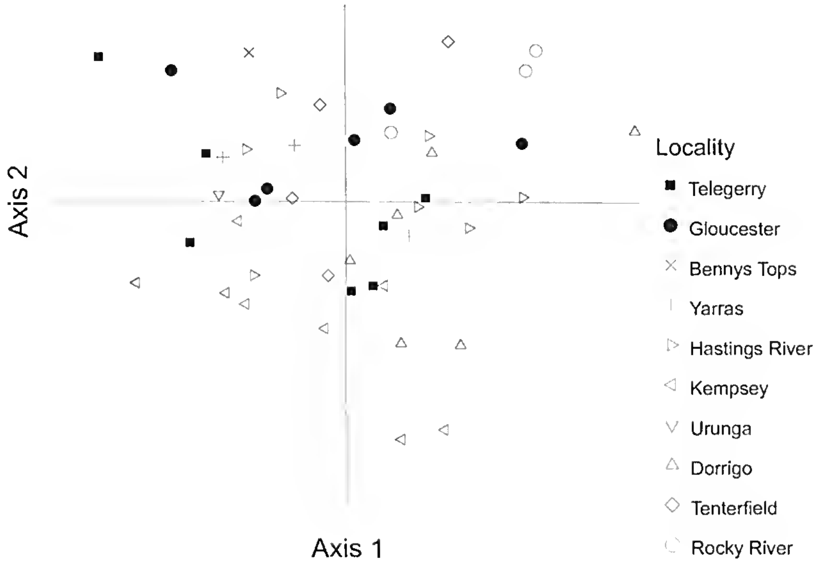


Fig. 8. Ordination from PCoA of *D. speciosum* var. *hillii* individuals using vegetative and floral morphological characters. Axis 1 v. 2.

15–41 cm long, 18–115-flowered: flower density varying from openly spaced to fairly densely clustered. Pedicel including ovary 2.7–5.6 cm long. *Flowers* usually opening moderately or widely, variable in substance, vertical height 4.2–8 cm, horizontal width 4.3–7.8 cm, off white to deep gold, labellum variously and diffusely marked with purple spots or short bars over forelobe and midlobe. *Dorsal sepal* 2.5–4.6 cm long, 0.4–1.0 cm wide at the base, tapering to an obtuse-rounded apex. *Lateral sepals* 1.8–3.9 cm long, 0.7–1.2 cm wide at base, falcate-oblong, obtuse at apex. Petals 2.2–4.1 cm long, 2–5 mm wide, slightly falcate, with an acute apex. *Labellum* 1.1–1.7 cm long, 0.8–1.5 cm wide when flattened; forelobe 0.6–0.9 cm long, 0.8–1.5 cm wide, incurved, subtriangular; midlobe shortly clawed, 0.3–0.8 cm long, 0.6–1.2 cm wide when flattened, presenting as a curved channel with a short acute apex; callus slightly raised, 2-ridged, yellow to orange. *Column* 4–5 mm long with a foot 5–6 mm long at right angles to it. Mentum bifid, rounded, 6–7 mm from ovary to apex.

Flowering time: August–October, or November in eastern Victoria.

Distribution: from Genoa, eastern Victoria (formerly at Cann River, but reportedly extinct there now), north to Bulahdelah, Barrington Tops, New South Wales. Inland, west 200 km to Munghorn Gap near Mudgee, New South Wales.

Notes: large robust plants which may form dense colonies covering whole rock faces on the eastern escarpments of the Great Dividing Range. Occur from sea level to the tops of ranges in open and closed sclerophyll forest and rainforest. In rainforest it is also lithophytic and less frequently an epiphyte, occasionally with aerial roots. Pseudobulbs wide at base, often curved and tapering towards the apex. Flowers relatively large and well spaced, including superior horticultural forms. Larger flowered forms occur in the

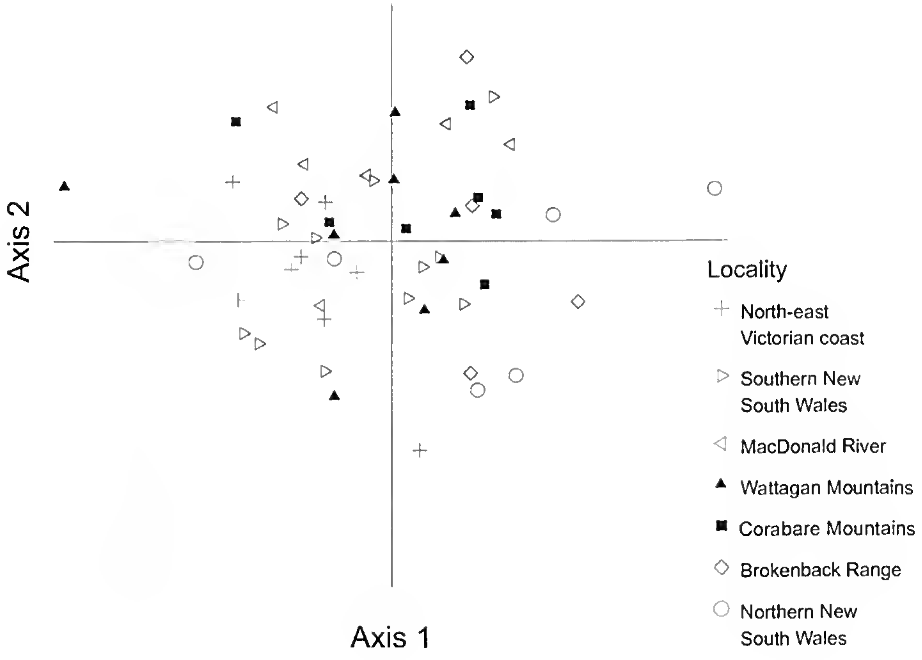


Fig. 9. Ordination from PCoA of *D. speciosum* var. *speciosum* individuals using vegetative and floral morphological characters. Axis 1 v. 2.

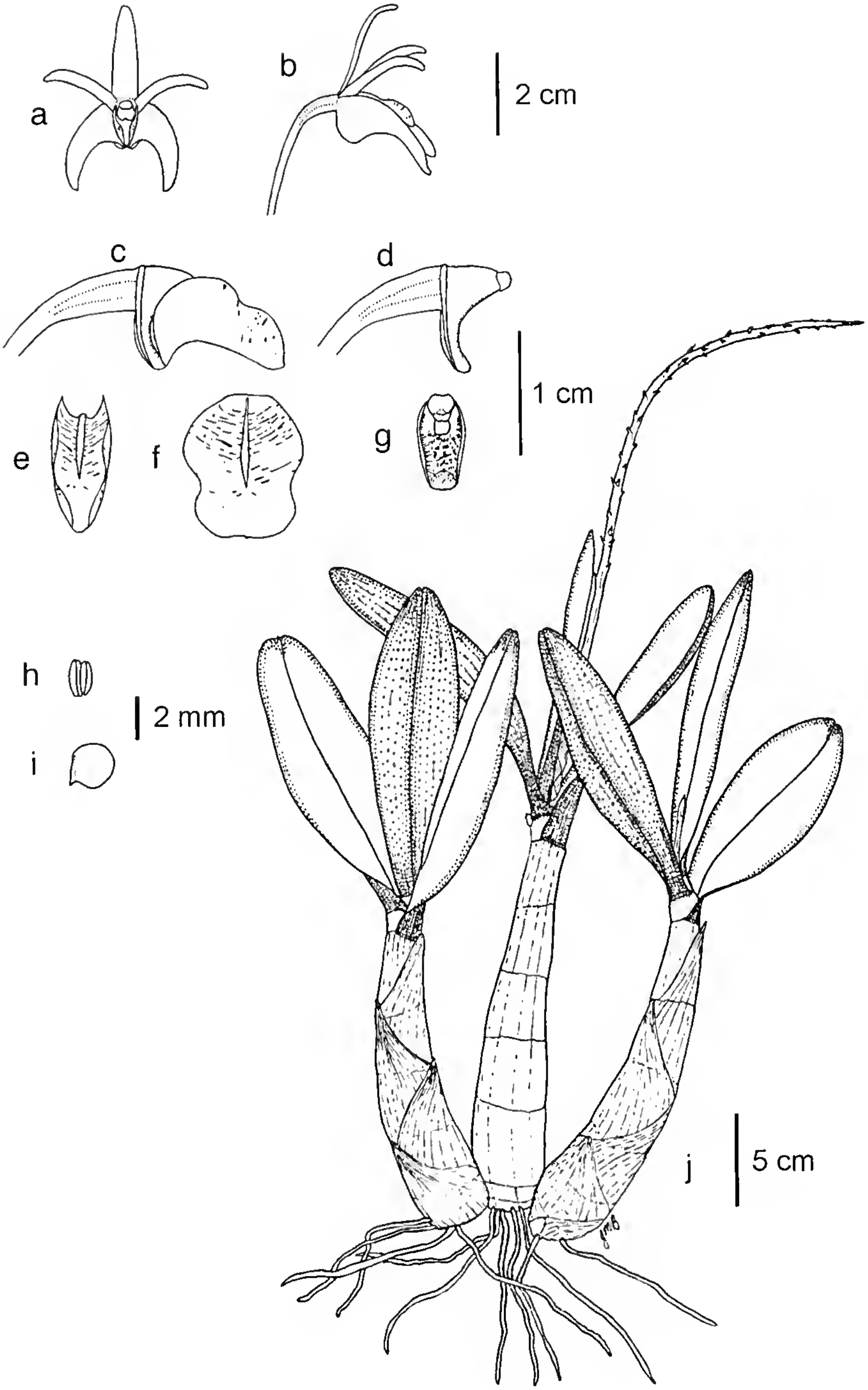


Fig. 10. *Dendrobium speciosum* var. *blackdownense*: (a) whole flower, front view; (b) whole flower, side view; (c) ovary, column and labellum, side view; (d) ovary and column, side view; (e) labellum, top view; (f) flattened labellum, top view; (g) column, front view; (h) pollinium; (i) anther, side view; (j) plant habit.

northern half of the range, from pure white to golden yellow. The variety is variable in size, plant shape and floral dimensions, but less so than most of the more northerly varieties, and intergrades with var. *hillii* primarily north of the Hunter River, New South Wales.

Dendrobium speciosum Sm. var. ***hillii*** Mast., *Gard. Chron. (new ser.)* 7: 112, f. 18 (1877)

Plants variable, tall and upright in habit, commonly producing aerial roots, especially prominent and erect in large rainforest plants. Leaf bearing axes 16–68 cm long, 1.8–5.2 cm wide at mid point, oval in cross section, may be considerably flattened, variably erect or gently curved, 1.4–4.4 cm wide at base, 1.5–4.2 cm wide at apex. *Leaves* terminal, 2–5, often very large, rigid, concave, sub-elliptic to oblanceolate, occasionally ovate, relatively broad at the sheathing base, 13–28 cm long, 6–12 cm wide, 1–2 mm thick. *Racemes* 1–4, 26–65 cm long; peduncle 6–13.6 cm long, 4–9.5 mm wide, with 1–4 medium sized bracts; rachis 20–51 cm long, 44–221-flowered: flower density varying from openly spaced to densely clustered. Pedicel including ovary 2.3–4.6 cm long. *Flowers* small to medium, opening variably, may remain cupped, usually light in substance, vertical height 3.4–5.2 cm, horizontal width 2.9–5.3 cm, usually off white to pale yellow, the labellum variously and diffusely marked with purple spots or short bars over forelobe and midlobe. *Dorsal sepal* 1.9–3.7 cm long, 0.4–0.6 cm wide at the base, tapering to an obtuse-rounded apex. *Lateral sepals* 1.4–2.7 cm long, 0.6–0.9 cm wide at base, falcate-oblong, obtuse at apex. Petals 1.8–3.2 cm long, 2–3 mm wide, slightly falcate, with an acute apex. *Labellum* 0.8–1.3 cm long, 0.7–1.0 cm wide when flattened; forelobe 0.5–0.8 cm long, 0.7–1.0 cm wide, incurved, subtriangular; midlobe shortly clawed, 0.3–0.5 cm long, 0.5–0.8 cm wide when flattened, presenting as a curved channel with a short acute apex; callus slightly raised, 2-ridged, yellow to orange. *Column* 4–5 mm long with a foot 4–6 mm long at right angles to it. Mentum bifid, rounded, 5–6 mm from ovary to apex.

Flowering time: August–October.

Distribution: occurs, or formerly occurred, just south of the Hawkesbury River in central eastern New South Wales, to Mt Mee–Crows Nest in southern Queensland, where it begins to intergrade with var. *grandiflorum*.

Notes: in optimal moist rainforest habitat these plants are very large epiphytes with pseudobulbs more than a metre in height, and forming masses in the canopy several metres in diameter. They are much more abundant and larger in upland forest. In more exposed and drier habitat, rainforest or open forests, they are smaller, and occur as lithophytes or epiphytes. Recognizable by erect, relatively slender, virtually non-tapering pseudobulbs, relatively large leaves and long racemes crowded with many small, white to cream, or occasionally pale yellow flowers. Aerial roots are less common in more exposed sites. At the western limit and at the intergrade with *D. speciosum*, plants may be squat, atypical, and with widely spaced large flowers which are difficult to identify as this variety.

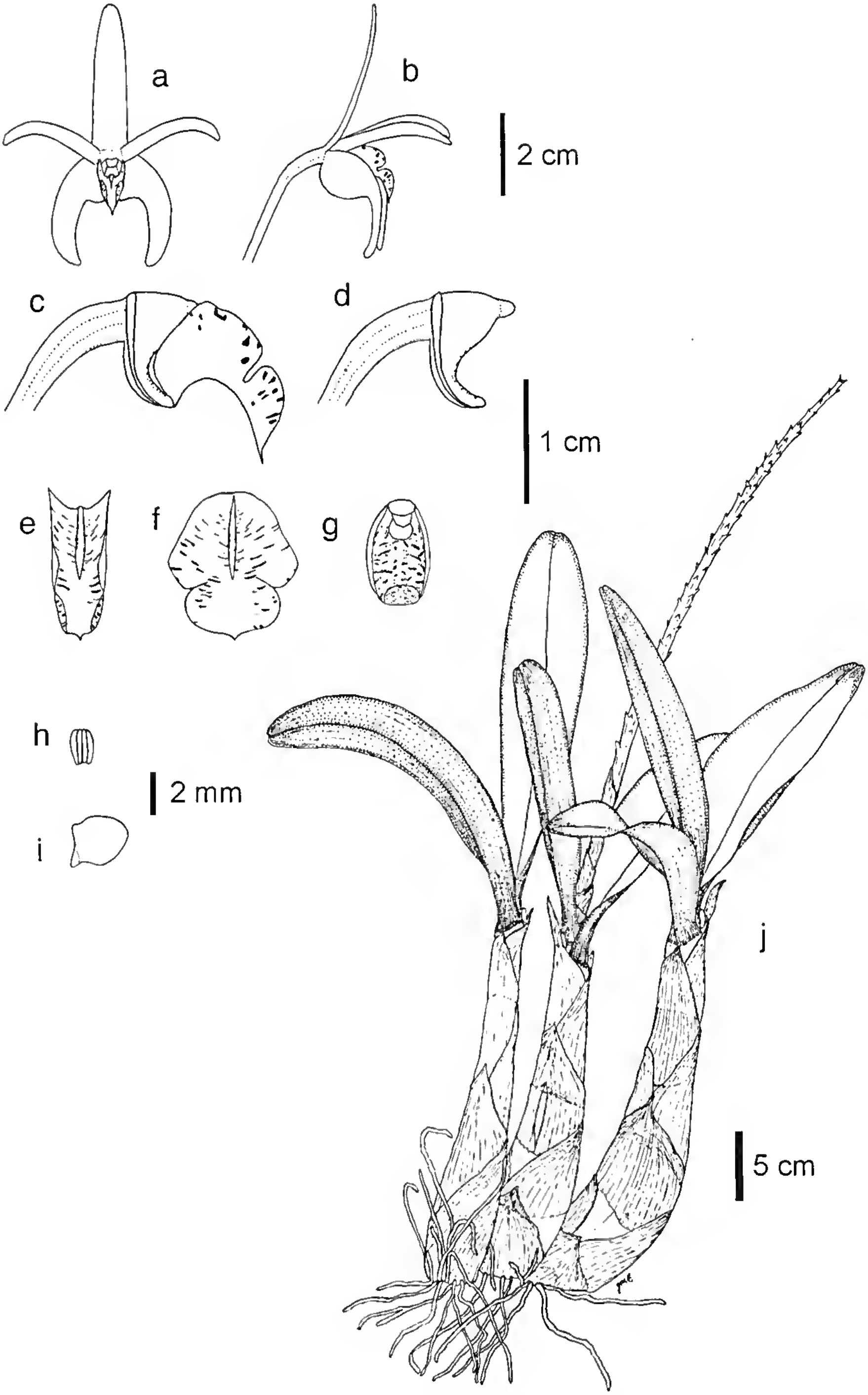


Fig. 11. *Dendrobium speciosum* var. *carnarvonense*: (a) whole flower, front view; (b) whole flower, side view; (c) ovary, column and labellum, side view; (d) ovary and column, side view; (e) labellum, top view; (f) flattened labellum, top view; (g) column, front view; (h) pollinium; (i) anther, side view; (j) plant habit.

Dendrobium speciosum Sm. var. ***grandiflorum*** F.M.Bailey, *Bot. Bull., Dept Agric* 14:12 (1896)

Plants variable, often epiphytic, with very large rainforest forms, commonly with well developed aerial roots. Leaf bearing axes 17–95 cm long, 2.6–5.5 cm wide at mid point, oval or flattened oval in cross section, variably erect or curved, 1.8–3.3 cm wide at base, 1.5–3.2 cm wide at apex. *Leaves* terminal, 2–6, often large, rigid, concave, sub-elliptic to oblanceolate, with a short sheathing base, 12–37 cm long, 5–10 cm wide, 1–2 mm thick. *Racemes* 1–4, short to very long, 25–70 cm long; peduncle 9–16 cm long, 4.5–9.5 mm wide, with 1–5 medium sized bracts; rachis 16–54 cm long, 41–123-flowered: flower density varying from openly spaced to densely clustered, small to large sized including some of the largest in the species. Pedicel including ovary 3.2–5.7 cm long. *Flowers* very variable in substance, usually opening widely, pale yellow to deep gold, occasionally bicolour with a cream-white centre, and rarely pure white, vertical height 4.7–8.1 cm, horizontal width 4.8–8.0 cm, the labellum variously and diffusely marked with purple spots or short bars over forelobe and midlobe. *Dorsal sepal* tends to be much larger in relation to other segments, 2.7–4.7 cm long, 0.6–0.9 cm wide at base, tapering to an obtuse-rounded apex. *Lateral sepals* 2.3–4.5 cm long, 0.8–1.1 cm wide at base, falcate-oblong, obtuse at apex. Petals 2.4–4.2 cm long, 3–5 mm wide, slightly falcate, with an acute apex. *Labellum* 1–1.6 cm long, 1.7–2.5 cm wide when flattened; forelobe 0.6–0.9 cm long, 1–1.4 cm wide, incurved, subtriangular; midlobe shortly clawed, 0.4–0.7 cm long, 0.7–1.1 cm wide when flattened, presenting as a curved channel with a short acute apex; callus slightly raised, 2-ridged, yellow to orange. *Column* 5–6 mm long with a foot 5–7 mm long at right angles to it. Mentum bifid, rounded, 6–8 mm from ovary to apex.

Flowering time: August – October.

Distribution: including the interface with var. *hillii*, it occurs from Mt Mee–Crow's Nest, to the Mt Morgan area.

Notes: found in suitable rainforest habitat where it forms dense populations in the canopy on many rainforest trees, and hoop pines (*Araucaria cunninghamii* Aiton ex D. Don) and along rocky creeks and escarpments. Pseudobulbs may be almost one metre long in the rainforest, and similar to, but often thicker than those seen in var. *hillii*, with very large leaves in shady habitat. In more exposed situations as epiphytes or lithophytes, plants may be only 20 cm high, with short, straight or curved pseudobulbs. In the south of the range there is a gradual merging with var. *hilli*, where many plants are short, smaller, or with pale yellow flowers. Deep yellow colour and large flowers with prominent dorsal sepals help to distinguish only some plants of the variety. Unusual coloured forms of yellow flowers with white centres are reported between Kroombit Tops and Miriam Vale.

Dendrobium speciosum Sm. var. ***capricornicum*** Clemesha, *Orchadian* 7: 103 (1982)

Plants variable, relatively short and compact, small to medium sized, usually upright in shape and lithophytic, without aerial roots; axes and leaves exhibiting purple pigmentation in parts exposed to direct light. Leaf bearing axes usually cylindrical, 7–19 cm long, 2–3.8 cm wide at mid point, round to oval in cross section, variably erect or curved, 2–3.9 cm wide at base, 1.6–2.5 cm wide at apex. *Leaves* terminal, 2–5,

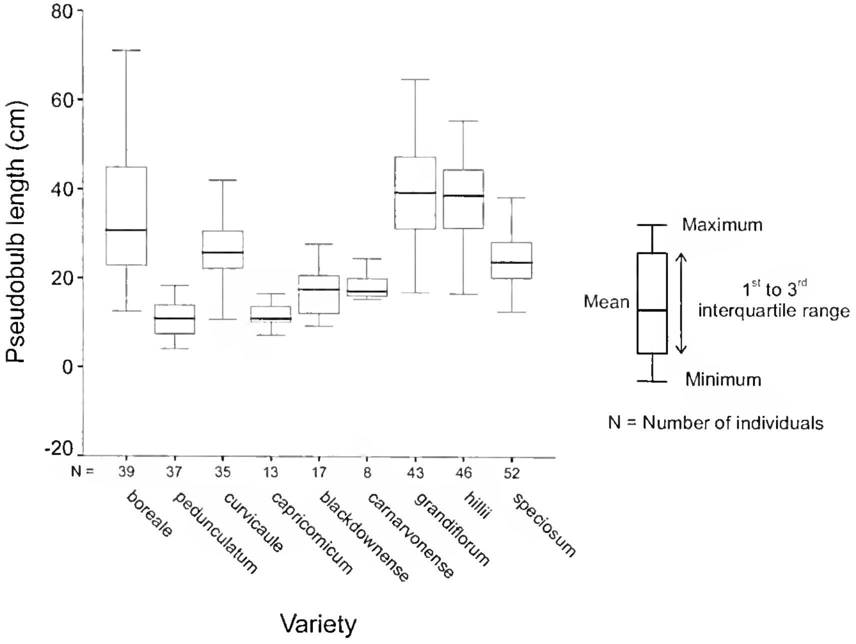


Fig. 12. Variation in pseudobulb length of *Dendrobium speciosum* varieties. N = number of individuals measured.

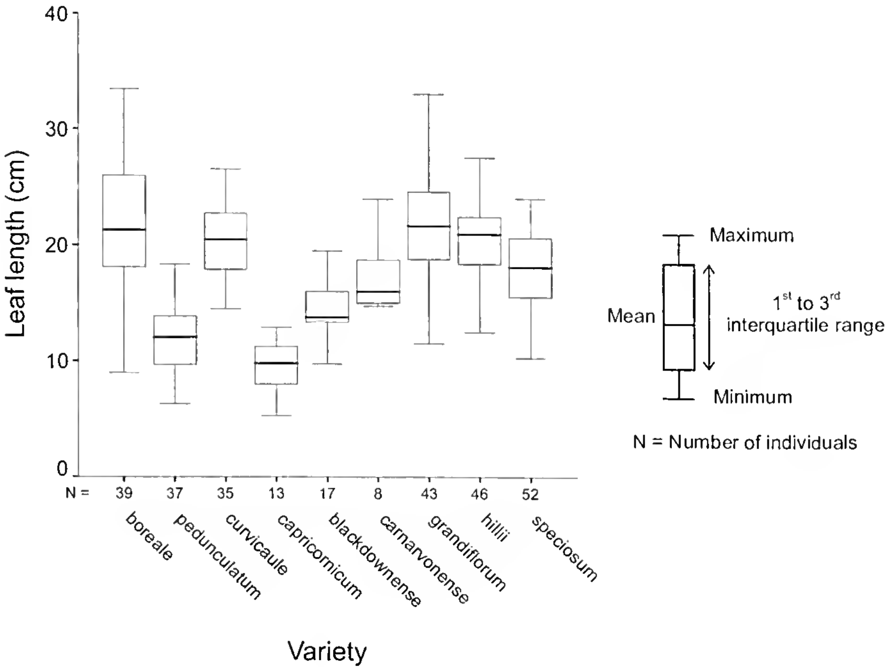


Fig. 13. Variation in leaf length of *Dendrobium speciosum* varieties. N = number of individuals measured.

very rigid and coriaceous, often channelled, sub erect, ovate to oblanceolate, with a short sheathing base, 5–16 cm long, 4.5–6 cm wide, 1–3 mm thick. *Racemes* arching or erect, 1–2, 17–49 cm long; peduncle short to long, 9–22 cm long, 5–7 mm wide, with 1–3 medium sized bracts; rachis 8–27 cm long, 11–68-flowered; flower density varying from openly spaced to clustered. Pedicel including ovary 2.7–4.4 cm long. *Flowers* usually opening widely, very variable in substance, vertical height 3.4–5.9 cm, horizontal width 3.9–5.6 cm, off white to deep gold, the labellum variously and diffusely marked with purple spots or short bars over forelobe and midlobe. *Dorsal sepal* 2.1–3.4 cm long, 0.5–0.8 cm wide at the base, tapering to an obtuse-rounded apex. *Lateral sepals* 1.6–2.9 cm long, 0.7–1.1 cm wide at base, falcate-oblong, obtuse at apex. Petals 1.9–3.0 cm long, 3–5 mm wide, slightly falcate, with an acute apex. *Labellum* 1–1.6 cm long, 1–1.2 cm wide when flattened; forelobe 0.6–0.9 cm long, 1–1.2 cm wide, incurved, subtriangular; midlobe shortly clawed, 0.4–0.7 cm long, 0.8–1.1 cm wide when flattened, presenting as a curved channel with a short acute apex; callus slightly raised, 2-ridged, yellow to orange. *Column* 4–5 mm long with a foot 5–6 mm long at right angles to it. Mentum bifid, rounded, 6–7 mm from ovary to apex.

Flowering time: May–August.

Distribution: Mt Morgan area to Byfield, and west to Berserker Range.

Notes: in east Capricorn, localised colonies with short and very coriaceous leaves are restricted to suitable habitat on volcanic plugs, and in forest and creek side locations at Byfield. On volcanic plugs, plants are exposed to full sun, and only their leaves may be evident between rock crevices. The bulk of the pseudobulbs are protected between layers of stone. In the northern part of the range occasional colonies occur with a wide variety of plant form, and well spaced yellow to gold flowers.

Dendrobium speciosum Sm. var. ***curvicaule*** F.M.Bailey, *Bot. Bull., Dept Agric.* 14:12 (1896)

Neotype (Adams et al. 2006a): Queensland. Kennedy North District: Cathu State Forest, *P.B. Adams & S.D. Lawson*, 27 Jun 1993 (holo: QRS; isoneo: BRI, MEL).

Brief Neotype Diagnosis: Leaf-bearing axes short to medium (10.7–52 cm long), collum usually inconspicuous, peduncle short (7.5–16 cm long), flowers moderately spaced to crowded, off white to bright yellow, tepals variably long, lateral sepals broad (0.8–1.2 cm wide), variably incurving.

Plants very variable in shape and size, aerial roots prominent in occasional plants. Leaf bearing axes curved, fusiform or linear, 10.7–52 cm long, 1.7–5.1 cm wide at midpoint, with an indistinct or absent collum at base, if collum present then widening distally over only 1–2 cm, axis at base 1.3–4.0 cm wide, round to oval in cross section. Apex of axes usually narrowing to 1.4–3.4 cm wide, variably sharply edged only in the distal few centimetres. Leaves terminal, 2–4, 15–26.6 cm long, 4–9.2 cm wide, leaf shape variable, sub-elliptic to oblanceolate with a short sheathing base, concave, rigid, 1–2.7 mm thick, thinner, larger and more flexible leaves in dense shade, smaller and thicker when exposed to sun. *Racemes* 1–3, 20–65 cm long, peduncle 7.5–16 cm long, 3.7–7.9 mm wide, shorter than the rachis with prominent bracts; rachis 12.5–45.5 cm long, bearing 20–135 flowers, open or very closely spaced and overlapping, pedicel including ovary medium to very long, 2.2–5.2 cm long. *Flowers* small to

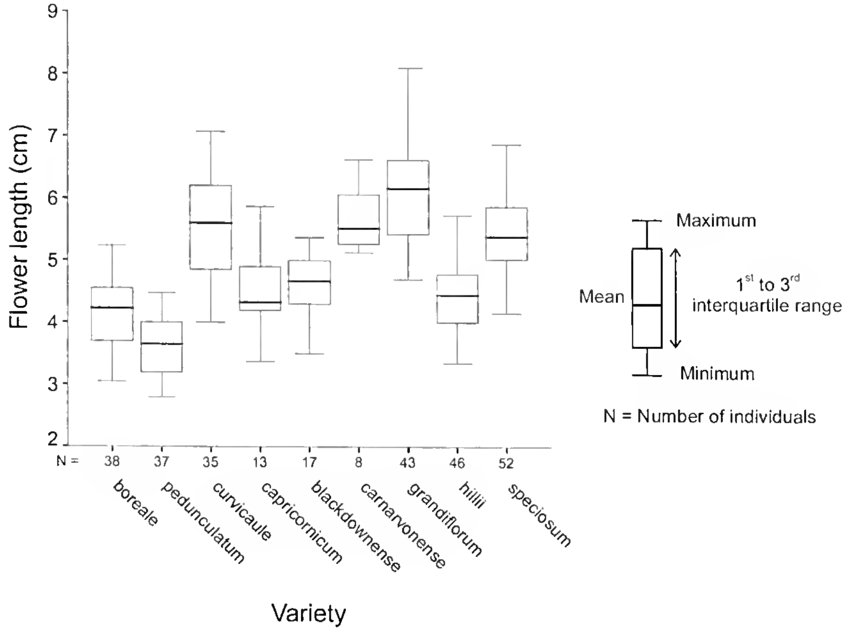


Fig. 14. Variation in flower length of *Dendrobium speciosum* varieties. N = number of individuals measured.

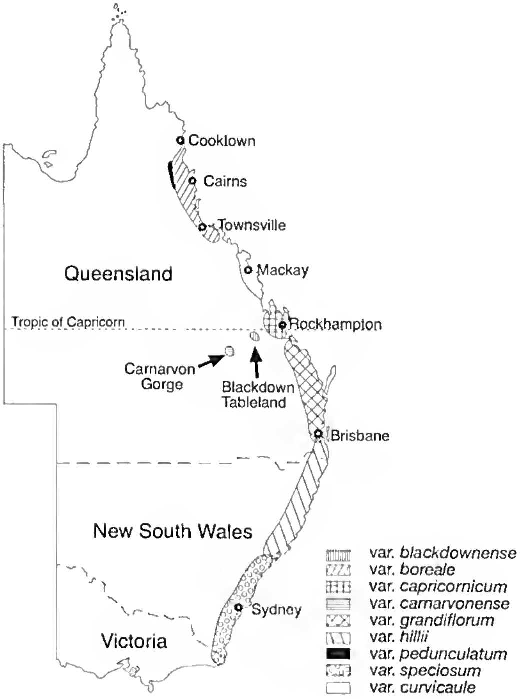


Fig. 15. Distribution of taxa of *Dendrobium speciosum* Smith.

large, usually opening widely but sometimes cupped, 4–7.1 cm long vertically, 4.1–7 cm wide horizontally, off white to deep yellow segments with heavy substance, labellum white to cream, variously marked with purple spots or bars on forelobe and midlobe. *Dorsal sepal* 2.2–4.1 cm long, 0.6–1.0 cm wide, tapering from base to an obtuse-rounded apex. *Lateral sepals* 1.4–2.5 cm long, 0.8–1.2 cm wide, falcato-oblong and obtuse at apex. Petals relatively long 2.1–3.6 cm long, 3–5 mm wide, almost linear and ending acutely. *Labellum* 0.9–1.5 cm long, 1–1.3 cm wide, forelobe 0.6–0.9 cm long, 1–1.3 cm wide when flattened, incurved and subtriangular, midlobe on a short claw, midlobe 0.3–0.6 cm long, 0.7–1.6 cm wide when flattened, presenting as a curved channel with short acute apex. *Column* c. 5 mm long with a foot 5–6 mm long at right angles to it, mentum bifid, rounded, 6–7 mm from ovary to apex. Callus raised, 2-ridged, low profiled, orange coloured.

Distribution: Mt Dryander north east of Proserpine, to St Lawrence, and the Whitsunday Islands.

Flowering time: August–September.

Notes: previously more broadly circumscribed to include plants treated here as var. *boreale* (Adams et al. 2006a). Predominantly a rainforest epiphyte from sea level to 1200 metres, on large trees such as Tulip Oak (*Argyrodendron actinophyllum* (Bailey) Edlin) and Red Cedar (*Toona australis* (F. Muell.) Harms), often as very large plants over two metres in diameter, usually high in the canopy, where populations may be very dense. Smaller, shorter plants are found in more exposed open forest as epiphytes or lithophytes, and along watercourses on *Casuarina* L. ex Adans. Short diminutive plants are found at sea level on the Whitsunday Coast. They have been discussed and illustrated by Dockrill (1992, pp. 462–463), who considered it a possible sub coastal variety. These forms represent atypical ecotypes comparable to those that are often seen at the eastern and western habitat limits for most other varieties (see also var. *hillii*). South of Sarina, colonies are isolated, and form an intergrade with var. *capricornicum* along dry watercourses. Flowers are usually cream, but may be deep yellow or gold. They may be small or large, with broad segments, and represent some of the finest horticultural forms of the species.

Dendrobium speciosum Sm. var. ***boreale*** P.B.Adams, J.M.Burke & S.D.Lawson [ms.] *Aust. Syst. Bot.* (2006a)

Type: Queensland. Cook District: Windsor Tableland, *B. Gray, P.B. Adams, J.M. Burke & S.D. Lawson*, 3 Aug 2004, (holo: QRS; iso: BRI, MEL).

Brief Diagnosis: Leaf-bearing axes short to long (12.6–71 cm), rarely curved; collum usually prominent; peduncle moderately long (8–29 cm) but not longer than rachis; flowers well spaced; tepals off white to pale yellow, broad in relation to length; lateral sepals moderately broad (0.7–1.0 cm) with little incurving.

Plants very variable in shape and habit, occasionally producing aerial roots. Leaf-bearing axes 12.6–71.0 cm long, 1.4–4.6 cm wide at mid point, with little tapering or shorter and fusiform, usually with a prominent collum at base 1.3–4.4 cm long, axis at base 1.3–2.7 cm wide, oval or flattened in cross section, erect or curved or gently angled once or twice in distal half, sharply edged over distal half (especially notable in axes of taller plants 1–2 years old), tapering or broadening towards apex

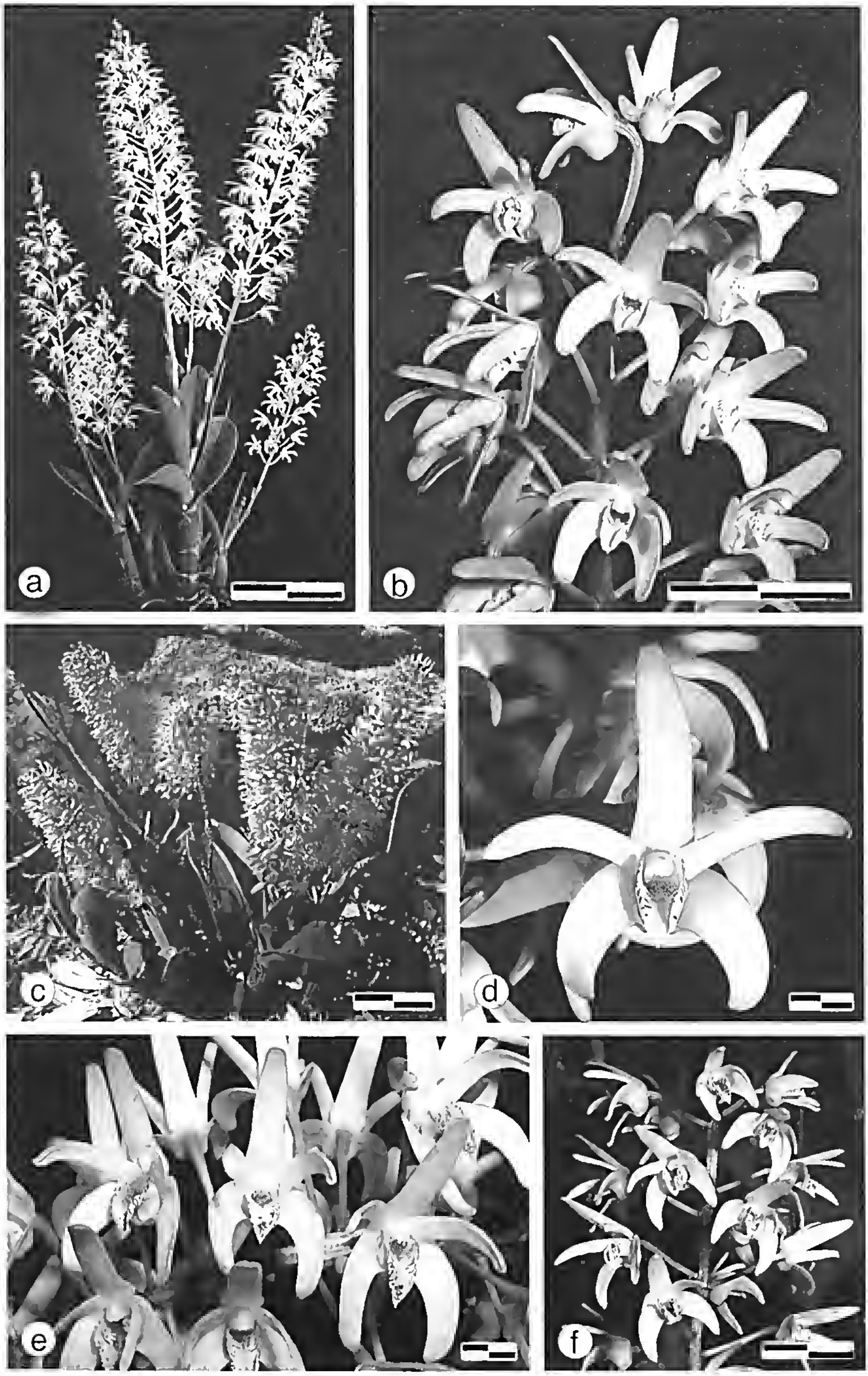


Fig. 16. *Dendrobium speciosum* var. *capricornicum*: (a) Rockhampton area; (b) north of Byfield. *Dendrobium speciosum* var. *blackdownense*: (c) densely flowered gold form; (e) open raceme form; (f) off white form. (d) *Dendrobium speciosum* var. *carnarvonense*, Carnarvon Gorge. Scale bars: (a), (c) = 10 cm; (b), (f) = 5 cm; (d), (e) = 1 cm.

1.2–4.2 cm wide. *Leaves* terminal, erect and narrower in shorter forms, 2–4, 9–34 cm long, 5–11 cm wide, sub-elliptic to oblanceolate with a sheathing base, concave, rigid, 1–2.6 mm thick, relatively thin, large, and flexible in dense shade, relatively small and thick when exposed. Axes and leaves sometimes showing purple pigment in areas exposed to strong light. *Racemes* 1–3, 18–76 cm long; peduncle 8–29 cm long, 3–8 mm wide, shorter or no longer than the rachis, with 1–5 prominent bracts; rachis 10–48 cm long, with 9–125 star-like flowers openly spaced and displayed. Pedicel including ovary 2.5–5.3 cm long. *Flowers* usually opening widely, 3–5 cm long vertically, 3.3–5.5 cm wide horizontally, off white to cream, occasionally pale yellow, with purple spots or short bars marking the forelobe and midlobe of the labellum; tepals presenting with wide bases and heavy substance. *Dorsal sepal* 1.8–3.0 cm long, 0.55–0.9 cm wide at base, tapering from base to an obtuse-rounded apex. *Lateral sepals* 1.3–2.1 cm long, 0.7–1.0 cm wide at base, falcato-oblong, slightly incurved, obtuse at apex. Petals 1.6–2.7 cm long, 2–5 mm wide, almost linear, ending acutely at apex. *Labellum* 1.1–1.7 cm long, 1–1.3 cm wide; forelobe 0.7–1.0 cm long, 1–1.3 cm wide when flattened, incurved, subtriangular; midlobe on a short claw, 0.4–0.7 cm long, 0.6–1.0 cm wide when flattened, presenting as a curved channel with a short acute apex. *Column* c. 5 mm long, with a foot c. 6 mm long and at right angles to it. Mentum bifid, rounded, c. 7 mm long from ovary to apex. Callus raised, 2-ridged, low profiled, yellow to orange.

Flowering time: July–September, usually later than var. *pedunculatum*.

Distribution: Annan River, south to Mt Elliot (south of Townsville).

Etymology: the epithet alludes to the most northerly distribution of *D. speciosum* (Latin: *boreale* = northern).

Notes: in Adams et al. (2006a) we reviewed *D. speciosum* var. *curvicaule* and showed it to be a name of uncertain application, and described var. *boreale* for plants north of Mt Elliot, which were previously attributed to var. *curvicaule*. Lithophytic or epiphytic in and around rainforest, very variable in plant size but commonly tall in densely shaded rainforest gullies, shorter plants lithophytic in more exposed sites and along rocky creeks with similar floral characters, often associated with small shrubs and moss beds. Occurs east of the Great Dividing Range from almost sea level to over 1200 metres. Plants may form dense colonies or be scattered. Tall rainforest forms and short forms are often only a few metres apart at the forest edges. Flowers are similar in both forms, and not greatly variable compared with other varieties.

There is a small degree of overlap with var. *curvicaule* in morphology and numerical characteristics. *Dendrobium speciosum* var. *boreale* is distinguished from typical var. *pedunculatum* in drier habitats, the latter having smaller pseudobulbs, shorter racemes and usually smaller flowers with more rounded segments.

In drier rainforest and sclerophyll forests e.g. Tinaroo Dam, Paluma, Bluewater, Mt Elliot, Hidden Valley and Tully areas, smaller plants show floral and vegetative characteristics that are intermediate in morphology between rainforest forms and var. *pedunculatum*. These forms are interpreted as shorter variants of var. *boreale*. The PCoA ordination indicates overlap between var. *boreale* and var. *pedunculatum* in a continuum (Fig. 4). The intermediate forms have variable peduncle length, from shorter to longer in relation to rachis. Axes of var. *boreale* are not significantly curved unless growing on vertical surfaces or in dense shade.

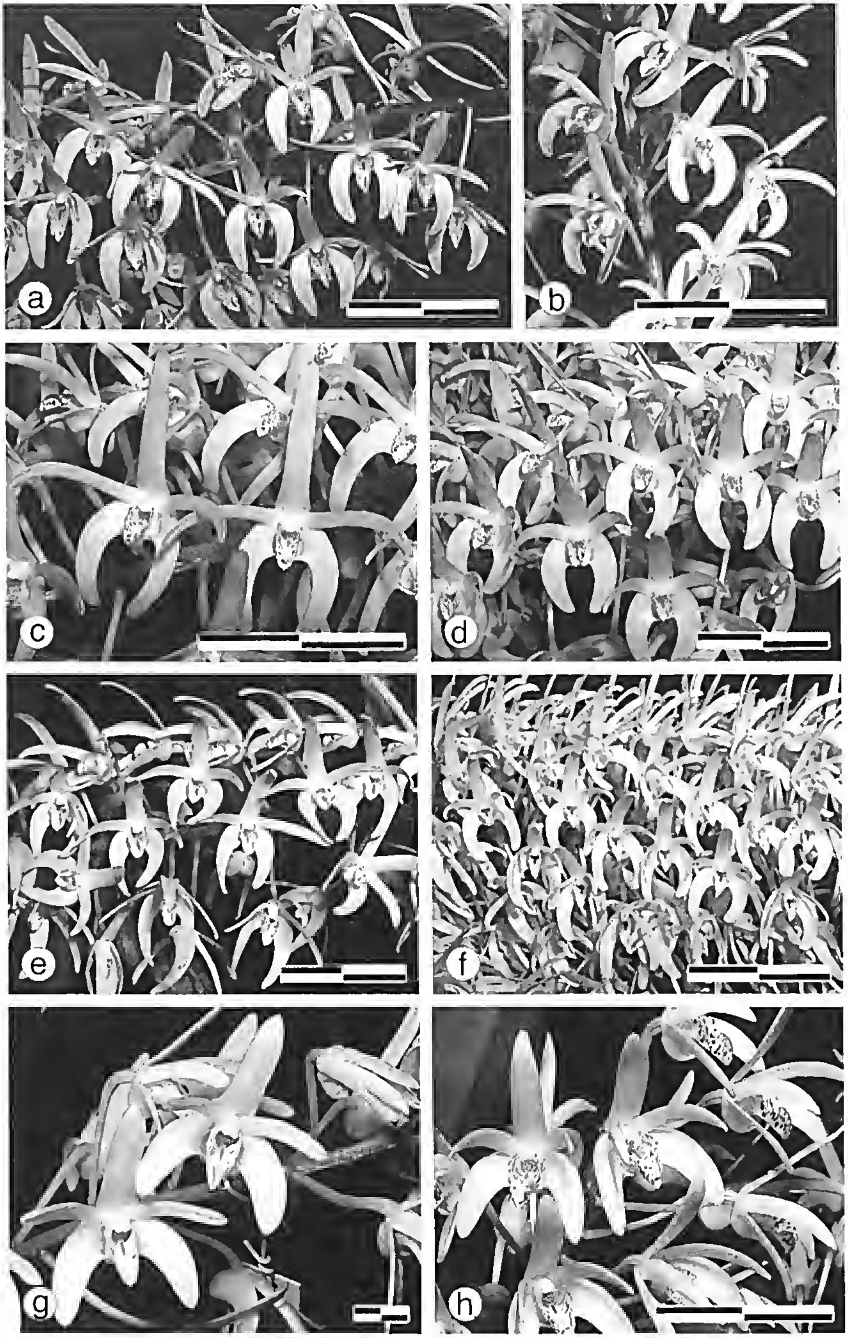


Fig. 17. *Dendrobium speciosum*: (a) var. *boreale*, cream flowers, Mt Finnigan, Queensland; (b) var. *boreale*, white flowers, Paluma, Queensland. (c) var. *grandiflorum*, gold form, Miriam Vale, Queensland; (d) var. *curvicaule*, Crediton, Queensland; (e) intermediate form from the boundary of var. *grandiflorum* and var. *hillii* territory, Blackbutt, south Queensland; (f) var. *hillii*, west of Wauchope, New South Wales; (g) var. *pedunculatum*, west of Mareeba, Queensland; (h) var. *speciosum*, Kangaroo Valley, New South Wales. Scale bars: (a)–(f), (h) = 5 cm; (g) = 1 cm.

At Paluma and Hidden Valley some plants are shorter, 20–40 cm, with narrower cylindrical axes and small rounded white flowers up to 90 per raceme. To the north there is a gradation towards the typical rainforest form of var. *boreale*, as the habitat becomes wetter and the rainforest canopy denser. Southwards to Townsville and beyond, where populations are more isolated and close to sea level, they may be diminutive with a less distinct or absent collum.

Dendrobium speciosum Sm. var. ***pedunculatum*** Clemesha, *Orchadian* 6: 261 (1981)

Plants variable, usually short, compact lithophytes without aerial roots. Leaf-bearing axes 4.1–36 cm long, 1.8–4.4 cm wide at midpoint, round to oval in cross section, collum usually absent, 1.2–3.7 cm wide at base, erect or mildly curving. Apex of axes usually narrowing to 1.1–2.7 cm wide. *Leaves* terminal, tending erect, 2–4, 6.3–19.3 cm long, 3.2–8.6 cm wide, leaf shape variable, sub-elliptic to ovate, relatively broad at the sheathing base, very coriaceous and rigid, concave, 1.1–2.5 mm thick. Axes and leaves exhibiting purple pigmentation in parts exposed to direct light. *Racemes* 1–2, 15.9–56.9 cm long, peduncle longer or shorter than the rachis, 8.4–30.7 cm long, 2.2–5.7 mm wide with small bracts; rachis 7.5–26.2 cm long, with 9–72 flowers, open or very closely spaced and overlapping forming a brush. Pedicel including ovary medium to very long, 1.9–4 cm long. *Flowers* usually opening widely or cupped, 2.8–4.5 cm long vertically, 3.1–4.7 cm wide horizontally, off-white to yellow segments of heavy substance, labellum white to cream, variously marked with purple spots or bars on forelobe and midlobe. *Dorsal sepal* 1.8–2.7 cm long, 0.45–0.78 cm wide at base, tapering from base to an obtuse-rounded apex. *Lateral sepals* 1.3–2.1 cm long, 0.7–1.1 cm wide, falcato-oblong and obtuse at apex. Petals 1.5–2.5 cm long, 2–3.8 mm wide at base, almost linear and ending acutely. *Labellum* 0.9–1.6 cm long, 0.9–1.3 cm wide, forelobe 0.6–0.9 cm long, 0.9–1.3 cm wide when flattened, incurved and subtriangular; midlobe on a short claw, 0.3–0.6 cm long, 0.65–1.0 cm wide when flattened, presenting as a curved channel with short acute apex. *Column* c. 5 mm long with a foot c. 6 mm long at right angles to it, mentum bifid, rounded, 6–7 mm long from ovary to apex. Callus raised, 2-ridged, low profiled, orange colour.

Flowering time: July–September.

Distribution: Parker River headwaters to Lumholz National Park, south of Atherton Tableland, representing a narrow strip of open forest. The distribution is smaller than previously considered, and habitat has been reduced by altered land use.

Notes: occurs on and to the west of the Great Dividing Range in northern Queensland. It includes some plants informally described as "var. *compactum*". Plants are scattered diffusely along rocky exposed watercourses, cliff faces and escarpments, and occasionally found on the base of small trees. Leaves tend to be very coriaceous, and may exhibit purple anthocyanin pigment. There is usually only one raceme per pseudobulb, which is apical, with well spaced (occasionally closely) pale cream to yellow flowers of heavy substance. The peduncle is often as long as or longer than the rachis, but forms are found with much shorter peduncles.

Variation of characters within and between varieties

The variation in pseudobulb, leaf and flower length for plants assigned to varieties across the geographic range is presented in Figs 12–14, which provide the median, first to third interquartile range, and extremes in the data set. Other characters show similar patterns of continuous variation within and between described varieties.

Distribution of *Dendrobium speciosum* in major regions of eastern Australia

Our explorations indicate an almost continuous north to south distribution between the Annan River south of Cooktown (Queensland) and Genoa (eastern Victoria), with the qualification that small populations in marginal habitat may be up to 50 km apart. Small populations occur in locations previously considered to be unsuitable habitat. These include areas between Rockhampton and Gladstone, between Rockhampton and Sarina, and dry forests 100 km north and south of Townsville. We indicate the approximate limits of the varieties confirmed in this paper in Fig. 15.

Field surveys concentrated near the geographic limits of varieties revealed areas where populations exhibited characteristics intermediate between the two adjacent varieties. Within these populations we could not identify typical individuals of the varieties admixed with intermediate forms, or the presence of sporadic hybrids. Each population subtly varied from the next, forming an intergrade or continuum.

Between adjacent varieties along the Great Dividing Range there are plants with intermediate characters occupying territory generally less than 150 km apart. The following areas of intermediate forms were identified in relation to Fig. 1. There is a narrow zone between Regions 1a and 1b, between rainforest and dry, exposed cliff faces (var. *pedunculatum*–var. *boreale* interface). Between Regions 2 and 3, the interface between var. *curvicaule* and var. *capricornicum*, scattered populations occur in dry country. A narrow zone of populations with intermediate characteristics is recognized between Regions 3 and 5 (Mt Morgan area) at the var. *capricornicum* and var. *grandiflorum* interface. There is a broad zone of around 150 km between Regions 5 and 6, which extends north from a line between Mt Mee and Crows Nest, and includes Blackbutt, Gallangowan, Conondale and Kilkivan. This represents the var. *grandiflorum* and var. *hillii* interface. Between Regions 6 and 7, the interface between var. *hillii* and var. *speciosum* forms a band between Bulahdelah and Barrington Tops, which extends south-west to Munghorn Gap near Mudgee.

Discussion

Interpretation of analyses

This extensive study of variation indicates that *D. speciosum* is a single variable species differing mainly in size characteristics, occurring in widely varied habitats. There are intergrading groups best interpreted as varieties, and no discrete qualitative differences between any populations or regions. Some plants do not fit exactly with any varietal description and are most satisfactorily designated by geographical notation. Based on UPGMA cluster analysis, the most distinct varieties are var. *boreale* (Region 1a) and var. *hillii* (Region 6).

The variation within this species complex indicates morphological forms with a geographic pattern that is largely allopatric. Multivariate analyses of *D. speciosum* could not demonstrate a phenetic gap between any identified groups, all of which overlapped in ordination space to varying degrees. Plants described as varieties may overlap in ordination space, but in the areas of interface between two varieties they are not identifiable as admixtures with intervarietal hybrids. These populations consist of plants which all show intermediate characteristics.

The addition of plants from newly surveyed areas, and interpretations of groups as three new varieties, one in northern Queensland and two in central Queensland, has expanded the recognised level of variation. The areas of greatest complexity and most difficult interpretation occur in north Queensland, and central Queensland along the Tropic of Capricorn, as demonstrated in the regional ordinations (Figs 4–6).

Distribution of Taxa

The distributional range of taxa within *D. speciosum* has been difficult to define due to wide inherent variation, zones of intermediate forms, and significant loss of habitat, particularly at the var. *speciosum*/ var. *hillii* and var. *hillii*/ var. *grandiflorum* interfaces. For the six most northerly varieties our surveys have clarified the distributions. Habitat loss is not confounding, except at the interface of var. *pedunculatum* and var. *boreale* on the Atherton Tableland.

The distribution is much more continuous than previously considered, especially north of Rockhampton. The gradation between var. *curvicaule* and var. *capricornicum* between Clairview and Byfield represents the largest north-south zone of intermediates. The more southerly intermediate zones between var. *grandiflorum* and var. *hillii*, and between var. *hillii* and var. *speciosum* have been noted by previous reviewers, who have highlighted the difficulty of assigning these plants to varieties. Gregory (1988) noted that varieties "gradually merge into one another up and down the Great Dividing Range". Jones (1988 p. 478) stated that "confusing intermediate forms may occur where ranges (of varieties) overlap". Dockrill (1992, vol. 1 p.457) noted that "all varieties within themselves are quite variable, and merging of intermediates.... made it virtually impossible to give a satisfactory determination of a particular clone." Banks and Clemesha (1990) noted intermediate areas where it was "difficult to say where one stops and another starts".

For the var. *hillii* and var. *speciosum* interface, the intermediate zone requires more exploration at the western limit. There has been considerable habitat loss and plant collection, especially south of the Hunter River. Reports of plants attributed to var *hillii* from Peat's Ridge (Clemesha 1986), and from the Wattagan area, cannot be conclusively evaluated. Our recent surveys on the coastal ranges south of Newcastle, including the Wattagan Mountains, indicated only plants attributable to var. *speciosum*.

Biogeography

In north Queensland, medium to large plants of var. *boreale* have the largest distribution, in wet tropical rainforest (Region 1a). In Region 1a there are also shorter forms of var. *boreale*, usually in intermediate sclerophyll forest habitat on margins of rainforest. In the dry zone north and south of Townsville, shorter plants attributed to var. *boreale* are found in small isolated populations, and a similar plant form is found in isolated colonies between Sarina and Rockhampton.

Variety *pedunculatum* is a short plant form occupying a very narrow strip of dry country on or west of the Great Divide, on the fringe of var. *boreale* territory, from west of the Windsor Tableland to Lumholz National Park (Region 1b). The distribution area of var. *pedunculatum* is extremely small in relation to that of var. *boreale* (Fig. 15). The type form of var. *pedunculatum* from Bone's Knob is in this narrow strip, and one of the major clarifications of this study is the designation of shorter plants east of the divide in and around rainforest as variants of var. *boreale*. Many of these were previously regarded as forms of var. *pedunculatum*. They are usually differentiated by long upright racemes with many small to medium sized white or pale cream flowers which have wide segments, and their peduncles are variable, often short in relation to rachis length.

On volcanic plugs near Rockhampton, short plants meeting the description of var. *capricornicum* (Clemesha 1982) intergrade with forms similar to those in the southern area of Region 2 (var. *curvicaule*). West to Blackdown Tableland and Carnarvon Gorge, two new taxa are described on the basis of morphological characteristics and regional PCoA analyses, var. *blackdownense* and var. *carnarvonense*. These groups abut in ordination space and are geographically distinct, with a small amount of overlap in numerical analyses with plants of Regions 2, 3 and 5 (Figs 3, 5 and 6). Clemesha (1982) and Walsh (2000) commented that some plants of var. *capricornicum* may resemble var. *grandiflorum*. We consider from repeated observations that var. *carnarvonense* and var. *blackdownense* are clearly distinguishable from var. *grandiflorum*.

In Region 5, primarily consisting of var. *grandiflorum*, there is a fairly abrupt narrow interface between var. *capricornicum* and var. *grandiflorum* in the north, determined by a limit of moister rainforest south of Rockhampton. There is a considerable gradation between var. *grandiflorum* and var. *hillii* at the boundary of Regions 5 and 6, the var. *grandiflorum* at the southern limit being usually shorter in stature, with smaller flowers. Around Gladstone, tall forms in dry rainforest and shorter forms on volcanic plugs are found with large gold flowers.

Plants of Regions 7 and 8 (var. *speciosum*) are easily identified by their locality, but overlap considerably with populations from other regions in the ordination (Fig. 3). Skilled observers are usually able to identify them from their vegetative and floral form, except for the area of intermediate forms at the var. *speciosum* and var. *hillii* interface. The associations of populations with habitat assist in designation of varieties in Region 1 and on the volcanic plugs of Region 3 (Table 4), and suggests that much of the variation is ecophenetic.

Table 4. Associations of varieties with habitat in regions.

Region	Variety	Rainforest	Sclerophyll Forest, or Riparian	Rocky Plugs
1a	*boreale*	+	+	-
1b	*pedunculatum*	-	+	-
2	*curvicaule*	+	+	-
3	*capricornicum*	-	+	+
4	*blackdownense*	-	+	-
4	*carnarvonense*	-	+	-
5	*grandiflorum*	+	+	+
6	*hillii*	+	+	-
7, 8	*speciosum*	+	+	-

Recommended taxonomy

There are no generally accepted criteria or definitions for grouping or ranking in botanical taxonomy, especially at specific and infraspecific level. Subspecies, varieties, subvarieties and forms have been used in many ways to interpret degrees of difference. More recent practice has tended to treat intergrading taxa, and even subgroupings within some clines, as subspecies. Stuessy (1990, p. 193) attempted to define levels of difference for subspecies, varieties and forms, and recommended that existing ranks be retained in the interest of nomenclatural stability for groups with a history of taxonomic study, and that subspecies could be preferred for newly studied groups. Choice of rank remains an individual decision of taxonomists based on their understanding of a group.

In taxonomic studies of *Dendrobium*, Schlechter (1982) arranged individual species as naturally as possible within the genus, and did not provide a species definition. Dockrill (1969, 1992) discussed the difficulties of interpretation of sub specific taxa and species, questioning the proposals of Clements (1989) to upgrade varieties to species, and disputing the proposal to elevate varieties of *D. speciosum*. He considered it important to take into account similarities as well as differences (Dockrill 1995). We have found no clear-cut qualitative differences between regional subgroups of *D. speciosum*, with the possible exception of the earlier but still variable flowering time for *D. speciosum* var. *capricornicum*, and thus have not used specific rank, as proposed by Clements (1989) and Clements and Jones (2002). In this study we experienced difficulty in defining taxa in a large data set encompassing all major variation, even with numerical techniques that maximise separation.

The following reasons are advanced for the decision to interpret the variation as representing varieties in a species complex.

1. We understand the species as having a clinal or continuum of variation, with features running north-south along the Great Dividing Range, and east-west along the Tropic of Capricorn. We describe nine sub taxa within the species, but within each there are atypical forms and considerable infra taxa variation, all characters varying continuously over the geographic range. We could find no convincing evidence to support the interpretation of taxa at specific level.

2. Analyses and observations did not demonstrate any qualitative differences for any sub group. This interpretation is in accord with the view of Stuessy (1990) that varieties may have one to few conspicuous differences, and subspecies several differences. Bayly and Kellow (2006) have made similar distinctions in their use of subspecies and varieties for *Hebe* Jussieu.

3. All subgroups overlap to a significant extent in ordinations.

4. Near the geographic limits of varieties there are populations of plants identifiable as intermediates.

5. Despite disjunct distributions we found that var. *carnarvonense* and var. *blackdownense* have a similar level of differences from other varieties, and consider they are best regarded as varieties.

6. A satisfactory key to groups cannot be constructed, even for 70% (estimated) of plants, similar to the opinion of Dockrill (1992).

7. The rank of variety maintains nomenclatural stability for a species with a long history of description and classification. *Dendrobium speciosum* is one of the most spectacular horticultural plants and a species widely discussed by orchid taxonomists and enthusiasts. There is a need for infraspecific classification to aid communication concerning variation over a very large distribution range. The rank of variety has been effective for communication, and we concur with the guidelines proposed by Entwisle and Weston (2005) of minimal taxonomic change, especially in plant groups of high interest.

A summary of the proposed taxonomy for *D. speciosum* is presented in Table 7. Examples of varieties and forms illustrated in Figs 16 and 17 represent a small part of the total variation in plant and floral characteristics in the respective regions.

Table 7. Taxonomic nomenclature for *Dendrobium speciosum*.

Region No.	Region	Taxa
1.	North Queensland	var. *boreale* var. *pedunculatum*
2.	Whitsunday	var. *curvicaule*
3.	East Capricorn (central Queensland)	var. *capricornicum* atypical individuals and populations intermediate between var. *capricornicum* and var. *curvicaule*, and var. *capricornicum* and var. *grandiflorum* specified by locality
4.	West Capricorn (central Queensland)	var. *blackdownense* var. *carnarvonense*
5.	Southern Queensland	var. *grandiflorum* intermediates with var. *hillii* specified by locality
6.	Southern Queensland and Northern New South Wales	var. *hillii* intermediates with var. *speciosum* specified by locality
7.	Southern New South Wales	var. *speciosum*
8.	Far south New South Wales to Victoria	var. *speciosum*

Most of the plants of var. *hillii* fit Masters' (1877) description, except at the distribution limits. Plants from eastern Victoria to the Hunter River form a cohesive group that can be ascribed to var. *speciosum*. *Dendrobium speciosum* var. *grandiflorum* is useful to refer to plants between southern Queensland and the Gladstone area, but at the southern boundary with var. *hillii*, intermediates are shorter with smaller flowers, and require a locality designation.

Plants of central Queensland may meet descriptions of var. *capricornicum* in the east on some volcanic plugs, but others in forest and on other plugs form a variable group. This finding extends the field observations made by Walsh (2000). He noted a resemblance of floral characteristics to var. *grandiflorum*, in particular the gold flower colour. Clemesha (1981a) described some west Capricorn plants as a dwarf race of var. *grandiflorum*. Our analyses do not support a close relationship to var. *grandiflorum*. The Carnarvon plants have shorter, curving robust pseudobulbs like var. *speciosum*, but clearly differ in floral characteristics consistent with a separate entity.

Taxonomic approaches in Australian Orchidaceae

The purpose of all classificatory systems is to advance the understanding of individuals, their variation and relationships, and to promote ease of communication when discussing them. Orchids are a difficult taxonomic group, and Australian orchids with large distributions over diverse habitat pose particular problems in achieving adequate sampling for assessment of their variation, and consideration of taxonomic rank. We contend that several dendrobiums, including *D. speciosum* and *D. kingianum*, are species complexes with various levels of continuous and sometimes discontinuous variation (Adams et al. 2006b). Within these complexes there may be sub groupings which intergrade and cannot be easily differentiated. If a complex is not optimally sampled, sub groups may appear to represent distinct taxa.

Subjective assessment of gross morphology is difficult in these complexes, as noted in the early phases of classificatory systems of Locke, Ray, du Buffon, Linnaeus (Huxley 2003). Non-morphological methods such as biochemistry and DNA analyses could be used to form a data set for analysis and interpretation to recognise taxa. At the infraspecific level, these may be limited in usefulness or practicality. For *D. speciosum* we have found that all varieties are compatible in cross pollination, giving rise to inter varietal seedlings; bee pollination was not variety specific (Adams 1991, Adams & Lawson 1993), and fragrance biochemistry did not provide useful taxonomic characters (Adams 1991). An alternative approach for users is to specify plants by their original location, or to use ordination and other numerical representations as has been proposed for infraspecific taxa by Prentice (1986).

Species complexes like *D. speciosum* are best categorised by considering the full range of variation and accurately describing similarities and partial differences between populations. Intermediates and atypical variants must be described as such, and not ignored or categorised arbitrarily. The value of naming systems, given their inherent limitations, is appreciated in how effectively they establish conventions for communication and development of ideas (Pearson 2001).

Acknowledgments

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Telopea 11(2) 233-244

New combinations in the genus *Vachellia* (Fabaceae: Mimosoideae) from Australia

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Abstract

Based on the evidence that the genus *Acacia* sens. lat. is polyphyletic and the acceptance that the major groups warrant generic status, and because the name *Acacia* has been conserved with a new type, the following new combinations in *Vachellia* Wight & Arn. are necessary for Australian taxa formerly included in *Acacia* subg. *Acacia*: ***Vachellia bidwillii*** (Benth.) Kodela, *V.* ***clarksoniana*** (Pedley) Kodela, *V.* ***ditricha*** (Pedley) Kodela, *V.* ***douglasica*** (Pedley) Kodela, *V.* ***pachyphloia*** (W.Fitzg.) Kodela and *V. pachyphloia* subsp. ***brevipinnula*** (Tindale & Kodela) Kodela, *V.* ***pallidifolia*** (Tindale) Kodela, *V.* ***suberosa*** (A.Cunn. ex Benth.) Kodela, *V.* ***sutherlandii*** (F.Muell.) Kodela, and *V.* ***valida*** (Tindale & Kodela) Kodela. *Vachellia farnesiana* (L.) Wight & Arn., a pre-European introduction to Australia, has previously been transferred to the genus. *Acacia nilotica* (L.) Delile has been left for the attention of other researchers more familiar with this taxon, its synonymy and its various subspecies.

Introduction

Synopses of recent morphological and molecular studies showing that the genus *Acacia* sens. lat. is polyphyletic and requires division into at least five genera are provided by Maslin et al. (2003, 2003a). At the July 2005 International Botanical Congress in Vienna a conservation proposal by Orchard and Maslin (2003) was endorsed, resulting in the retypification of the genus *Acacia* (McNeill et al. 2005). This decision results in the type of the genus being changed from the African species *Acacia nilotica* (L.) Delile to the Australian species *Acacia penninervis* Sieber ex DC. As a result of this, if the genus is split, *Vachellia* Wight & Arn. is the earliest available name applicable to species formerly included in *Acacia* subg. *Acacia*, while the name *Acacia* is retained for species of the former *Acacia* subg. *Phyllodineae*, the majority of which occur in Australia.

In Australia there are eleven species of the former *Acacia* subg. *Acacia* (Pedley 2002); nine of these are endemic to tropical Australia. *Acacia farnesiana* (L.) Willd., which is widespread through the tropics in central America, Africa and Asia, probably arrived in Australia prior to European settlement (Kodela & Tindale 2001, Pedley 2002). The more recent introduction, *Acacia nilotica* subsp. *indica* (Benth.) Brenan (Fig. 1), which

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is naturalised in Queensland and the Northern Territory, is now known to show genetic diversity in Australia indicating that more than one infraspecific taxon may be present here (Wardill et al. 2006).

Acacia farnesiana is the type of the genus *Vachellia*, so the combination *Vachellia farnesiana* (L.) Wight & Arn. (*Prodr. Fl. Ind. Orient.* 272, 1834) already exists. Plants of this taxon in Australia seem all to be referable to var. *farnesiana* (Pedley 2002, Kodela pers. obs., Seigler pers. comm.) (Fig. 2). Combinations in *Vachellia* for New World taxa of the former *Acacia* subg. *Acacia* have recently been made by Seigler and Ebinger (2006).

New combinations in *Vachellia* are made here for the endemic Australian taxa so that these names are available for use in floras and checklists. No combination, however, is made for *Acacia nilotica* (L.) Delile, which presents more difficulties (see Wardill et al. 2006) and has been left for the attention of other researchers more familiar with this taxon, its synonymy and its various subspecies.

New Combinations

1. ***Vachellia bidwillii*** (Benth.) Kodela, ***comb. nov.*** (Fig. 3)

Basionym: *Acacia bidwillii* Benth., *Linnaea* 26: 629 (1855).

Holotype: Queensland: 'Ad Wide-Bay, Australiae boreali-orientalis (Bidwill)' (K).

A. leptoclada var. (?) *polyphylla* Benth., *Fl. Austral.* 2: 416 (1864).
Holotype: 'East Coast' [Queensland], *R. Brown* [Bennett sheet No. 4331], 1802–5 (K; photo NSW).

A. bidwillii var. *bidwillii*, *Fl. Austral.* 2: 420 (1864), autonym.

A. bidwillii var. *polytricha* Domin, *Biblioth. Bot.* 89: 273 (1926).
Type citation: 'Nord-Queensland: Savannenwälder bei Mungana (Domin II. 1910)'
Holotype: Queensland: in xerodrymio apud opp. Mungana, *K. Domin '5148'*, Feb 1910 (PR 527948).

2. ***Vachellia clarksoniana*** (Pedley) Kodela, ***comb. nov.***

Basionym: *Acacia clarksoniana* Pedley, *Austrobaileya* 6: 184, fig. 1 A, B (2002).

Holotype: Queensland: 3.9 km from 'New Dixie' homestead, *J.R. Clarkson 3585*, 15 Oct 1980 (BRI). Isotypes: ILL, K, MEL, MO, NSW, PERTH, PR, QRS.

3. ***Vachellia ditricha*** (Pedley) Kodela, ***comb. nov.*** (Fig. 4)

Basionym: *Acacia ditricha* Pedley, *Austrobaileya* 1: 307 (1980).

Holotype: Queensland: Kowanyama Aboriginal Reserve on the Mitchell River, *B. Alpher*, Dec 1977 (BRI).

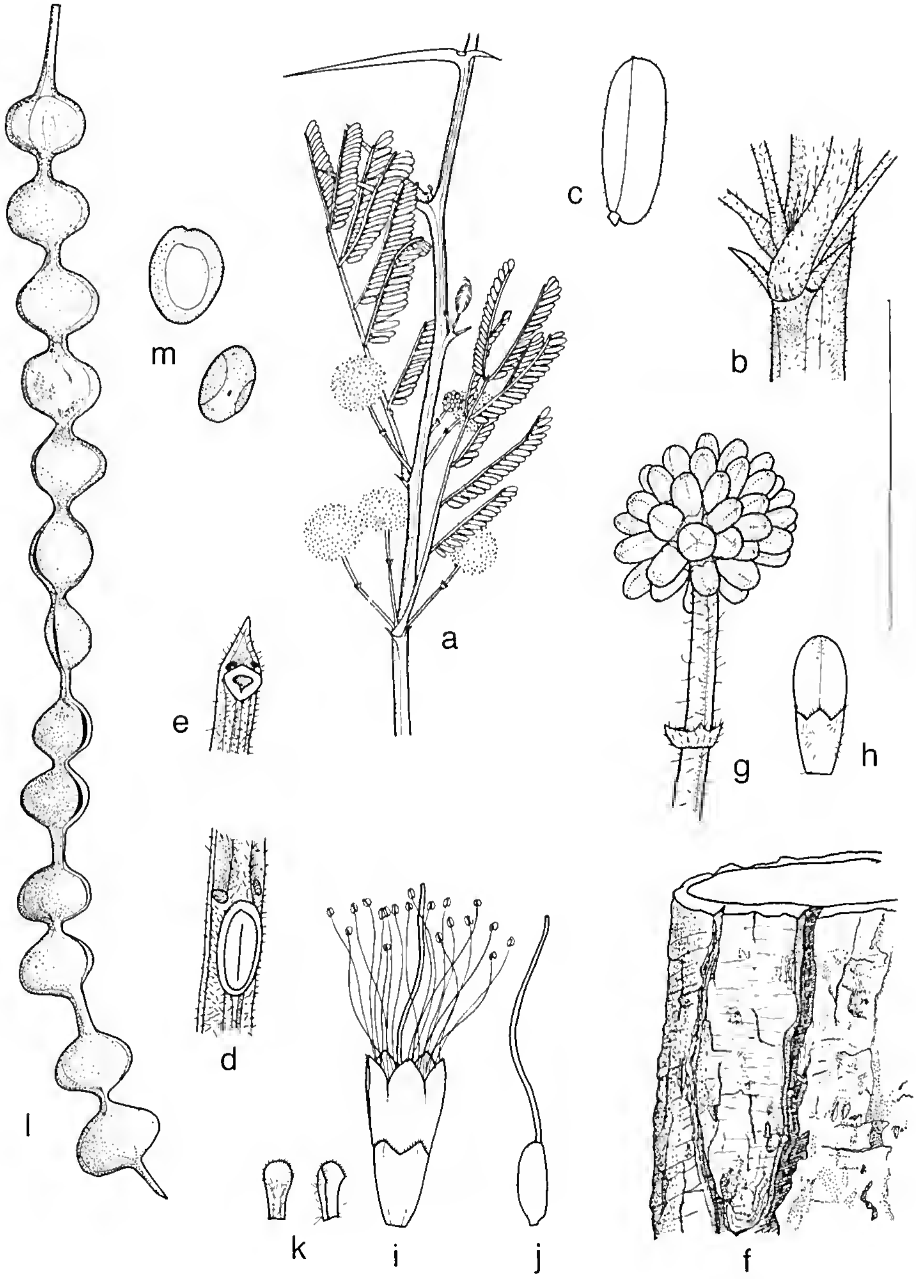

Fig. 1. '*Acacia*' *nilotica* subsp. ?*indica*. **a**, branchlet with leaves and inflorescences; **b**, leaf base and stipular spines; **c**, pinnule; **d**, petiolar gland; **e**, gland at apex of leaf rachis; **f**, bark; **g**, inflorescence in bud; **h**, flower bud; **i**, flower; **j**, gynoecium; **k**, bracteoles; **l**, pod; **m**, seeds. a–e, i–k, *Newman 565* (NSW); f, *Coveny 6925 & Hind* (NSW); g, h, l, m, *C.E.F. Allen* (NSW271068). Scale bar = 0.6 cm (d, e, h–k), 1 cm (c), 1.2 cm (b, g), 3 cm (m), 6 cm (a, f, l).

4. *Vachellia douglasica* (Pedley) Kodela, ***comb. nov.***

Basionym: *Acacia douglasica* Pedley, *Austrobaileya* 6: 181, fig. 1 C, D (2002).

Holotype: Northern Territory: 0.5 km W of Douglas River, *M. Parker 508*, 23 Oct 1974 (BRI). Isotypes: CANB, DNA, NSW.

Acacia 'Douglas R.', C.R. Dunlop *et al., Fl. Darwin Region* 2: 20, fig. 4 (1995).

Note: Pedley (2002) suggested that Tindale and Kodela (1996) included *A. douglasica* as part of *A. ditricha* but this was not the case. Although specimens of the then undescribed species *A. douglasica* were known at the time and were considered as a possible variant of *A. ditricha* they were neither included in the description of *A. ditricha* nor cited in the Tindale and Kodela (1996) paper. The Douglas River taxon was later addressed in the *Flora of Australia* (Kodela & Tindale 2001: 202) under *Acacia bidwillii.*

5. *Vachellia pachyphloia* (W.Fitzg.) Kodela, ***comb. nov.***

Basionym: *Acacia pachyphloia* W.Fitzg. in J.H. Maiden, *J. & Proc. Roy. Soc. New South Wales* 51: 116 (1917).

Type citation: 'Slopes of Bold Bluff; hills near C. 92, in proximity to the Synnott Range; hills by the Charnley and Calder Rivers (W.V.F.)'

Lectotype (*fide* Tindale & Kodela 1996: 311): Western Australia: near Synnott [Synnot] Range, *W.V. Fitzgerald 1267*, July 1905 (NSW). Isolectotype: PERTH.

Residual syntypes [paralectotypes]: slopes of Bold Bluff, *W.V. Fitzgerald*; hills by the Charnley and Calder Rivers, *W.V.Fitzgerald* (*n.v.*, location unknown).

5a. *Vachellia pachyphloia* (W.Fitzg.) Kodela subsp. ***pachyphloia***

5b. *Vachellia pachyphloia* subsp. ***brevipinnula*** (Tindale & Kodela) Kodela, ***comb. nov.***

Basionym: *Acacia pachyphloia* subsp. *brevipinnula* Tindale & Kodela, *Austral. Syst. Bot.* 9: 314, fig. 3 (1996).

Holotype: Western Australia: 26 km N of turnoff to Mitchell Falls along road to Port Warrender, *M. McDonald 336*, 14 June 1987 (NSW). Isotype: PERTH.

6. *Vachellia pallidifolia* (Tindale) Kodela, ***comb. nov.*** (Fig. 5)

Basionym: *Acacia pallidifolia* Tindale, *Telopea* 1: 82 (1975), based on *Acacia pallida* F. Muell., *J. Linn. Soc., Bot.* 3: 147 (1859), *partim*, *non* Humb. et Bonpl. ex Willd. (1806).

Lectotype (*fide* Tindale, *loc. cit.*): Northern Territory: Fitzmaurice River, 'arbuscula in campis apricis', *F. Mueller 76, 75*, Oct 1855 (MEL). Isolectotype: NSW.

Residual syntypes [paralectotypes]: McAdam Range, *F. Mueller 75*, Oct 1855 (K, PERTH).

Acacia turbata Pedley, *Austrobaileya* 6: 180 (2002).
Holotype: Northern Territory: E of Mary River, *S.T. Blake 17095*, 29 Sep 1946 (BRI). Isotype: NSW.

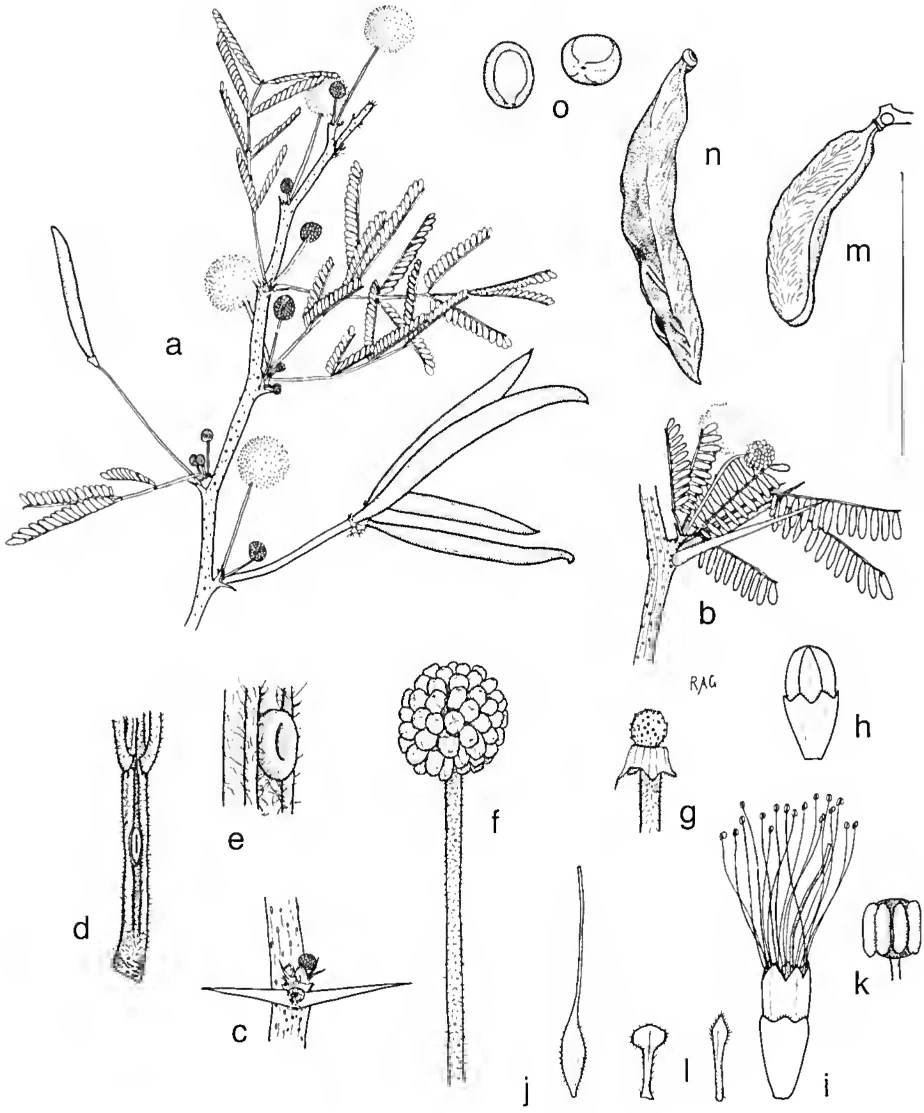

Fig. 2. *Vachellia farnesiana* var. *farnesiana*. **a**, branchlet with leaves, inflorescences and immature pods; **b**, leaves, inflorescences and stipular spines; **c**, stipular spines; **d**, petiole showing gland; e, petiolar gland; **f**, inflorescence in bud; **g**, involucel of united bracts at apex of peduncle (usually hidden by flowers); **h**, flower bud; **i**, flower; **j**, gynoecium; **k**, anther; **l**, bracteoles; **m**, **n**, pods; **o**, seeds. a, f, h–j, l, *Coveny 6572 & Powell* (NSW); b, d, *Milvain* (NSW108509); c, m, *K. Moore* (NSW108510); **e**, *G.M. Cunningham 704* (NSW); g, *Milthorpe 3821* (NSW); k, *Rodd s.n.* (NSW70825), n, o, *Coveny 6522 & Powell* (NSW). Scale bar = 0.075 cm (k), 0.4 cm (e), 0.6 cm (h–j, l), 1.2 cm (d, f, g), 2 cm (c), 3 cm (o), 6 cm (a, b, m, n).

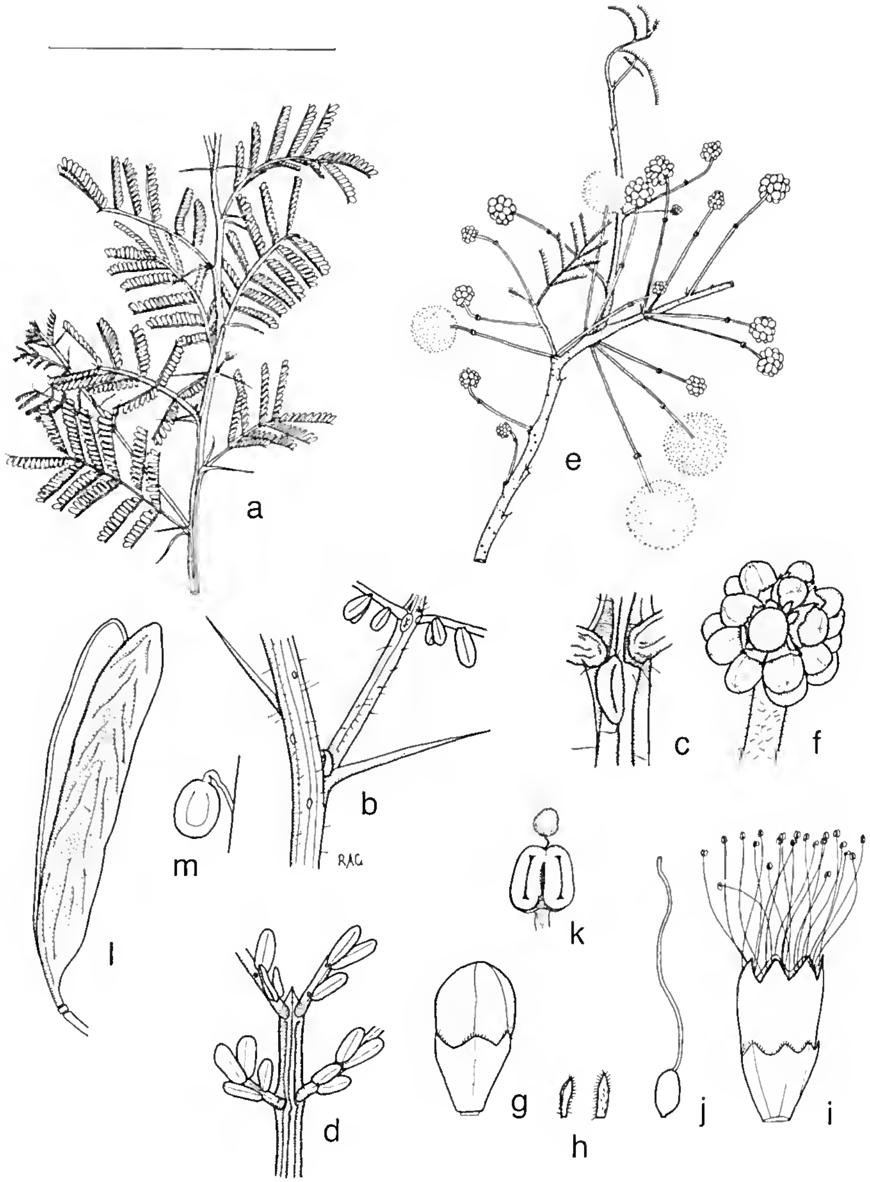

Fig. 3. *Vachellia bidwillii.* **a**, branchlet with leaves; **b**, petiole and stipular spines; **c**, petiolar gland; **d**, apex of leaf rachis; **e**, inflorescences; **f**, inflorescence in bud; g, flower bud; **h**, bracteoles; **i**, flower; **j**, gynoecium; **k**, anther; **l**, pod; **m**, seed. a–l, *Tindale* (NSW52690); m, *Coveny 6876 &Hind* (NSW). Scale bar = 0.1 cm (k), 0.4 cm (c), 0.6 cm (g–j), 1 cm (b, d), 1.2 cm (f), 4 cm (m), 6 cm (a, e, l).

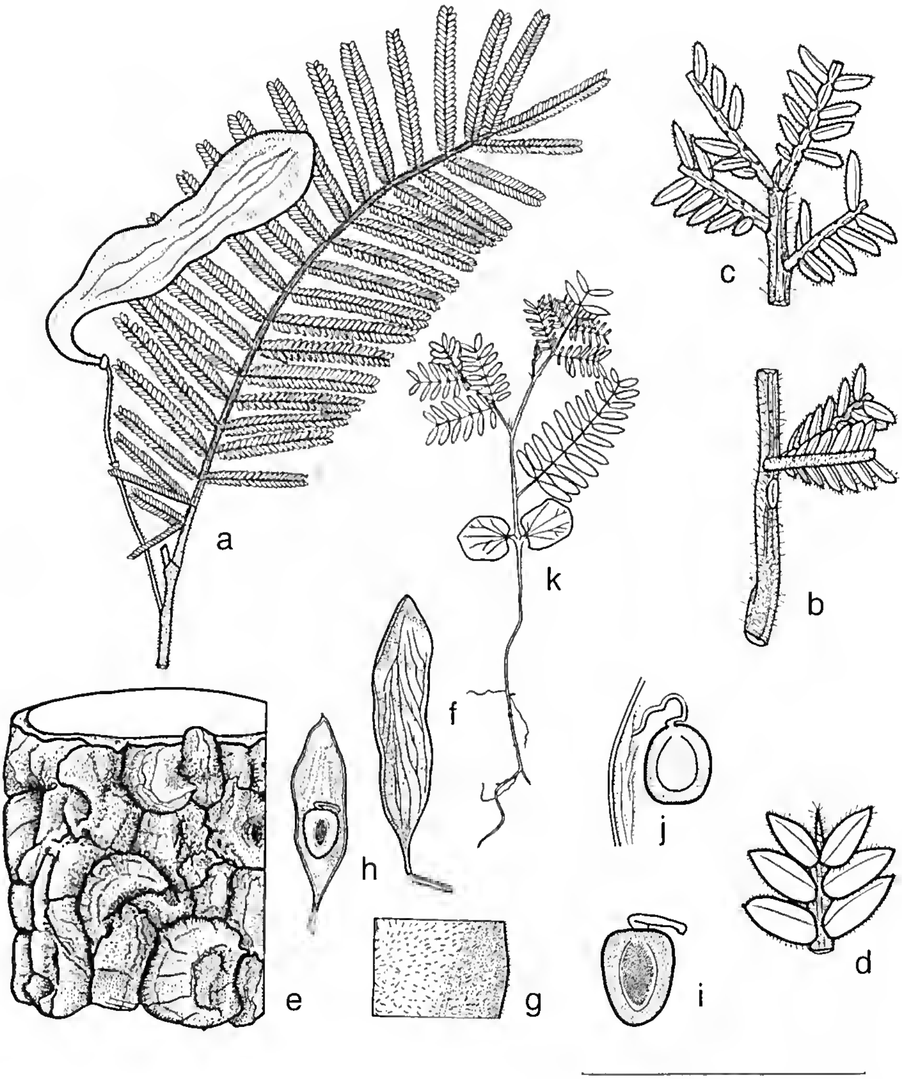

Fig. 4. *Vachellia ditricha*. **a**, apex of branchlet with leaf and pod; **b**, base of leaf showing petiolar gland; **c**, apex of leaf; **d**, apex of pinna; **e**, bark; **f**, pod; **g**, section of pod showing indumentum on outer surface; **h**, seed in pod; **i**, **j**, seeds; **k**, seedling. a, *Maconochie 206* (DNA); b–d, j, *Perry 2833 & Lazarides* (CANB); e–i, *Jacobs 1732* (NSW); k, AZRI (NT sheet), seedling grown from seed of *N. McK. Henry 7* (NT31554). Scale bar = 0.5 cm (g), 0.6 cm (d), 1.2 cm (b, c), 3 cm (i), 4 cm (a, j), 6 cm (e, f, h, k).

Note: The possible type material of *Acacia pallida* F.Muell., nom. illeg., includes two different taxa. However, there have been two different interpretations of this material that have resulted in the replacement name *A. pallidifolia* Tindale being applied to each of these two different taxa. We have followed the concept adopted by Tindale (1975) while Pedley (2002) applies this name to the taxon named *A. valida* by Tindale and Kodela (1996). To further add to the confusion, Pedley (2002) reverses Tindale's application of the name *Acacia pallidifolia*, renaming her species concept as *A. turbata* Pedley. The species concept originally adopted by Tindale (1975), and which was in use for almost 30 years, has now been challenged by Pedley's (2002) rejection of her lectotypification. While Pedley's view has merit, we suggest that nomenclatural stability is not well served by his approach because it would lead to a confusing reversal of names. A case for conservation of the name *A. pallidifolia* in the sense of Tindale (1975) is in preparation and will be submitted for consideration by the Committee for Spermatophyta.

7. ***Vachellia suberosa*** (A.Cunn. ex Benth.) Kodela, ***comb. nov.*** (Fig. 6)

Basionym: *Acacia suberosa* A.Cunn. ex Benth., *London J. Bot.* 1: 499 (1842).

Lectotype (*fide* Kodela, *Fl. Australia* 11A: 642, 2001): Western Australia: Careening Bay, North West Coast, 3rd Voyage of 'Mermaid', *A. Cunningham 300*, Sep 1820 [larger, right-hand element] (K). Isolectotype: BM.

Residual syntypes [paralectotypes]: Western Australia: Encounter Cove, Vansittart Bay, North West Coast, 2nd Voyage of 'Mermaid', *A. Cunningham 488*, Oct 1819 (BM, K).

8. ***Vachellia sutherlandii*** (F.Muell.) Kodela, ***comb. nov.*** (Fig. 7)

Basionym: *Albizia sutherlandi* F.Muell., *Fragm.* 6: 22 (1867). *Acacia sutherlandii* (F.Muell.) F.Muell. (as 'Sutherlandi'), *Iconogr. Austral. Acacia* Dec. 12: [pl. 8] (June 1888).

Holotype: Queensland: Flinders River, *J. Sutherland 114* (MEL).

Acacia melaleucoides F.M.Bailey, *Proc. Roy. Soc. Queensland* 5: 121 (Sep 1888).
Holotype: Queensland: South-eastern slope of Newcastle Range, between Georgetown and Junction Ck, *R.C. Burton* (?BRI, *n.v.*)

9. ***Vachellia valida*** (Tindale & Kodela) Kodela, ***comb. nov.***

Basionym: *Acacia valida* Tindale & Kodela, *Austral. Syst. Bot.* 9: 307, fig. 1 (1996).

Holotype: Northern Territory: Mathison Ck, c. 91.5 km W of Katherine on the Victoria Hwy, *M.D. Tindale 10101, P. Munns & R. Turley*, 2 Aug 1989 (NSW). Isotypes: AD, BRI, CANB, DNA, K, MEL, MO, PERTH.

A. pallida F.Muell., *J. Linn. Soc., Bot.* 3: 147 (1859), *partim*, *non* Humb. et Bonpl. ex Willd. (1806).

A. bidwillii Benth. var. (?) *major* Benth. (as 'Bidwilli'), *Fl. Austral.* 2: 421 (1864).
Holotype: (Dry) ridges of the Victoria River, *F. Mueller 76*, Nov 1855 (MEL). Isotype: K.

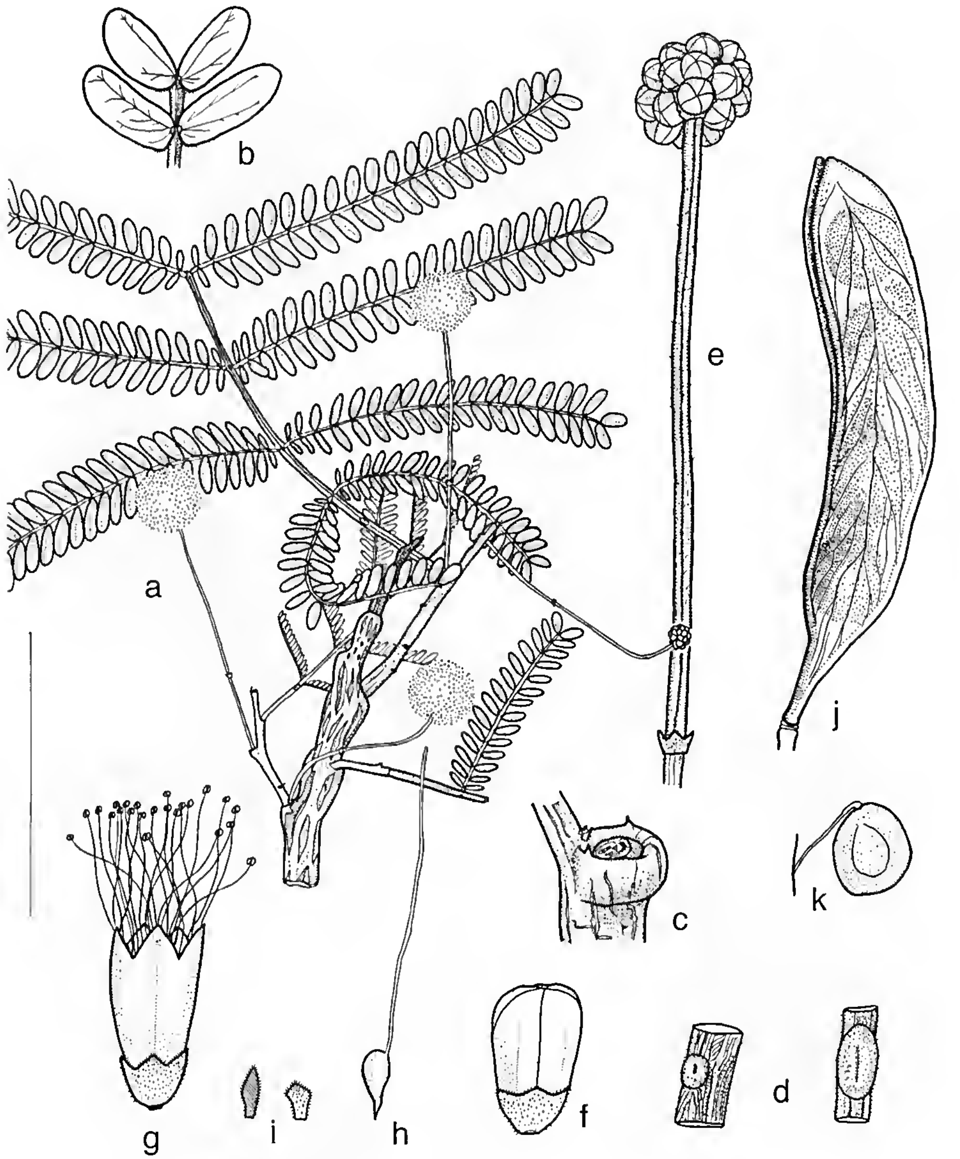

Fig. 5. *Vachellia pallidifolia.* **a**, branchlet with leaves and inflorescences; **b**, pinnules at apex of pinna; **c**, leaf scar showing small stipular spines; **d**, leaf glands; **e**, inflorescence in bud; **f**, flower bud; **g**, flower; **h**, gynoecium; **i**, bracteoles; **j**, pod; **k**, seed. a, b, d–i, *M. White* MR13(CANB); c, j, k, *Blake 17095* (NSW). Scale bar = 0.4 cm (f), 0.6 cm (g–i), 0.66 cm (d), 1.33 cm (e), 2 cm (b, c), 4 cm (k), 6 cm (a, j)

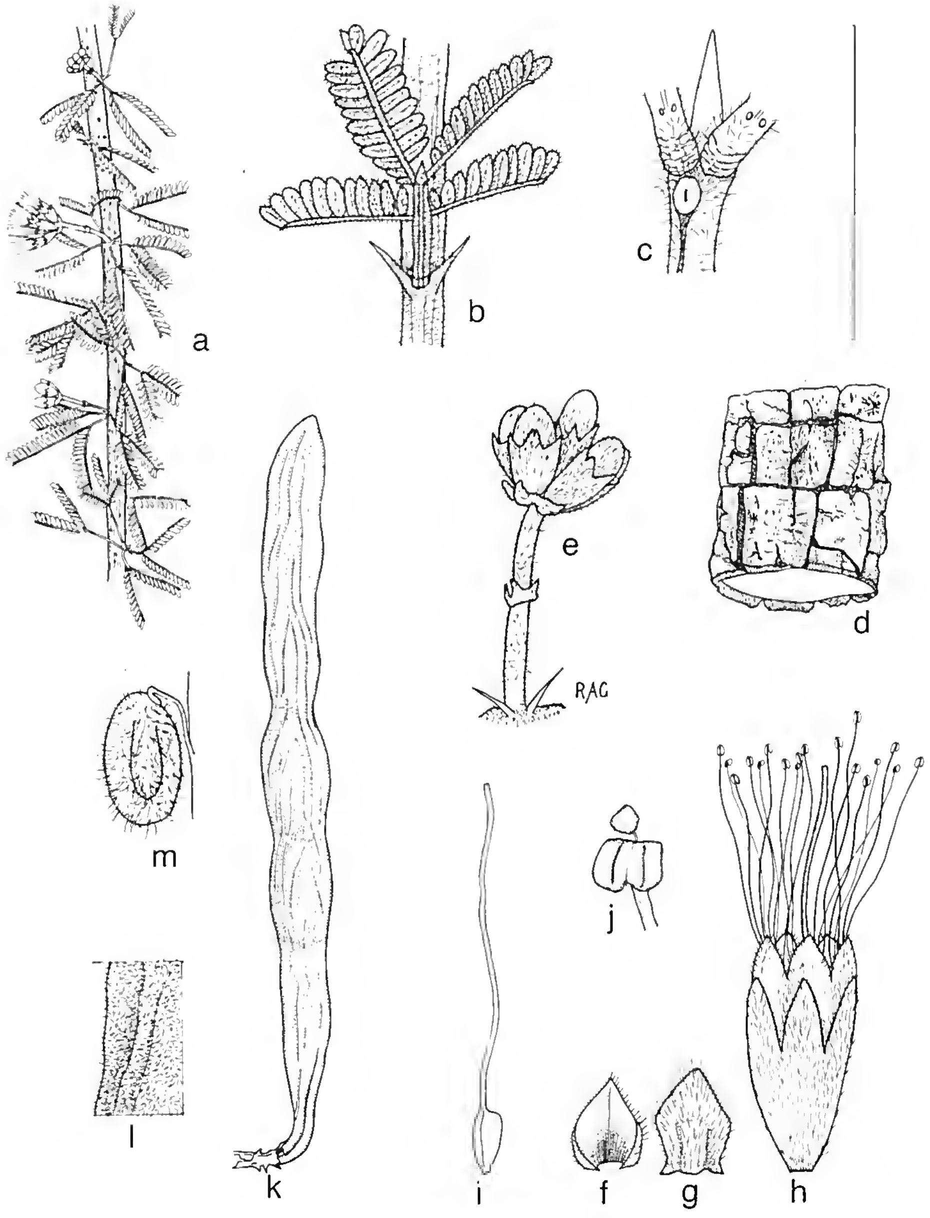

Fig. 6. *Vachellia suberosa*. a, branchlet with leaves and inflorescences; **b**, leaf and stipular spines; **c**, gland at apex of leaf rachis; **d**, bark; **e**, inflorescence in bud; **f**, inner surface of bracteole; g, outer surface of bracteole; **h**, flower; **i**, gynoecium; **j**, anther; **k**, pod; **l**, section of pod showing indumentum on outer surface; **m**, seed. a, c, e, j, *Lazarides 7744* (NSW); b, *Lazarides 3104* (NSW); d, *Maconochie 1183* (NSW); f–i *Byrnes 2228* (NSW); k–m, *Lazarides 6515* (NSW). Scale bar = 0.1 cm (j), 0.3 cm (l), 0.4 cm (c), 0.6 cm (f–i), 1.5 cm (e), 2 cm (b), 4 cm (m), 6 cm (a, d, k).

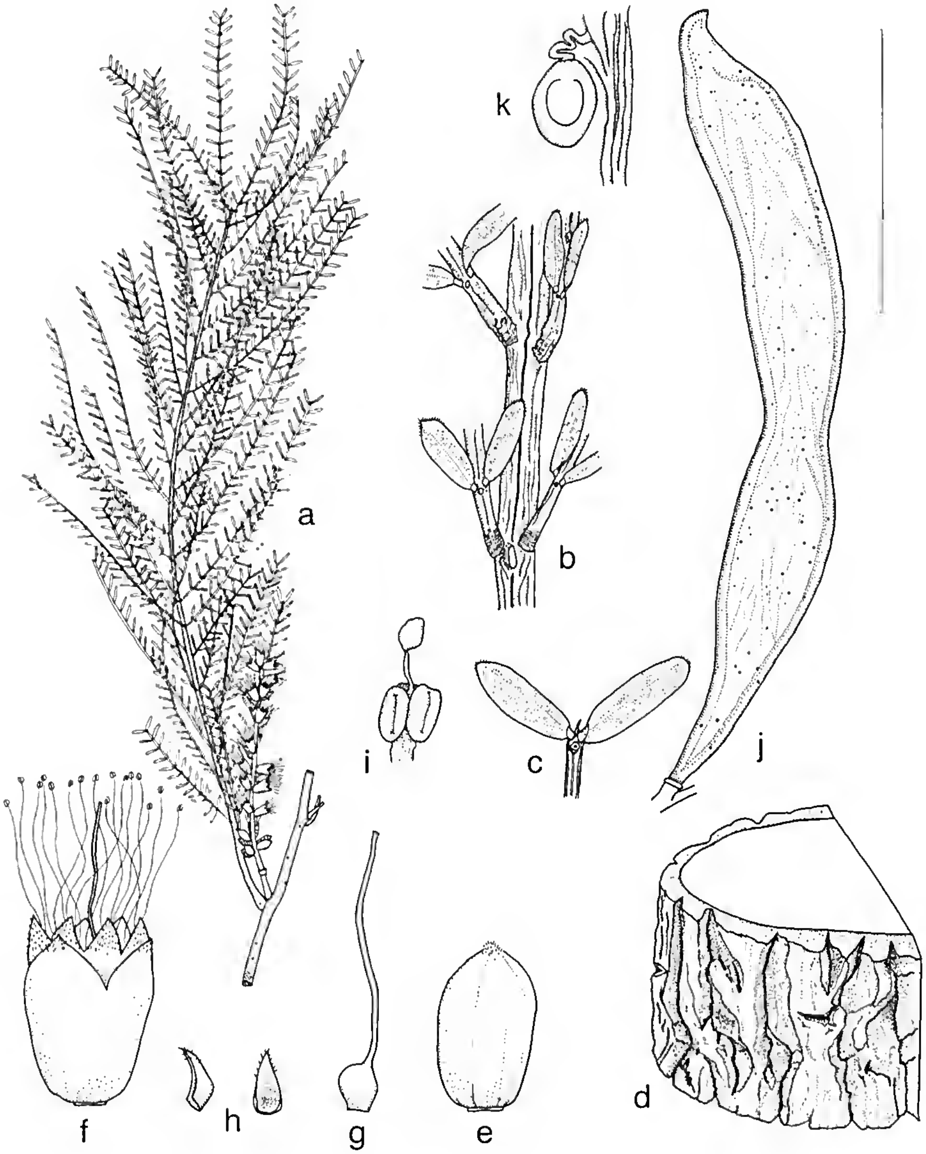

Fig. 7. *Vachellia sutherlandii.* **a**, part of branchlet with leaf and inflorescence; **b**, part of leaf rachis showing petiolar gland; **c**, apex of pinna; **d**, bark; **e**, flower bud; **f**, flower; **g**, gynoecium; **h**, bracteoles; **i**, anther; **j**, pod; **k**, seed. a–c, e–i, *Waterhouse s.n.* (NSW108060); d, *Jacobs 1374* (NSW); j, k, *Hind 1069 & Ingram* (NSW). Scale bar = 0.1 cm (i), 0.6 cm (c, e–h), 1 cm (b), 4 cm (k), 6 cm (a, d, j).

Note: Pedley (2002) treated *A. valida* as a synonym of *Acacia pallidifolia*. Correct application of the latter name is contingent upon resolution of the issue of its typification, as discussed above.

Acknowledgments

We are grateful for comments and advice on the *Acacia pallida* typification issue provided in 2000 by Drs Mary Tindale and Jim Ross (MEL), as well as earlier advice provided to Dr Tindale by the late Dr L.A.S. Johnson. Many thanks also to Bruce Maslin and Paul Wilson for constructive comments on this manuscript. Dave Seigler kindly provided details of his recently published paper and other information. Access to collections was generously provided by BM, K and MEL. Illustrations were by Robin Griffiths and made available by Dr Tindale. Catherine Wardrop and Julia Sideris assisted with the final preparation of the illustrations and scale bars.

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Manuscript received 20 February 2006, accepted 1 March 2006

Corrigenda — Telopea 11(1)

J.C. Millott & K.L. McDougall. A new species of *Pomaderris* (Rhamnaceae) from the Central Tablelands of New South Wales.

Page 86: should read as follows.

Pomaderris graniticola (N.G.Walsh & F.Coates) K.L.McDougall & J.C.Millot, ***comb. & stat. nov.***

Pomaderris argyrophylla N.A. Wakef. subsp. *graniticola* N.G. Walsh & F. Coates, Muelleria 10: 46 (1997).

Type: Queensland, Girraween National Park, c. 50 m W of Dr Roberts Waterhole, towards its southern reach, *N.G. Walsh 3883*, 15.ix.1994 (holotype MEL; isotypes BRI, CANB, NSW, UNE).

Instructions for Authors

Telopea is published twice a year. It covers systematic botany in Australia and the Asia-Pacific region specialising in the flora of New South Wales. Short Communications are welcome (see previous issues for format).

Deadlines for the submission of papers for the next two issues can be found at http://plantnet.rbgsyd.nsw.gov.au/Telopea/auth.php.

Authors are expected to have their papers peer-reviewed before submission. All papers will be refereed. Supply full contact details for main author. Electronic submission is preferred; please see http://plantnet.rbgsyd.nsw.gov.au/Telopea/auth.php for more detailed instructions on submission.

Formatting

- The title should be explicit and descriptive of the content; a short running head and an abstract (except for Short Communications) should be included.
- Check most recent issue for format. The Macquarie Dictionary, latest edition, and the Style Manual for Authors, Editors and Printers, latest edition, should be consulted for spelling, abbreviations, units and other conventions.
- References in the text should be made by giving the author's name with the year of publication in parentheses. For reference list at end of paper see papers in the latest issue for style. Titles of journals should be given in full.
- An Index to taxa is useful if the paper is large and deals with many species and synonyms. The author should prepare the basic alphabetic listing including all names in recent use.

Citations

- Cite Type details in full, giving details from protologue and from specimen label separately if there are important differences. Type citations should be in a consistent format, e.g: Type: New South Wales: North Western Plains: 10 km W of Moree (29°08'S 129°48'E), B. Wiecek 1250, 2 Jan 1989; lecto NSW (Weston 1990: 21); isolecto K, MO.
- Cite no more than 20 (except for very widely distributed species) and arrange by Botanical Divisions. Use accepted format: locality, collector & number, date (herbarium code plus institutional number if there is no collector's number) Only latitudes and longitudes on the original labels should be included. Give dates in the following format: 12 Jan 1987, 2 Jun, 30 Jul, 10 Dec etc.

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Tables

- Tables should preferably be portrait rather than landscape shape (i.e. taller rather than wider). Column headings should be brief. Each table must be referred to in the text and its approximate position should be indicated in the margin of the manuscript.

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