

## Naturalised species of *Psoralea* (Fabaceae: Psoraleeae) in Australia

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### Introduction

The tribe Psoraleeae (Fabaceae) occurs predominantly in southern Africa, Australia and North America, with outliers in South America, Mediterranean Europe and Asia (Stirton 1981, 2005). *Psoralea* L., comprising some 75 species, is endemic to southern Africa, being mainly restricted to wet montane and lowland fynbos of the Cape Floristic Region, but with a few species extending to eastern and Afromontane regions with outliers in Angola and St Helena Island (Stirton & Schutte 2000). There are also a number of specialised species that have adapted to drier regions (renosterveld, arid fynbos, and sand dunes) and which are found in the Sandveld, Klein Karoo and Namaqualand. The majority of species occur on low nutrient soils derived from Table Mountain Sandstone; a few are habitat specialists and occur on shales, silcrete and limestone.

A number of species of *Psoralea* have become naturalised in other regions (Australia, New Zealand and the United States). This paper reports on the occurrence of Southern African *Psoralea* in Australia giving full descriptions, synonymy, photographs, and a key to the naturalised taxa. One previously unrecorded species, *P. arborea* Sims, is noted as new to the Australian naturalised flora.

### Abstract

Two species of the African genus *Psoralea* L. (Psoraleeae, Fabaceae) have become naturalised in Australia. *Psoralea pinnata* L. is well recorded, and in this paper we report an unrecorded second species *P. arborea* Sims. Full descriptions and distributions in Australia are given for each species and a key is provided.

**Key words:** biodiversity, flowering plants, invasives, legumes, peas, taxonomy, South Africa

## Materials and methods

A comparative morphological study was undertaken of available spirit and herbarium specimens (AD, BOL, CANB, BM, HO, K, MEL, NBG, NSW, PERTH, PRU, NH and NU (acronyms follow Index Herbariorum (Thiers 2015))).

## Species treatment

### 1. *Psoralea pinnata* L., Sp. Pl. 2: 1074 (1762)

**Type:** Collector unknown (Hort. Cliff. 370). When the lectotypification was made (Stirton in *Taxon* 41: 568, 1992), only 'Hort. Cliff. 370, *Dorycnium* 1, BM' was cited. However, *Dorycnium* 1 consists of two sheets, annotated A and B, and neither was specified. Under Art. 9.17 it is possible to designate one of these sheets in a subsequent lectotypification. We choose *Dorycnium* 1A accordingly. *Dorycnium* 1B (BM000646706) is a sterile specimen and does not match the protologue. Lectotype, here designated, *Dorycnium* 1A (BM000646705!).

Thunb., *Prodri.* 136 (1800); Poir. in Lam., *Encycl.* 5: 690 (1804); Dietr., *Lex. Gart. Bot.* 7: 612 (1807); DC., *Prodri.* 2: 216 (1825); Eckl. & Zeyh., *Enum.* 224 (1836); E. Mey., *Comm.* 82 (1836); Reichenb., *Ic. Descr. Pl. Cult.* t.97, f.1 (1823); Harv. in Harv. & Sond. *Fl. Cap.* 2: 144 (1862); Forbes in *Bothalia* 3: 125 (1930); Salter in Adamson & Salter, *Fl. Cape Penins.* 485 (1950); Kidd, *Wild Flow. Cape Penins.* t. 81.12 (1972); Pitman and Palmer, *Trees S. Afr.* 2: 920 (1972); Bond & Goldblatt, *Pl. Cape Flora* 296 (1984); Gibbs Russell et al., *Mem. Bot. Surv. S. Afr.* 56: 88 (1987). For fuller synonymy see Stirton and Muasya (unpublished manuscript 2015).

For Australian treatments and records of naturalisation see: Hooker (1859); Blakely (1923); Gardner (1925); Beadle, Evans and Carolin (1962); Curtis (1975); Weber (1986); Jeanes (1996 p.p., not fig. 138a); Grieve (1998); Blood (2001); and Norris and Harden (2002). For New Zealand see Kirk (1870); Cheeseman (1883, 1885); Allan (1937); Webb, Sykes and Garnock-Jones (1988).

**Vernacular names:** Australia: African Scurf-pea, Blue Butterfly Bush, Blue Psoralea, Taylorina. Western Australia: Albany Broom, Blue Broom. New Zealand: Dally Pine. South Africa: Bloukeur, Fonteinbos, Fountain Bush, Penwortel, Pinnate-leaved Psoralea.

*Much-branched shrub to small tree up to 5 m tall. Stems erect, 1(2), yellowish tan with storied white lenticels when young*, becoming grey with age. Branches and

twigs angular, sparsely hairy when immature. ***Stipules fused for most of their length***, subulate, with incurved margins, hairy, ***overlapping like short stacked planks, becoming woody with age***. Leaves 7–9-foliolate, imparipinnate, 25 mm long, 45–50 mm wide, ***villoso-pubescent***, terminal leaflet shortest, basal pair longest, petiolate. Leaflets linear or linear-lanceolate, 20–45 mm long, 0.8–2.0 mm wide, acute to acuminate, dark green, glandular. Petiole 4–7 mm long, rachis 10–15 mm long. ***Inflorescences hidden within leaves, borne on short shootlets which are spread along the length of seasonal shoots, pseudo-spicate or pseudo-capitate, axillary, weakly scented or odourless***. Flowers 14–18 mm long, pale mauve to blue, axillary, ***sessile or subsessile***, 1–6 per axil, subtended by a pinnate leaf; bracts a ***fused trifid cupulate structure situated at apex of a 2–5 mm long pedicel, overlapping the base of the calyx, carinal tooth longer than other two teeth***, sparsely white hairy, margins ciliate with few black hairs. Calyx 8–9 mm long, ***glabrescent***, mainly white-haired but also with black hairs on margins, or a mixture of black and white hairs, ***teeth dark green***, shorter than yellowish green tube; ovate-acute to triangular. Standard petal 15–16(–18) mm long, 11 mm wide, ***obovate***, white suffused with pale mauve in the central area and with a single purple 3–4 mm long flash situated between and above the free swollen callosities at the top rim of the claw; ***veins hyaline***. Wing petals 13–14 mm long, 4 mm wide, longer than keel petals; white to pale mauve, blade folded and puckered along the mid-line; sculpturing present. Keel 12 mm long, 3.5–4.0 mm wide; white to pale mauve, shorter than wings. ***Androecium 6–7 mm long***. Pistil 12 mm long; ovary 2 mm long, covered in club-shaped glands; style filamentous but thickened at point of flexure, stigma penicillate. Fruits 4–5 mm long, 2.5–3.0 mm wide. Seeds 1.2–4 mm long, dark brown to black. (Fig. 1)

***Specimens examined: WESTERN AUSTRALIA.*** Albany, x.1867, F. Mueller s.n. (MEL 116942A); Yanchep, Loch McNess, ix.1966, A.J. & J.A. McComb McC 211 (PERTH, UWA); Lesmurdie Falls, 12.xii.1947, C.A. Gardners.n. (PERTH 04510208); Inlet Drive, Denmark, 11.i.1984, G.J. Keighery 6512 (PERTH); Mount Barker Hill, 100 m N of Sothard Road, 5 km S of Mount Barker, 7.xii.1987, G.J. Keighery 9271 (CANB, PERTH); 3.8 km NE of Bakers Junction on road to Jerramungup, 15.xi.1995, B.J. Lepschi & T.J. Lally 2327 (AD, BRI, CANB, K, MEL NSW, NY, PERTH); From Wheatley Coast Road turn right into Lanepool Road, right side of road,



**Figure 1.** *Psoralea pinnata*: **a.** habit; **b.** inflorescences; **c.** trifid cupulate bract (from Ross 3818); **d.** calyx (from Lepisci 2327 & T.R. Lally). Photo credits: **a–b**, Charles Stirton; **c–d** Val Stajsic.

Northcliffe, 30.xii.1994, G.A. Oxnam 99 (NFE, PERTH). **SOUTH AUSTRALIA.** Dismal Swamp, 10 km N of Mt Gambier, xii.1979, R.J. Bates 566 (AD). **NEW SOUTH WALES.** Swamps between Cooggi [Coogee] and Botany, ii. or xi. (month unclear)1889, Mr Grant s.n. (NSW 30589); Waterfall, xi.1913, C. Shambler s.n. (NSW 820492); Native vegetation between Sayers Street and St Bernard's Drive, Lawson, 4.xii.2003, C.H. Barker 27 & J.R. Hosking (CANB, MEL, NE, NSW, TARCH). **VICTORIA.** Port Phillip, xii.1884, [F.M.] Reader 30 (MEL 116938A); 6.5 km N of Portland P.O., 9.vii.1977, A.C. Beaglehole 56287 (MEL); Great Ocean Rd, S of Gellibrand River, 3.2 km N of Moonlight Heads turn-off, 20.v.1977, A.C. Beaglehole 56262 (MEL); 3 km N of Foster on South Gippsland Hwy, 13.iii.1991, J.H. Ross 3434 (MEL, NSW); Mornington Peninsula, Rosebud, Mornington Peninsula Freeway, 16.xi.1996, J.H. Ross 3818 (MEL, NY); On Moe-Erica Road, 17.2 km by road from Moe trotting track, c. 200 m S of Wild Cow Track, 9.xii.1997, P.G. Neish 485 (MEL). **TASMANIA.** Lenan Valley, Giblin Street Quarry, 8.x.1998, A.M. Buchanan 15299 (HO); King Island, Sea Elephant Road, 250 m N of Fraser Road junction, 25.ii.2009, M.L. Baker 2062 & M.F. Duretto (HO).

**Flowering period:** In South Africa, flowering takes place from October to December. In Australia, peak flowering occurs between November and January.

**Ecology and habitat:** In its native range *Psoralea pinnata* occurs in mountain fynbos, forest margins, and riverbeds at altitudes between 230 and 1060 m and favours damp sandy or peaty locations. In Australia, *P. pinnata* reproduces mainly by seed (shed copiously locally then secondarily dispersed by water) in contaminated soil and in dumped garden waste. On account of the confusion with *P. arborea*, some of the ecological information about *P. pinnata* in Australia will also pertain to *P. arborea*, but based on our examination of specimens from Australian herbaria most of what is currently known about the ecology of the species in Australia holds true. In Australia, *P. pinnata* occupies various vegetation formations along streams, in swamps, heathland, dry coastal vegetation, dry sclerophyll forest and woodland, grassy woodlands, rocky outcrops, disturbed tracks and roadsides, rubbish tips, waste places and quarries. It occurs on sand, loam, clay and rocky soils (Carr et al. 1992; Hussey et al. 1997; Muyt 2001; AVH 2012). Hussey et al. (1997) note that *P. pinnata* has become the dominant vegetation in swamps, creeks and roadsides in the Albany coastal agricultural region in Western Australia. Gilfillan and Barrett (2004) list the species as being a threatening

competitor to *Ornduffia calthifolia* (F.Muell.) Tippery & Les, a rare species in Western Australia. Carr et al. (1992) consider it as posing a very serious threat to dry coastal vegetation, heathland and heathy woodland, lowland grassland and grassy woodland, and dry sclerophyll forest and woodland vegetation in Victoria. Muyt (2001) noted that it is highly invasive in Australia in heathlands. As it is an excellent nitrogen fixer it can change the soil fertility and thereby affect the persistence of indigenous species over the long term (Muyt 2001). In New South Wales, *P. pinnata* invades open sclerophyll forest (e.g. *Eucalyptus piperita* Sm. and *Corymbia gummifera* (Gaertn.) K.D.Hill & L.A.S. Johnson woodland, at Lawson) and swamps. In Tasmania, *P. pinnata* is currently only known from disused tips and disused mine sites. As in *P. arborea*, this species produces copious seeds. Regeneration is dependent on fire. If fire episodes are too far apart, the species can become locally extinct. However, one of us (CHS) is aware of 40-year intervals between fires where the species regenerated from seed after most of the parent plants had been absent for over 30 years. Germination is stimulated by fire and, in the long run, dependent on it for regeneration. After fire, the plants produce masses of rapidly growing seedlings with copious production of root nodules associated predominantly with *Mesorhizobium* (Lemaire et al. 2014). It is reported to be one of the key weeds threatening sea bird habitats on Albany's offshore islands (Frodsham 2008).

**Biology in South Africa:** Not a lot is known about the biology of this species in South Africa. The following notes are provided as useful leads for possible future biocontrol of the species in Australia. Flowers are visited predominantly by large Xylocopid (see Stirton 2007a, 2007b, 2007c, 2007d) and Megachilid bees, which divide large plant colonies into scattered communal feeding trees interrupted by localised adjacent territories of two to five trees, which the bees defend vigorously. Butterflies have been recorded feeding opportunistically on flowers of this species (*Vanessa cardui* (Linnaeus, 1758) – Painted Lady (see Voget 2011)), and there is some evidence that larvae of some butterflies feed on the leaves (see Rebelo 2011; Brink 2013) sometimes forming caterpillar tents (see Van den Bosch 2012). Seeds are heavily infested by Bruchid beetles (Bruchidae, Coleoptera), many of which are known to be species-specific in Cape legumes (Stirton pers. obs.).

Monkey beetles (Tribe Hopliini) feed on flower parts and can cause extensive damage to inflorescences. It should be noted that the Hopliini can be serious pests of cultivated crops and lawns. Xylocopid bees use old wood as nesting sites and the Rooibos Longhorn Beetle (*Ceropales aethiops* (Fabricius, 1775)) deposits its eggs on old wood (Stirton pers. obs.). Black aphids can be found on young shoots. Scale insects, such as *Icerya purchasi* Maskell, 1878 (Cottony Cushion Scale), can be common in some areas and are protected by ants (*Camponotus niveosetosus* Mayr, 1862: see Rebelo (2012)). Underground root-feeding pink aphids have also been found (Stirton pers. obs.).

Biocontrol specialists might want to know that there are a number of distinct ecotypes in South Africa. Along Chapman's Peak Drive and in the Silvermine Nature Reserve area on the Cape Peninsula and at Betty's Bay and in the Kogelberg the plants form small trees 4–5 m tall; elsewhere they tend to be shorter untidy shrubs to about 2 m tall.

**Note:** The treatment of *Psoralea pinnata* in Jeanes (1996) includes a description which is consistent with that species. However, the illustration is clearly of *P. arborea*, as is apparent from the flowers being exerted beyond the leaves, and was confirmed by examination of the voucher (Lyne 446).

**Etymology:** The epithet refers to the pinnate leaves (from Latin: *pinnatus*, feathered, winged).

## 2. *Psoralea arborea* Sims, *Bot. Mag.* 46: t. 2090 (1819)

**Type:** *Bot. Mag.* 46: t. 2090 (holo.). No herbarium material has been found that matches the protologue. The painting was made from a cultivated specimen in James Vere's Garden in Kensington that was grown from seed from the Cape of Good Hope. No mention is made of either preserved material or of Sims having seen any other specimens. However, two cultivated specimens in K (both on same sheet) could be considered as

candidates for typification. One of these (K000392612) was accessioned on 1st May 1889 after publication of the species and is discounted. The other specimen (K000392611) has been annotated by the author of the species, Sims. He wrote that 'There is no doubt that this is "*P. arboreascens*"'. Further research is needed to ascertain when this specimen was accessioned at Kew.

DC., *Prodri.* 2: 216 (1825); G. Don., *Gen. Syst.* 2: 201 (1832); E. Mey., *Comm.* 82 (1836); Walp., *Repert.* 1: 655 (1842); Lock, *Leg. Afr. Check-list*: 458 (1989); Jeanes (1996 as *P. pinnata* p.p., specifically fig. 138a, the voucher of which is Lyne 446); non Eckl. & Zeyh. (1836) nec Sesse & Mocino (1889).

*Psoralea pinnata* L. var. *quinquijuga* Eckl. & Zeyh., *Enum.* 224 (1836). Type: "in humidis (alit. III) laterum montis Duyvelsberg supra Gele Klee (Cap.)", Ecklon & Zeyher s.n. Walpers (1839) synonymised this taxon under *Psoralea arborea* but the type has not yet been found.

*Psoralea pinnata* sensu Palmer & Pitman, *Trees of Southern Africa* 2: 918–919 (1976).

*Psoralea affinis* sensu Hutchinson, *Bot. Mag.* 136: t. 8331 (1910), non Eckl. & Zeyh. (1836).

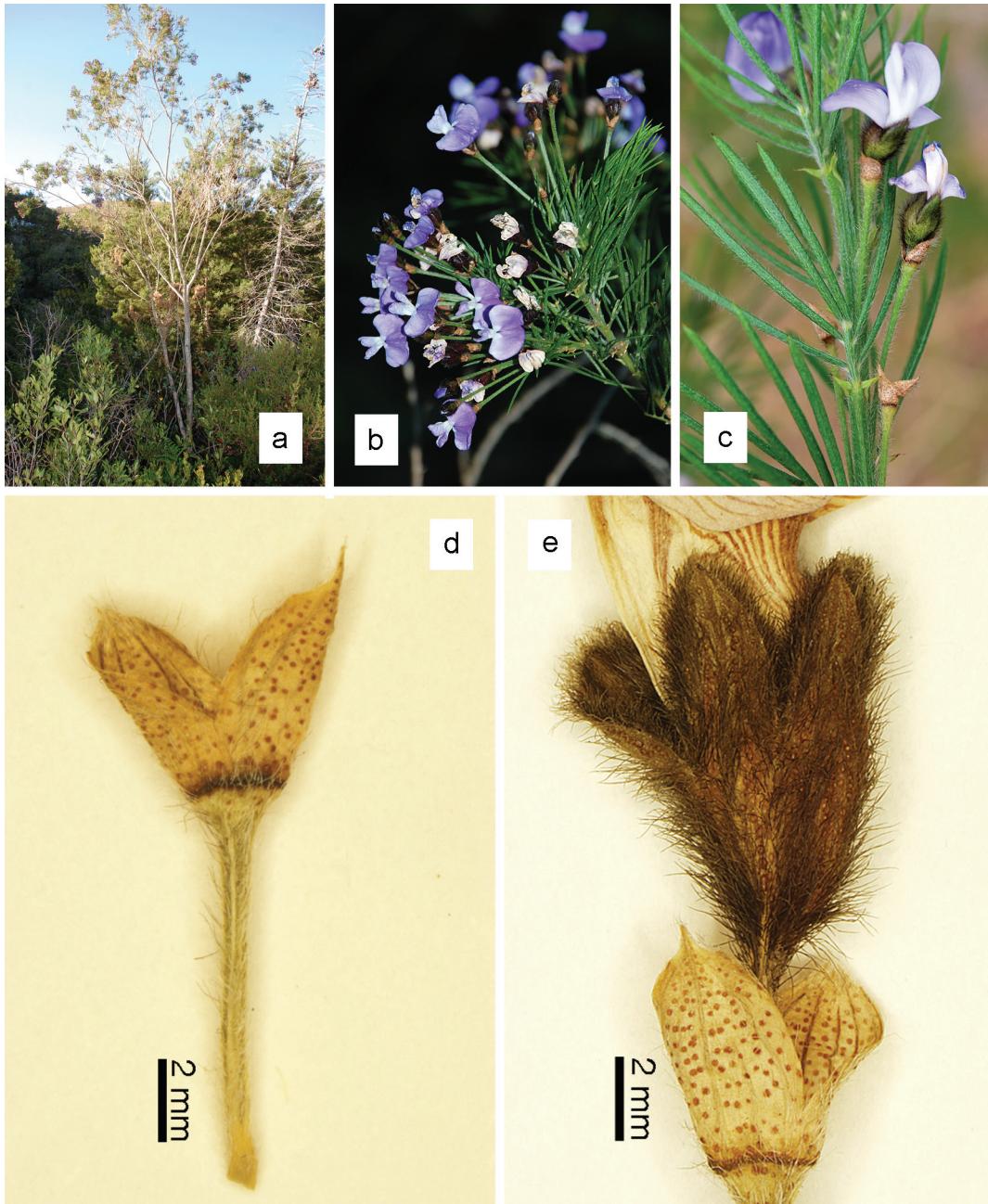
Verdcourt (2000) refers to this species in the *Flora Zambesiaca* but his species is *P. latifolia* (Harv.) C.H.Stirt. (see note under distribution).

**Vernacular names:** South Africa: Fonteinbos.

*Large slender shrub to small tree, 3–5(–10) m tall. Stems erect, 1(2), rigid, diameter up to 50 cm, greenish grey when young, becoming grey when old with scattered white lenticels. Stipules fused for part of their length, persistent, shorter than petiole, margins inrolled, narrowly subulate, hairy, rapidly senescent. Leaves 7–9-foliolate, imparipinnate, 25–30 mm long, 45 mm wide, glabrescent above, wispily hairy below, petiolate. Leaflets 30–45 mm long, 1–2 mm wide, terminal leaflet shortest, basal pair longest, linear or linear lanceolate, acute, green, glandular. Petiole 4–5 mm long, shorter on younger leaves, rachis 10–12 mm long. Inflorescences well exerted from leaves, in upper*

### Key to species of *Psoralea* naturalised in Australia

- 1 Leaflets villosa-pubescent on both surfaces; flowers hidden within leaves, pale mauve to light blue, scentless or faintly scented; pedicels 2–5 mm long terminating in a trifid cupulate bract; calyces mainly white-haired but also with black hairs on the margins, or a mixture of black and white hairs ..... *P. pinnata*
- 1: Leaflets glabrescent above, wispily hairy below; flowers exerted beyond leaves, deep blue to purple, strongly sweet scented; pedicels 11–35 mm long terminating in a bifid cupulate bract; calyces mainly black-haired (with or without occasional white hairs mainly near base), or mostly black haired with a mixture of black and white hairs on the margins of the lobes ..... *P. arborea*



**Figure 2.** *Psoralea arborea*: **a.** habit; **b.** inflorescences; **c.** leaves and flowers; **d.** bifid cupulate bract (from Lyne 446); **e.** calyx (from Lyne 446). Photo credits: **a–c** Charles Stirton; **d–e** Val Stajsic.

parts of seasonal shoots but without leafy extension, **congested and pseudo-capitate or laxly clustered in axils.** Flowers (10–)13–15(–19) mm long, **long pedicellate, 2–3 per axil**, deep blue to purple, **strongly scented**, axillary, each set subtended by a pinnate leaf; bracts a **fused bifid cupulate structure** situated at apex of a 11–35 mm long densely hairy pedicel, **overlapping up to one third of the base of the calyx in bud stage, splitting to base with age**, lower tooth cleft, **teeth equal**, green at anthesis **becoming scarious, straw-coloured and ridged** when old, retained even after seed shed; teeth broadly triangular, acute to rounded, sparsely to moderately covered in short black hairs; glandular, drying orange. Calyx 6–8 mm long, **densely hairy**, mainly black-haired with or without occasional white hairs on calyx, mainly near base, or mostly black haired on body of calyx, with a mixture of black and white hairs on margins of calyx lobes; **teeth and tube blackish**, triangular to rounded. Standard petal 15–16 mm long, (13.5–)14.5–15 mm wide, **very broadly ovate**; deep blue to purple with large M-shaped white nectar guide with a dark purple flash in crotch, paler towards margins, veins darker than blade. Wing petals 14 mm long, 5 mm wide, longer than keel petals; mauve, blade folded and puckered along the mid-line; sculpturing present. Keel 10–11 mm long, 3.5–4 mm wide, white, shorter than the wings. Androecium **12 mm long.** Pistil 6 mm long; ovary 3 mm long, upper end covered in club-shaped glands; style filamentous but thickened at point of flexure, stigma penicillate. Fruits 4–5 mm long, 2 mm wide. Seeds 3–4.5 mm long, 2 mm wide. (Fig. 2)

**Specimens examined:** **WESTERN AUSTRALIA.** Forrest Grove Forest Block, SE of Witchcliffe, 29.x.1996, G.J. Keighery 14611 (PERTH); On the banks of Blackwood River estuary, Augusta, South West, 24.x.1994, A. Worz 04.10.24.08 (PERTH). **NEW SOUTH WALES.** West Ryde, 25.xi.1964, O.D. Evans s.n. (NSW 920329) (possibly cultivated); South of Prince Henry Hospital, Little Bay towards La Perouse, 20.x.1975, R.[G.] Coveny 7274 & V. Shanker (A, K, L, MO, NSW, RSA); La Perouse, Grose Street, edge of Botany Bay National Park, 24.viii.1987, R.O. Makinson 315 & S. Krauss (DAO, MEL, NSW); Burill Lake, 06.x.1991, A.M. Lyne 446 (AD, CBG, MEL, NSW); Bermagui, Haywards Beach, Old Tilba Road, N end of disused section, 18.ix.1995, N. Schultz 185 (CANB, MEL, NSW); Helensburgh Cemetery, c. 2 km S of town centre, 20.x.1996, P.C. Jobson 4485 (CANB, MEL, NSW); Lawson Tip, end of Ridge Road, Lawson, 22.ix.2000, M. Williams s.n. (NSW 604386); Nambucca Heads – along track leading to

beach, xi.1966, C. Debenham s.n. (NSW). **VICTORIA.** Braybrook, 07.x.1976, C. LeBreton s.n. (MEL 2184225A) (possibly cultivated); Old Marlo tip, Conran-Marlo Road, c. 1 km E of Marlo, 26.viii.1992, K. Twyford s.n. (MEL 2014611A); Old Marlo Tip, Marlo-Conran Road, c. 1 km E of Marlo, 23.ix.1992, K. Twyford s.n. (MEL 2013726A). **TASMANIA.** Ironcliffe Road, Penguin, 2 km S of town, 28.xii.1978, B. Robinson s.n. (HO 28682); Summit of Hardwickes Hill, 24.xi.1983, A.M. Buchanan 1751 (HO); St Mary's Pass, 18.xi.1997, A.M. Buchanan 14901 (HO); Dover Golf Course, 09.ii.1998, A.M. Buchanan 15073 (HO); Minna Road, ca. 800 m from Bass Highway, Burnie, 30.x.2003, M. Baker 234 (HO); Eaglehawk Neck, Arthur Highway, 21.xi.2003, M. Baker 306, A.M. Gray & M.F. Duretto (HO); Bush opposite motel, Blowhole Road, Eaglehawk Neck, 16.i.2004, M. Baker 419 (HO); Trial Harbour, N end, at junction of camping area, 15.ix.2004, M. Baker 609 & A.M. Gray (HO); Greens Beach, West Tamar Road, just S of built-up area, 31.x.2006, M.L. Baker 1731, A.M. Buchanan & A.M. Gray (HO); Flinders Island, Barron, 14.i.2007, A.M. Buchanan 16654 (HO).

**Flowering period:** In South Africa flowering takes place from June to December as it does in Australia. Seed is produced from December to February.

**Ecology and habitat:** In its native range in South Africa *Psoralea arborea* is a species of lowland fynbos, forest margins, vleis (marshes) and inundated areas on black turfy substrates. It has recently become established along roadside ditches and in much drier situations. If it is protected from fire, as in fire-protected valleys in the Koudberg Mountains, this species can grow up to 10 m tall with substantial trunks up to 50 cm d.b.h. (1 m level). It has become seriously invasive in many parts of Australia (Csurhes & Edwards 1998). In Western Australia it has been collected from near a brackish swamp on the banks of Blackwood River estuary, at Augusta, and at an old gravel pit, on lateritic loam near Witchcliffe (Western Australian Herbarium 2008–). In South Africa, *P. arborea* is found between 30–330 m above sea level whereas in Australia it has been collected from elevations between 3–700 m above sea level. The first clearly naturalised plants from Little Bay were noted as being scattered in disturbed areas at the edge of a golf course. It is uncertain whether an earlier specimen collected in 1964 from West Ryde was self-established or planted, the collecting notes 'on footpath, just outside a garden' being ambiguous. In Tasmania it was first collected at Iron Cliff Road, Penguin, on 28 December 1978, but with no habitat and abundance information provided. It occurs along roadsides and escapes into bushland,

and at sites such as Burnie it can form very dense and large populations where it can be dominant such as at Eaglehawk Neck, neglected and disturbed weedy areas, and quarries. Groves et al. (2005) record it as one of the ten most serious invasive garden plants available for sale in Tasmania (referred to as *P. pinnata* in their report).

**Associated species:** In Australia, *Psoralea arborea* occurs in coastal areas behind fore-dunes at Bermagui, with *Banksia integrifolia* L.f. subsp. *integrifolia* and *Acacia longifolia* subsp. *sophorae* (Labill.) Court, in dry sclerophyll forest, on clay soil at Nungatta State Forest, the Lawson rubbish tip, weedy disturbed open shrubland on siliceous sand at La Perouse, disturbed *Corymbia* K.D.Hill & L.A.S.Johnson and *Eucalyptus*

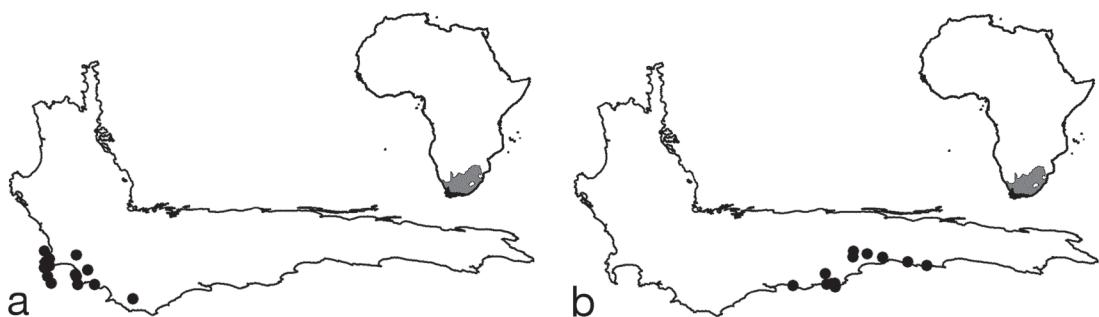
L'Hér woodland, and on gravelly clay at Helensburgh Cemetery. In Victoria, it was collected in a *Banksia* L.f. and *Eucalyptus botryoides* Sm. woodland on an escarpment at the old Marlo tip. The collecting notes indicate that it was common but localised at the time that the collection was made in 1992.

**Biology in South Africa:** The species is pollinated by Xylocopid bees (e.g. Giant Carpenter Bee – *Xylocopa flavorufa* (De Greer, 1778), (see Marlow 2013)). Seedlings, as in *Psoralea pinnata*, produce copious root nodules (Stirton pers. obs.).

**Etymology:** The epithet refers to the habit of the plant (from Latin: *arbor*, tree). It is one of the few trees in the genus.



**Figure 3.** Distribution in Australia: **a.** *Psoralea pinnata*; **b.** *P. arborea*



**Figure 4.** Distribution in South Africa: **a.** *Psoralea pinnata*; **b.** *P. arborea*

## Distribution and naturalisation

In Australia the *Psoralea* species reported here are naturalised in all states except Northern Territory and Queensland, with differences in their dominance in certain states (Fig. 3a & 3b). *Psoralea arborea* is more widespread than *P. pinnata*, and more commonly collected. In Tasmania, *P. arborea* is certainly the commoner of the two species, *P. pinnata* being rarely collected. In New South Wales, *P. arborea* is the more widespread and more frequently collected species whereas *P. pinnata* is mostly confined to the greater Sydney area. In Western Australia and Victoria, *P. pinnata* is the commoner of the two species. *Psoralea pinnata* is the only naturalised *Psoralea* in South Australia, known only from a 1979 collection from Dismal Swamp, near Mt Gambier, in the far south-east of South Australia.

The earliest probable naturalised record of *Psoralea* in Australia is a Ferdinand Mueller collection of *P. pinnata* collected in October 1867 at Albany in Western Australia (MEL 0116942A). The notes on the collecting label indicate that the species is 'Now in the utmost profusion at Albany. Cannot be extirpated'. *Psoralea arborea* started to become a problem considerably later than *P. pinnata*. The first clearly naturalised plants of *P. arborea* were collected from Little Bay, Sydney, New South Wales, in 1975. In Western Australia, it is known from only two sites: on the banks of the Blackwood River estuary, Augusta, which represents the earliest record of the species in Western Australia, and at Forrest Grove Forest Block, south-east of Witchcliffe, where it is locally common. It is absent in South Australia, and in Victoria it is known from only a single site at Marlo tip, in the far eastern part of the state.

*Psoralea pinnata* is the only naturalised species of *Psoralea* in New Zealand and is mostly restricted to the North Island (Webb 1980; see map in Breitwieser et al. 2010–2015). Early records of naturalisation of *P. pinnata* are (Kirk 1870), Cheeseman (1883, 1913, 1925), Randall Page (1922) and Allan (1937). The pattern of early naturalisation followed a similar pattern to that in Australia. Thompson (1925) noted that in New Zealand this species was reported by Kirk to already occur in the Takapuna District, Auckland, and that 'as it seeds profusely, small specimens are not uncommon in the neighbourhoods of gardens, deserted homesteads,

etc. where it can scarcely be expected to become fully naturalised'. Later, however, Cheeseman (1912) had recorded it, on the authority of O. Oakley, as occurring wild at Waipu and threatening to become a nuisance. Further study is needed to track its path of naturalisation in New Zealand.

In their native habitats in South Africa *P. pinnata* (Fig. 4a) and *P. arborea* (Fig. 4b) are endemic to the Western Cape Province. They occupy similar habitats and scarcely overlap in their distribution except in the Hermanus region where they are known to hybridise. *Psoralea arborea* extends from Stanford to Mossel Bay but has been recorded from Hermanus in the past. All references to this species outside this distribution belong to other taxa (Bello et al. 2014). In its native habitat *P. pinnata* extends from the Cape Peninsula to the Kogelberg Mountains.

*Psoralea* L. emend. C.H.Stirt. has a long horticultural history in Australia, and species have been listed in nursery catalogues, botanic gardens, and floras (Hooker 1859) from the early 1800s. For example, *P. pinnata* was listed in unpublished manuscript ledgers (Fraser 1828) and the published catalogues of J. Bailey's Hackney Nursery in Adelaide (1845) and Shepherd's Darling Nursery in Sydney (1857). However, because plants listed as *P. affinis* Eckl. & Zeyh. and *P. arborea* may also have been misidentified as *P. pinnata*, it will require a more detailed study to track the pathway of naturalisation. *Psoralea affinis*, although not yet an invader, should be considered a potential weed as it is in the same taxonomic group as *P. arborea* and *P. pinnata*.

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## References

- Allan, H.H. (1937). The origin and distribution of the naturalized plants of New Zealand. *Proceedings of the Linnean Society of London* **150**, 25–46.
- AVH (2015). Australia's Virtual Herbarium, Council of Heads of Australasian Herbaria. Accessed 6 July 2012. <<http://avh.chah.org.au>>
- Bailey, J. (1845). Catalogue of Plants cultivated in and for sale at the Hackney Nursery, Adelaide, 1845. 'The Adelaide Observer' 3 May, 1845, pp 1–2.
- Beadle, N.C.W., Evans, O.D. and Carolin, R.C. (1962). *Handbook of vascular plants of the Sydney district and blue mountains*. Printed for the authors by Brown Gem Print: Armidale, New South Wales.
- Bello, A., Muasya, A.M., Stirton, C.H. and Chimphango, S.B.M. (2014). A morphometric and taxonomic study of the *Psoralea pinnata* L. species complex (Fabaceae) in Southern Africa. Conference abstracts. 20th AETFAT conference, University of Stellenbosch (13th–17th January, 2014) (unpublished manuscript in possession of the author).
- Blakely, W.F. (1923). A census of the weeds and naturalised plants of New South Wales (abstract). Prepared for the Pacific Science Conference in 1923, in which he includes *P. pinnata* in swampy land near Sydney. A final draft of this census is in the Library of Botanic Gardens Sydney.
- Blood, K. (2001). *Environmental weeds – a field guide for S.E. Australia*. C.H. Jerram & Associates-Science Publishers: Mt. Waverley, Victoria.
- Breitwieser I., Brownsey P.J., Heenan P.B., Nelson W.A. and Wilton A.D. (eds) (2010–2015). *Flora of New Zealand Online – Weed Profile – 'Psoralea pinnata'*. Accessed 9 January 2015. <[http://www.nzflora.info/factsheet/Weed/Psoralea\\_pinnata.html](http://www.nzflora.info/factsheet/Weed/Psoralea_pinnata.html)>
- Brink, M. (2013). Kleinmond *Psoralea* eaters, observed 1st August 2013 by 'magrietb'. iSpot: share nature. The Open University. <<http://www.ispotnature.org/node/534803>>
- Carr, G.W., Yugovic, J.V. and Robinson, K.E. (1992). *Environmental weed invasions in Victoria: conservation and management implications*. Department of Conservation and Environment, and Ecological Horticulture Pty Ltd: Melbourne.
- Cheeseman, T.F. (1883). Naturalized plants of the Auckland Provincial District. *Transactions and Proceedings of the New Zealand Institute* **VI**, 268–291.
- Cheeseman, T.F. (1885). Die Naturalistern Pflanzen des Provincial-Districts Auckland. *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* **6**, 91–110 (translation into German of Cheeseman, 1883).
- Cheeseman, T.F. (1913). Contributions to a fuller knowledge of the Flora of New Zealand: No. 5. *Transactions and Proceedings of the New Zealand Institute* **46**, 1–9.
- Cheeseman, T.F. (1925). *Manual of the New Zealand flora*. 2nd edition (includes a list of naturalised plants, 1053 et seq.).
- Csurhes, S. and Edwards, R. (1998). *Potential environmental weeds in Australia*. National Weeds Program, Environment Australia: Canberra.
- Curtis, W.M. (1975). 'Psoralea pinnata', in *The students flora of Tasmania* **1**, p. 163 (2nd edn., revised By W. M. Curtis & D. I. Morris). T. J. Hughes, Government Printer: Tasmania.
- Fraser, C. (1828). *Catalogue of plants cultivated in the Botanic Garden, Sydney, January 1828*. Unpublished ledger.
- Frodsham, T. (2008). *Wetland conservation in the Albany region WA: King River*. Green Skills: Western Australia.
- Gardner, C.A. (1925). List of the naturalised plants of extra-tropical Western Australia. *Journal of the Royal Society of Western Australia* **40**, 69–80.
- Gilligan, S. and Barrett, S. (2004). *Interim recovery plan number 169. Mountain Villarsia* (*Villarsia calthifolia*): 2004–2009. Department of Conservation and Land Management: Albany, Western Australia. Accessed 8 November 2013. <<http://www.environment.gov.au/system/files/resources/9188b047-2805-4c42-a00b-22c033155095/files/v-calthifolia.pdf>>
- Grieve, B.J. (1998). 'Psoralea pinnata', in *How to know Western Australian Wildflowers*, 2nd edn, **II**, p. 461. University of Western Australia Press: Nedlands.
- Groves, R.H.R., Boden, R. and Lonsdale, W.M. (2005). *Jumping the garden fence: invasive garden plants in Australia and their environmental and agricultural impacts*. CSIRO report for WWF Australia: Ultimo, New South Wales.
- Hooker, J.D. (1859). *The flora of Australia, its origins, affinities and distribution, being an introductory essay to the Flora of Tasmania*. Lovell Reeve, Covent Garden: London. A reprint from his *Botany of the Antarctic Voyage*. Part 111.
- Hussey, B.M.J., Keighery, G.J., Cousens, R.D., Dodd, J. and Lloyd, S.G. (1997). *Western weeds, a guide to the weeds of Western Australia*. Plant Protection Society of Western Australia (Inc.): Victoria Park, Western Australia.
- Jeanes, J.A. (1996). 'Psoralea pinnata', in N.G. Walsh and T.J. Entwistle (eds), *Flora of Victoria* **3**, p. 681. Inkata Press: Melbourne.
- Kirk, T. (1870). On the naturalised plants of New Zealand, especially with regard to those occurring in the Province of Auckland. *Transactions and Proceedings of the New Zealand Institute* **II**, 131–146.
- Lemaire, B., Dlodlo, O., Chimphango, S., Stirton, C.H., Schrire, B., Boatwright, J.S., Honnay, O., Smets, E., Sprent, J., James, E.K. and Muasya, A.M. (2014). Symbiotic diversity, specificity and distribution of rhizobia in native legumes of the core Cape Subregion (South Africa). DOI: <http://dx.doi.org/10.1093/femsec/fiu024>
- Marlow, R. (2013). Carpenter bee, observed 2nd October 2013. iSpot: share nature. The Open University. <<http://www.ispotnature.org/node/540461>>
- Muyt, A. (2001). *Bush invaders of South-East Australia: a guide to the identification and control of environmental weeds found in South-East Australia*. R.G. and F.J. Richardson: Meredith, Victoria, Australia.
- Norris, E.H. and Harden, G.J. (2002). 'Psoralea pinnata', in G. Harden (ed), *Flora of New South Wales*, revised edn., **2**, p. 591. Royal Botanic Gardens Sydney, University of New South Wales Press: Kensington.
- Randall Page, H.W. (1922). *The naturalisation of plants and animals in New Zealand*. Cambridge University Press: Cambridge.
- Rebelo, T. (2011). Caterpillars, observed 9th August 2011. iSpot: share nature. The Open University. <<http://www.ispotnature.org/node/467402>>

- Rebelo, T. (2012). Ant, observed 14th June 2012. *iSpot: share nature*. The Open University. <<http://www.ispotnature.org/node/479927>>
- Shepherd, J.W. (1851). Catalogue of plants cultivated at the Darling Nursery, Sydney, New South Wales.
- Stirton, C.H. (1981). 'Psoraleeae', in R.M. Polhill and P.H. Raven (eds), *Advances in Legume Systematics* 2, pp. 337–343. Royal Botanic Gardens, Kew.
- Stirton, C.H. (2005). 'Tribe Psoraleeae', in G. Lewis, B. Schrire, B. Mackinder and M. Lock (eds), *Legumes of the World*, pp. 446–451. Royal Botanic Gardens, Kew.
- Stirton, C. (2007a). Carpenter bee visiting flowers of *Psoralea pinnata*, observed 31st December 2007. *iSpot: share nature*. The Open University. <<http://www.ispotnature.org/node/478966>>
- Stirton, C. (2007b). Carpenter bee visiting flowers of *Psoralea pinnata*, observed 31st December 2007. *iSpot: share nature*. The Open University. <<http://www.ispotnature.org/node/478962>>
- Stirton, C. (2007c). Bee visiting flowers of *Psoralea pinnata* (Fabaceae), observed 31st December 2007. *iSpot: share nature*. The Open University. <<http://www.ispotnature.org/node/478084>>
- Stirton, C. (2007d). *Xylocopa* visiting flowers of *Psoralea pinnata*, observed 31st December 2007. *iSpot: share nature*. The Open University. <<http://www.ispotnature.org/node/478085>>
- Stirton, C.H. and Muasya, A.M. (2015). *Monograph of Psoralea* (Psoraleeae, Fabaceae) (unpublished manuscript in possession of the author).
- Stirton, C.H. and Schutte, A.L. (2000). 'Psoralea', in P. Goldblatt and J.C. Manning (eds), *Cape Plants: a conspectus of the Cape flora of South Africa*, pp. 505–507. National Botanical Institute of South Africa: Pretoria.
- Thiers, B. (2015). *Index Herbariorum: a global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. <<http://sciweb.nybg.org/science2/IndexHerbariorum.asp>>
- Thompson, G.M. (1925). The naturalisation of plants and animals in New Zealand. *Proceedings of the Linnean Society of London* 150(1), 25–46.
- Van den Bosch, J. (2012). Communal caterpillar web, observed 4th November 2012 by 'jeltje'. *iSpot: share nature*. The Open University. <<http://www.ispotnature.org/node/544187>>
- Verdcourt, B. (2000). 'Tribe 10. Psoraleeae', in G.V. Pope (ed), *Flora Zambesiaca* 3(6), 3.6.43–3.6.50. Royal Botanic Gardens, Kew.
- Voget, C. (2011). Painted Lady, observed 24th December 2011. *iSpot: share nature*. The Open University. <<http://www.ispotnature.org/node/498299>>
- Webb, C.J., (1980). Checklist of dicotyledons naturalised in New Zealand 5. Leguminosae. *New Zealand Journal of Botany* 18, 463–472. DOI: 10.1080/0028825X.1980.10425167
- Webb, C.J., Sykes, W.R. and Garnock-Jones, P.J. (1988). *Flora of New Zealand* 4, 674. Manaaki Whenua Press: Lincoln.
- Weber, J.Z. (1986). 'Psoralea pinnata', in J.R. Jessop and H.R. Toelken (eds), *Flora of South Australia* 2, 598. South Australian Government Printing Division: Adelaide.
- Western Australian Herbarium (2008–). *FloraBase: The Western Australian Flora*. Department of Parks and Wildlife. Accessed 8 Nov. 2013. <<http://florabase.dpaw.wa.gov.au/>>