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Making it official—formal description of two orange-flowered *Tephrosia* (Fabaceae: Millettieae) species from north-west Western Australia

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Abstract

Butcher, R. Making it official—formal description of two orange-flowered *Tephrosia* (Fabaceae: Millettieae) species from north-west Western Australia. *Nuytsia* 29: 251–267 (2018). Two long-standing manuscript names in *Tephrosia* Pers. are herein formalised as *T. densa* (Benth.) Pedley ex R.Butcher and *T. gardneri* Pedley ex R.Butcher, and their various informal names synonymised. Full descriptions and images are provided for both these north-west Western Australian species and their histories and affinities are discussed.

Introduction

Following Bentham's (1864) treatment of *Tephrosia* Pers. in Australia, in which 18 new taxa were described for Western Australia, taxonomic endeavours in this State progressed *ad hoc* over the following 62 years (Mueller 1879, 1880, 1883; Skan 1905; Domin 1912; Ewart & Morrison 1913; Fitzgerald 1918; Gardner 1923; Domin 1926) before Les Pedley commenced a more comprehensive investigation in the 1970s, laying the foundation for a further suite of regionally-focussed, revisionary publications (Pedley 1977; Maconochie 1980; Wheeler 1992; Cowie 2004; Butcher 2012; Butcher & Hurter 2012; Pedley 2014; Butcher *et al.* 2017; Butcher 2018).

The two *Tephrosia* species described herein were recognised as discrete by Pedley in 1984, through a series of herbarium specimen annotations. At that time they were given manuscript names, which were erected on the Western Australian vascular plant census and widely taken up by botanists in the State, before being converted to phrase names under Australian Plant Census (APC) protocols in 2012. To minimise taxonomic and nomenclatural confusion, the two long-standing manuscript names are retained, and herein formalised as *T. densa* (Benth.) Pedley ex R.Butcher and *T. gardneri* Pedley ex R.Butcher.

The two new species have some similarity in their shared possession of orange flowers, frequently prominent inflorescence and floral bracts, frequently rufous indumentum on the rachides of their elongate inflorescence and on calyces, as well as their turgid, linear pods, and mottled, transversely obloid seeds, which have a slightly to obviously excentric hilum, but they are readily distinguished by the shape of their leaflets.

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Methods

All *Tephrosia* specimens housed at PERTH were critically studied, as were all Western Australian specimens housed at AD, BRI, CANB, DNA, MEL, NSW and NT, and on loan from K. Types of all Australian species have been viewed on loan and through *Global Plants* (https://plants.jstor.org). Field work in the Carnarvon, Murchison and Pilbara bioregions was undertaken in 2011 and allowed for *in situ* examination of plants. Bioregions referred to in the text and displayed on distribution maps follow *Interim Biogeographic Regionalisation for Australia* (IBRA) v. 7 (Department of the Environment 2013).

Leaf venation terminology follows Ellis *et al.* (2009). The inflorescence is interpreted as a pseudoraceme following Tucker (1987, 2003), where the elongate rachis has fascicles of flowers in the axils of first-order bracts (here termed 'inflorescence bract'), each flower subtended by a second-order bract (here termed 'floral bract'); paired bracteoles on the pedicel can be present or absent. Fascicles comprise one or more 3-flowered units, with the first two flowers opening in relatively close succession and the third flower in each unit often delayed developmentally, with anthesis commonly occurring once the first two flowers have developed into fruits. As such a fascicle can potentially contain a mixture of fruits at different stages of maturity, flowers and buds; when flowers are present there are usually one or two open at a time.

Taxonomy

Tephrosia densa (Benth.) Pedley ex R.Butcher, *comb. et stat. nov.*

Tephrosia bidwillii Benth. var. *densa* Benth., *Fl. Austral.* 2: 210 (1864). *Type*: 'N. Australia. Hills near Nichol [Nikol] Bay [Western Australia], [*s. dat.*,] *F. Gregory's Expedition*.' (*holo*: K 000217093!).

Tephrosia densa (Benth.) Pedley ms, Western Australian Herbarium, in *FloraBase*, https://florabase.dpaw.wa.gov.au/ [accessed 21 August 2018].

Tephrosia sp. Fortescue (A.A. Mitchell 606), Western Australian Herbarium, in *FloraBase*, https://florabase.dpaw.wa.gov.au/ [accessed 21 August 2018].

Tephrosia sp. Meentheena (S. van Leeuwen 4479), Western Australian Herbarium, in *FloraBase*, https://florabase.dpaw.wa.gov.au/ [accessed 21 August 2018].

Tephrosia sp. dense (A.C. Beauglehole 11456), *in sched.* [at DNA, NT].

Erect *subshrubs* to *shrubs*, few-stemmed, perennial, 0.2–1.4 m tall, 0.2–1.2 m wide. *Branchlets*, *leaf and inflorescence rachides* with a moderately dense to dense indumentum of short, straight, appressed to patent, white to stramineous to ferruginous hairs, 0.1–0.9 mm long. *Leaves* pinnate, 58–185 mm long including petiole; *stipules* persistent, antrorse, attenuate, 4.0–13.5 mm long, green drying stramineous, 1–3-nerved; *petiole* 6–30 mm long; *ultrajugal rachis* 0–8 mm long; *stipellae* absent; *petiolules* 0.9–3.5 mm long; *leaflets* (5–)7–17, narrowly lanceolate to narrowly elliptic, flat to V-shaped in T.S., at least some attached in the proximal half of the leaf; base cuneate; apex acute to rounded, straight or slightly deflexed; *lateral leaflets* 17–60 mm long, 2–10 mm wide, length 3.3–8.6(–10.4) × width; *terminal leaflet* 1–1.5 × the length of adjacent leaflets, 21–58 mm long, 3.0–10.1 mm wide, length (2.8–)4.2–9.3(–13.2) × width; lamina discolorous, greyish mid-green to glossy, dark green above, paler

grey-green below; upper surface glabrous or puberulous, hairs patent, fine, straight, hyaline, white; lower surface sparsely to densely pubescent, hairs appressed, straight, white or less commonly stramineous; secondary veins eucamptodromous, apically brochidodromous, in 7–15 pairs, intersecondary veins parallel to secondaries, which are often raised on the upper surface of the leaflets as well as the lower. *Inflorescence* pseudoracemose, leaf-opposed, 42–270 mm long, fascicles usually closely spaced, with 3–6 flowers in each cluster, 1 or 2 open at a time; *inflorescence bracts* antrorse, lanceolate, acuminate, 2.0–8.5 mm long, caducous; *floral bracts* lanceolate, 0.5–2 mm long, caducous; *bracteoles* absent; *pedicels* 1.3–5.8 mm long. *Calyx* 3.4–6.9 mm long, indumentum moderately dense to dense, usually ascending to patent, stramineous through ferruginous to dark chocolate brown, commonly mixed-coloured, rarely loosely appressed and white; tube 1.4–3.4 mm long, 0.6–1.2 × the length of lateral lobes; lower and lateral lobes narrowly deltoid to attenuate; vexillary lobes united higher than lower three, free for 0.4–1.5 mm length, upper lip divided to 20–60% length; lowest lobe 1.4–4.6 mm long, ±equal to laterals. *Corolla* orange, 8–12 mm long; *standard* (5.9–)6.2–9.2 mm long, (7–)8.1–11.2 mm wide, the claw 1.0–2.5 mm long, blade ovate to suborbicular, not or slightly callused at base, apex rounded to retuse; *wings* 6.4–9.5 mm long, 2.6–4.6 mm wide, ±equal to keel, the blade usually obovate, less commonly elliptic, with a rounded apex; *keel* 5.8–8.0 mm long, 2.6–3.7(–4.9) mm wide, the blade semi-circular, usually with hairs along the lower margin. *Staminal* tube usually glabrous or with short hairs present on margins of tube or on the sides near the tube apex, margins of fenestrae thickened to callused; vexillary filament straight, usually glabrous or with patent hairs in front of callosity or from middle of callosity to *c.* 2/3 filament length, callused near base; anthers 0.4–0.7(–0.8) mm long, 0.1–0.4(–0.6) mm wide. *Ovary* densely hairy; ovules (5–)6–10. *Style* flattened, tapering, glabrous; stigma penicillate, linear. *Pods* linear, straight with apex slightly upturned, 25–65 × 3.0–4.5 mm, turgid, stramineous at maturity, indumentum moderately dense to dense, appressed, inclined or patent, white, stramineous, ferruginous or brown, the hairs straight; beak in line with upper suture, straight to slightly inclined; white tissue present between seeds. *Seeds* 5–9 per pod, 4–6 mm between centres, transversely obloid-ellipsoid, 1.7–3.2 × 2.3–4.2 mm, finely mottled in combinations of olivaceous, light brown, brown, red-brown and black, the hilum encircled with green then orange, testa smooth or broadly dimpled, hilum excentric; rim-aril present, minute, annular, white. (Figure 1)

Diagnostic features. *Tephrosia densa* can be distinguished from all other species by the following combination of characters: pinnate leaves with (5–)7–17 narrowly lanceolate to narrowly elliptic leaflets 17–60 × 2–10 mm; persistent, antrorse, attenuate stipules; elongate pseudoracemes of orange flowers 8–12 mm long, with the calyx tube shorter than to *c.* same length as the lateral lobes, the hairs usually stramineous to brown and ascending to patent, and the stamens usually glabrous and callused near the base of the vexillary filament and on margins of fenestrae; (5–)6–10 ovules; turgid, linear pods with the apex slightly upturned and beak in line with upper suture and ±straight; transversely obloid-ellipsoid seeds 1.7–3.2 × 2.3–4.2 mm, with a finely mottled, ±smooth testa and excentric hilum.

Selected specimens examined. WESTERN AUSTRALIA: 13 km NNW of Mt Farquhar, pool of tributary of Serpentine Creek into Duck Creek at base of cliff, West Hamersley Ra., 25 July 1999, *B. Backhouse, D. Edinger & G. Marsh* BEM 105 (BRI, PERTH); Wittenoom Gorge, 18 Aug. 1963, *J.S. Beard* 2869 (PERTH); small granite range on N side of North West Coastal Hwy, *c.* 56 km SW of Nanutarra Roadhouse, 20 May 2011, *R. Butcher & S. Dillon* RB 1487 (DNA, PERTH, UWC); Meentheena Conservation Park; *c.* 57 km E along Ripon Hills Rd from Marble Bar, then 6.6 km S along track to Nullagine River camp, then walk *c.* 500 m W, 27 May 2011, *R. Butcher & S. Dillon* RB 1516 (PERTH, UWC); 14.6 km S of Nullagine on a tributary of Cajuput Creek, 11 Aug. 2007, *G. Byrne* 2831 (BRI, PERTH); Newman to Marble Bar road, 15 km S of Nullagine, 7 May 2006, *I.D. Cowie & R.A. Kerrigan* IDC 11129 (BRI, CANB, L, MEL, MO, NT, PERTH); 28.2 km S of Mt Minnie HS, 16.3 km SW of Mt Minnie, 31.8 km NNW of Mt Murray, 73.6 km SE of Onslow,

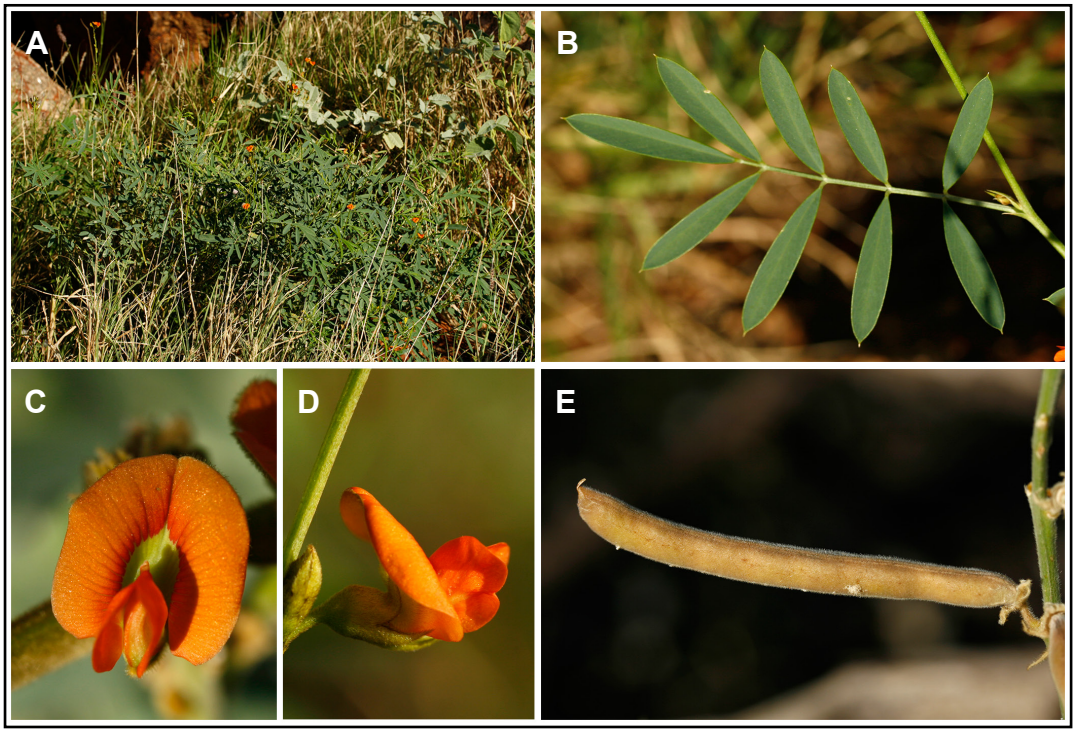

Figure 1. *Tephrosia densa*. A – spreading shrub habit; B – typical leaf, having a glabrous upper surface to oblanceolate leaflets; C – orange flower from front; D – orange flower from side, showing division and indumentum of the calyx; E – mature pod. Vouchers: *R. Butcher & S. Dillon* RB 1487 (A, B, D); RB 1490 (C, E). Photographer: R. Butcher.

Cane River Conservation Park, 23 June 2011, *S. Dillon & A. Markey* CR 9000 (AD, PERTH); Parry Ra., 7.7 km N of Mt Murray, 10.3 km NE of Nanutarra-Wittenoom Rd and North West Coastal Hwy intersection, 15 km NE Nanutarra Roadhouse, 100 km SE Onslow, Cane River Conservation Park, 27 June 2011, *S. Dillon & A. Markey* 9001 (DNA, PERTH); 142 mi. S of Port Hedland, on Wittenoom road, 26 Aug. 1960, *A.S. George* 1074 (PERTH); Barlee Range Nature Reserve, Kookhabinna Gorge below Currung-Kohndunna Pool, 24 km SSE of Mt Florry, 13 Sep. 1995, *S. van Leeuwen* 2292 (DNA, PERTH); Uaroo Stn, 21.8 km N of Towera Stn t/o on North West Coastal Hwy, 24 km SW of Globe Hill, 22.7 km SSW of Cheetara Rock, 16.2 km ENE of Old Barradale, 6 July 2002, *S. van Leeuwen* 5035 (BRI, DNA, PERTH); site: PHYE09, 10.3 km SW of Warrawagine Stn HS, 41.5 km WSW of Mt Cecelia, 95.8 km ENE of Marble Bar, 20 Aug. 2006, *S. van Leeuwen et al.* PBS 0244 (BRI, PERTH); site: TCMBE12, 10.1 km NE of Mt Nameless, 23.6 km W of Mt Hyogo, 7.8 km NE of Tom Price, 4 June 2006, *S. van Leeuwen et al.* PBS 0250 (DNA, PERTH); site: TCMBW01, 5.6 km W of t/o to Rocklea Stn HS on Munjina - Nanutarra Rd, 14.7 km SSW of Mt Turner, 43.8 km WSW of Tom Price, 6 June 2006, *S. van Leeuwen et al.* PBS 0254 (K, NT, PERTH); Rudall River region, June 1987, *W.G. Martinick & Associates s.n.* (PERTH); 5 km NW of Woodstock HS, 15 Aug. 1988, *A.A. Mitchell* 1668 (CANB, DNA, K, PERTH); 7 km NE of Quarry Hill, *c.* 120 km W of Tom Price, 1 Aug. 1984, *K.R. Newbey* 10670 (CANB, MEL, PERTH); Coolthara Pool, Ullawarra Stn, 16 Aug. 1961, *R.D. Royce* 6490 (CANB, PERTH); Marandoo Ridge, Hamersley Ra., 20 June 1975, *M.E. Trudgen* 1306 (K, MEL, PERTH); 8.4 km E of Coppin Pool on track to Juna Downs Stn, Hamersley Range National Park, 9 May 1980, *M.E. Trudgen* 2484 (AD, DNA, PERTH); site no. 901, 3 km NNE of West Angela Hill, Hamersley Ra., 5 July 1997, *M.E. Trudgen* MET 16119 (MEL, PERTH); site no. 967, 3.75 km WNW of Packsaddle Hill, Hamersley Ra., 12 July 1997, *M.E. Trudgen* MET 16150 (BRI, CANB, DNA, MEL, PERTH); site no. 1008, 8.5 km SSW of West Angela Hill, Hamersley Ra., 15 July 1997, *M.E. Trudgen* MET 16176 (MEL, PERTH).

Phenology. Flowers observed March to August, with fruits and seeds collected May to September.

Distribution. Widespread across the Pilbara and north-west Gascoyne bioregions of Western Australia, with limited collections from adjacent areas of the Carnarvon, Little Sandy Desert and Great Sandy Desert bioregions. Occurs in the area roughly bounded by Mt Augustus to the south, Giralia Station to the west, Karratha (and islands) to the north, and the Rudall River area to the east (Figure 2A).

An outlying specimen at PERTH (*J. Morrissey* 52; PERTH 02923882) is labelled as being from 'Wiluna area', which, if correct, places it over 350 km south of the geographically nearest collections around Newman. Despite them having different collection dates and locality statements on their labels, it is highly probable that this specimen is duplicate material of a specimen collected from '14 miles N Mt Phillipe [Phillips]' (*J.G.M. [J.G. Morrissey]* 52; PERTH 08003025), which is *c.* 30 km west of Mt Augustus. Not only do the fragments on each sheet have identical morphology, but the same discrepant pattern has been uncovered in other duplicated *Morrissey* numbers across a range of taxa. For example, for his following numbers (7, 8, 11, 14, 17, 19, 23, 24, 29, 31, 34, 42, 43, 58, 65) there are a pair of sheets at PERTH, one having the collection date 'Dec. 1970' and the locality 'Wiluna area', the other having the collection date '1971' or '1972' and a specific (and different) locality statement for each taxon; these latter sheets were transferred back to PERTH in 2008 from the Meekatharra District Office, Department of Agriculture and Food (MEEK.) following its closure in 2006. Morrissey was a rangeland researcher with the Agriculture Department and periodically sent specimens to PERTH for identification; these were retained, with a list of plant names being returned to MEEK. (J. Morrissey, pers. comm.). In the discrepant duplicates above, the original collections likely remained at MEEK. with excess material being sent to PERTH for identification; Morrissey (pers. comm.) believes that the collection information on the MEEK. specimens is accurate, therefore it is likely that the collection data on the other sheets was corrupted at some stage during specimen transfer and processing in the early 1970s. As such, the collection location near Mt Phillips for *Morrissey* 52 (PERTH 08003025, ex MEEK.) is viewed as correct, while 'Wiluna area' (which maps to Wiluna on AVH etc.) is viewed as an incorrect locality for the species.

Habitat. *Tephrosia densa* grows in a range of habitats, in red-brown gritty to stony clay loams, sandy loams and loams, usually in association with rocks (granite boulders, quartz hills, basalt rockpiles, silcrete/limestone, gully slopes). One collection is from a low coastal dune in pale brown coarse sand (*D.J. Edinger* 5978 C; Giralia Station); the specimen has very slender leaflets (L:W = 10–21; not included in taxon description) and is in bud only, but appears to be this taxon. Grows in open tall shrubland or open low *Acacia* woodland with low shrubs and tussock grassland, or *Triodia* hummock grassland with scattered *Corymbia* or *Eucalyptus*.

Conservation status. This species is widespread and is currently not considered to be under threat; it does not have a conservation listing in Western Australia.

Etymology. The epithet was raised as a manuscript name by Les Pedley and is an elevation of Bentham's (1864) varietal name. The taxon was recognised as distinct from typical *T. bidwillii* Benth. by its 'Leaflets shorter and more silky; inflorescence dense, but with the calyx of *T. [b]idwillii*' (Bentham 1864: 210). As noted, the inflorescences on the type are denser than those on *T. bidwillii* specimens; however, they are clearly not yet fully elongated. Despite this, the epithet is retained for nomenclatural stability.

Affinities. *Tephrosia densa* is similar to collections of *T.* sp. B Kimberley Flora (C.A. Gardner 7300) that have broader leaflets (mostly Kimberley and NT specimens), but that taxon can be distinguished

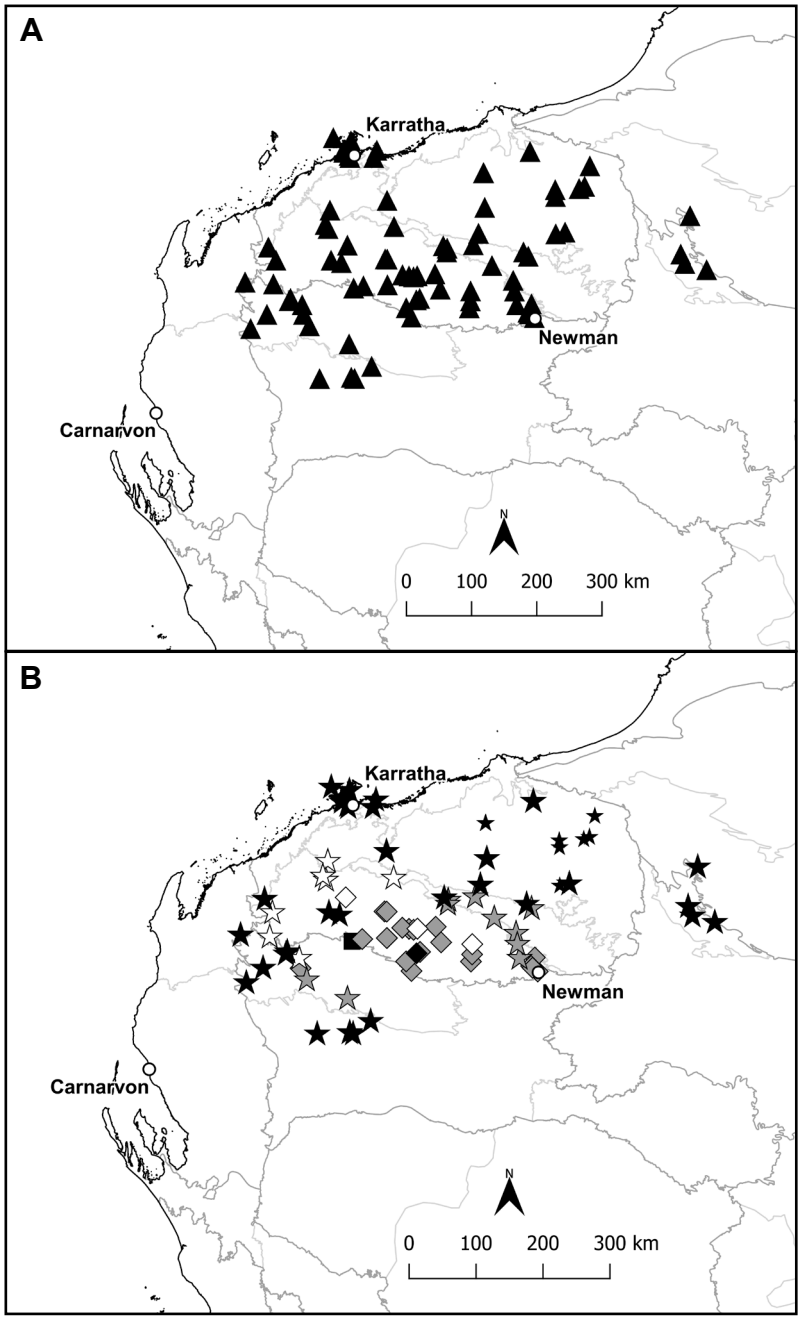

Figure 2. Distribution of *Tephrosia densa* in Western Australia, based on PERTH specimen data. A – all records of *T. densa* (black triangles); B – all records of *T. densa* by form and the indumentum of their upper leaflet surface and pods: formerly *T.* sp. Meentheena and *T.* sp. Fortescue/'*T. bidwillii*' identical to these with glabrous upper/appressed pods (small black stars), *T.* sp. Fortescue with glabrous upper/appressed pods (black stars), glabrous upper/inclined–patent pods (grey stars), glabrous upper/pilulose elsewhere/long-patent pods (white stars), patent upper/pilulose elsewhere/long-patent pods (white diamonds), patent upper/patent pods (grey diamonds), patent upper/appressed pods (black diamond), appressed upper/appressed pods (black square). *Interim Biogeographic Regionalisation for Australia* v. 7 (Department of the Environment 2013) bioregions are shown in grey, with subregions in light grey.

by its early deciduous stipules, sparsely appressed-sericeous indumentum on calyces and fruits, the calyx tube being more strongly curved on the adaxial surface, the standard petal having prominent, elongate callosities at the base, and the vexillary filament thickening in all directions from the base and having rounded protuberances on the upper and lower surfaces. Investigation of the status of *T. bidwillii* in Western Australia found that while there was superficial similarity between the two taxa, *T. densa* was a clearly different species (*cf.* a variety of the Queensland-New South Wales endemic *T. bidwillii*); the similarities and differences between them are discussed in Butcher (2012).

Notes. Although this taxon had a validly published varietal name (*T. bidwillii* var. *densa*), the decision to recognise the manuscript name *T. densa* (Benth.) Pedley ms as a phrase name at species rank (i.e. *T.* sp. Fortescue) for the APC recognised Pedley's prior taxonomic conclusion that it was a species distinct from *T. bidwillii*.

The type specimen of *T. bidwillii* var. *densa* comprises two small pieces, evidently taken from the upper part of the plant, with leaves, flowers and just-initiated fruits. The specimen is densely-flowered and has stramineous, appressed indumentum on the inflorescence rachis, and rufous, strongly inclined to patent hairs on the bracts and calyces; the leaves have 11–17 narrow leaflets, which are appressed-hairy below and glabrous on the upper surface, with prominent, raised secondary veins. A specimen held at PERTH that is a good match for the type (when the upper portions of the branches are considered) is *B.R. Maslin* 4707, collected from near Roebourne, *c.* 20 km from Nikol Bay.

The name *T.* sp. Meentheena (S. van Leeuwen 4479) was erected on the Western Australian vascular plant census in July 2003 following survey of Meentheena Conservation Park by (the then) Department of Conservation and Land Management staff and volunteers as part of a Landscope Expedition in May 2000. A duplicate of the specimen was sent to *Tephrosia* specialist Ian Cowie (DNA) for identification in February 2002; his response in November 2002 was '4479 *T.* sp. – I need to look into this more – new.' At this stage Cowie's revisionary work on the Western Australian taxa was in its infancy and, combined with the rather poor quality specimen (stems with few leaves with many leaflets missing, no mature flowers, fruits insect damaged) and the leaflets being narrow and widely spaced, it is easy to see why this was not identified as '*T. densa*' at the time. In addition to the handful of *T.* sp. Meentheena specimens at PERTH were a small number with identical morphology (i.e. having slender, widely-spaced leaflets that were glabrous on the upper surface and sparsely to moderately hairy below, long inflorescences, and paler indumentum) that were identified as either *T.* sp. Fortescue, or as *T. bidwillii*; they are all now included in *T. densa*.

Preliminary sorting of specimens identified two broad groups where the indumentum of the upper surface of the leaflet was correlated with the indumentum on the pods, suggesting that there may have been more than one taxon. Specimens in the first group had a glabrous upper leaflet surface and appressed hairs on the pods, while those in the second had short, hyaline or white, patent hairs on the upper leaflet surface and patent hairs on the pods. While the majority of specimens fall into one of these two groups, with a glabrous upper leaflet surface being most common, a smaller number of specimens with intermediate and novel combinations of indumentum characters were identified, as was additional variation in the density, length and orientation of hairs among specimens within each group. This variation is summarised in Table 1. There is a tendency for narrower leaflets to be glabrous on the upper surface and for broader leaflets to be patently hairy, but this is not consistent; leaflets with a range of widths and lengths can be found in both of these broad indumentum groups. Variation in the indumentum of the upper leaflet surface is also observable in the Pilbara taxa *T.* sp. NW Eremaean (S. van Leeuwen et al. PBS 0356), *T.* sp. clay soils (S. van Leeuwen et al. PBS 0273) and *T. clementii* Skan.

Table 1. Indumentum variation on upper and lower surfaces of leaflets, and pods, in *Tephrosia densa*, indicating representative specimens; a selection only (e.g.) is given for the two most common forms. * = typical form.

Leaflet upper surface	Leaflet lower surface	Pod	Representative specimens (PERTH sheets viewed)
glabrous	appressed, very sparse	appressed	*R. Butcher & S. Dillon* 1487 *R.J. Cranfield* 1786 *S. Dillon & A. Markey* CR 9000 *S.D. Hopper* 5037 *S. van Leeuwen* 1478 *S. van Leeuwen* 2205 *S. van Leeuwen* 5035 *L. Sweedman* 8315
glabrous	appressed	appressed	*e.g. *R. Butcher & S. Dillon* RB 1517 *K. Glennon* 409K *S. van Leeuwen et al.* PBS 0243 *Martinick & Associates s.n.* (June 1987) *K. Newbey* 10670 *M.E. Trudgen* MET 15512 *E. Wittwer* 1064
glabrous	appressed	inclined–sub-patent	*J.V. Blockley* 198 *T.R. Lally* TRL 725 *R.D. Royce* 6490 *C. Sgherza* 76 *E. Wittwer* S.1793
glabrous	appressed	patent	*J.S. Beard* 2869 *A.C. Beauglehole* 11456 *D.J. Edinger* 5132 *T. Edwards* MN 01.10 *A.S. George* 1074 *E. Mattiske* 34
glabrous	inclined–patent, pilulose–pilose	moderately long, inclined–patent	*S. Dillon & A. Markey* CR 9001 *M. Hay & S. Yandle* M 088 *S. van Leeuwen et al.* PBS 0252 *S. van Leeuwen* 2292 *A.A. Mitchell* PRP 1526 *B. Morgan & R. Warner* BES RW 014 *M.E. Trudgen & R. Parnell* MET 11626
patent to appressed	appressed	appressed	*J. Atkinson* JA 038 *A.A. Mitchell* 76/90

Leaflet upper surface	Leaflet lower surface	Pod	Representative specimens (PERTH sheets viewed)
patent	appressed–loosely appressed	patent	e.g. *B. Backhouse, D. Edinger & G. Marsh* BEM 184 *S. van Leeuwen et al.* PBS 0250 *S. van Leeuwen et al.* PBS 0253 *N. Walsh* 6473*, D. Halford & D. Mallinson* *F. Obbens* FO 11/06 *C. Sgherza* 77 *J. Young* 73
patent	inclined–patent	moderately long, patent	*B. Backhouse, D. Edinger & G. Marsh* BEM 105 *S. van Leeuwen et al.* PBS 0251 *M.E. Trudgen* MET 16150

Some of the morphological variation observed is correlated with geographic distribution. Specimens with a glabrous upper leaflet surface have the widest distribution (Figure 2B, stars) and can be found from the Gascoyne (Ashburton & Augustus subregions) to the Little Sandy Desert (Rudall subregion) bioregions and across the Pilbara (Roebourne, Chichester, Fortescue & Hamersley subregions), with narrow-leafleted specimens previously identified as *T.* sp. Meentheena (or *T. bidwillii*) occurring in the east and north-east of the range of *T. densa* (Marble Bar through Nullagine to Telfer; Figure 2B, small stars). Specimens with glabrous upper leaflet surfaces and longer hairs elsewhere have been collected from the western part of the Hamersley Range (Figure 2B, white stars) from sites frequently recorded as being gentle lower slopes, or in drainage lines. Interestingly, specimens with patent indumentum on the upper surface of the leaflet are nearly restricted to the Hamersley subregion, in the central part of the species' range (Figure 2B, diamonds). Also notable is that specimens having patent or pilulose indumentum on the pods, regardless of the indumentum on the leaflets, are again most frequent in the Hamersley subregion and adjacent areas (Figure 2B, white and grey stars and diamonds).

Additional variation across *T. densa* includes: number and density of the leaflets on the leaf rachis; leaflet length and width; prominence of the veins; length of the inflorescence; spacing of the flower fascicles; colour of the indumentum on rachides, calyces and bracts; presence or absence of hairs on the stamens; pod length. The presence of hairs on the stamens was variable in presentation (three specimens had hairs on the staminal tube only, one had hairs on the vexillary filament only, while seven had hairs on both; Table 2) and in most cases was not correlated with a higher density, or length, of hairs elsewhere on the specimen. Detailed study of specimens at PERTH has not identified any patterns of correlation between these characters that supports there being more than one taxon in *T. densa*.

Tephrosia gardneri Pedley ex R.Butcher, *sp. nov.*

Type: 3 km west of North West Coastal Highway on road to New Beach, *c.* 10 m south of road, south of Carnarvon, Western Australia, 7 September 2011, *R. Butcher & R. Davis* RB 1543 (*holo*: PERTH 08293015; *iso*: CANB, K, MEL).

Tephrosia gardneri Pedley ms, Western Australian Herbarium, in *FloraBase*, https://florabase.dpaw.wa.gov.au/ [accessed 21 August 2018].

Tephrosia sp. Carnarvon (J.H. Ross 2681), Western Australian Herbarium, in *FloraBase*, https://florabase.dpaw.wa.gov.au/ [accessed 21 August 2018].

Tephrosia sp. Onslow (K.R. Newbey 10571), Western Australian Herbarium, in *FloraBase*, https://florabase.dpaw.wa.gov.au/ [accessed 21 August 2018].

Tephrosia morrisonii Pedley ms, *in sched.* [at PERTH]

Tephrosia 'ovaria', *in sched.* [at BRI]

Ascending to erect, *subshrub* or *shrub*, single-stemmed just at base then widely branching, short- to long-lived perennial, 0.5–1.75 m tall, to 2 m wide. *Branchlets*, *leaf and inflorescence rachides* with moderately dense to dense (rarely sparse) indumentum of short, straight, ascending to patent, hyaline and white to stramineous to ferruginous or dark brown hairs, 0.05–0.6 mm long. *Leaves* pinnate, 60–230 mm long including petiole; *stipules* persistent or tardily caducous, antrorse becoming patent and reflexed with age, triangular to long-attenuate, 2.7–6.7 mm long, green to tan, 1–5-ribbed; *petiole* 12.0–54.5 mm long; *ultrajugal rachis* (1.5–)4–22.0 mm long; *stipellae* absent; *petiolules* 0.6–4.5 mm long; *leaflets* (3–)5–13, ovate through elliptic (incl. ±rhomboid) to obovate and narrowly obovate, flat in T.S., at least some attached in proximal half of leaf; base cuneate; apex rounded, frequently retuse, usually straight, minutely mucronate with mucro 0–0.8 mm long; *lateral leaflets* 9–49 mm long, 4–34 mm wide, length 1.0–3.1(–4.4) × width; *terminal leaflet* 0.7–1.8 × the length of adjacent laterals, 11.5–53.0 mm long, 5.0–39.5 mm wide, length 1.2–2.9(–3.4) × width; lamina discolorous, very pale to lime green above, light to mid-green below; upper surface sparsely to densely hairy, the hairs appressed to ascending, sometimes patent, straight, hyaline, silvery or white; lower surface moderately to densely hairy, the hairs appressed to ascending, sometimes patent, straight, hyaline, white to silvery, stramineous to brown on veins; secondary veins brochidodromous, but appearing craspedodromous to semireticulodromous in thinner-textured leaflets, in 7–16 pairs, intersecondary veins apparently reticulate, usually obscured by indumentum on lower leaflet surface, but raised on thicker-textured leaflets. *Inflorescence* pseudoracemose, leaf-opposed in a terminal position, 50–300(–400) mm long, fascicles moderately to closely spaced, 3–6-flowered; *inflorescence bracts* triangular to lanceolate, acute to acuminate, 2.0–6.7 mm long, caducous; *floral bracts* attenuate to filiform, 1.5–4.0 mm long, caducous; *bracteoles* absent; *pedicels* 2.0–6.5 mm long. *Calyx* 3.2–8.0 mm long, indumentum dense, the hairs patent to inclined, brown to ferruginous, occasionally white or stramineous; tube 1.5–3.5 mm long, 0.4–0.75 × the length of lateral lobes; lower and lateral lobes attenuate; vexillary lobes united higher than lower three, free for 1–2 mm, upper lip divided to (28–)46–83% length; lowest lobe 2.6–4.8 mm long, ±equal to lateral lobes. *Corolla* orange to orange-red, 7–15 mm long; *standard* (6.3–)7.0–12.5 mm long, (7.1–)9.0–15.2 mm wide, the claw 1.2–2.5 mm long, the blade ovate to sub-orbicular, not or slightly callused at base, apex retuse; *wings* (6.3–)8.5–14.0 mm long, (3.2–)4.1–8.4(–10.3) mm wide, shortly to greatly exceeding keel, the blade usually elliptic to ovate with an obtusely rounded apex; *keel* (5.2–)5.9–9.0 mm long, (2.2–)3.3–5.6(–7.9) mm wide, the blade usually semi-circular, glabrous or with very sparse short hairs along the lower margin. *Staminal* tube hairy near fenestrae with hairs concentrated on marginal callosities towards the base; vexillary filament straight in lower half, patently hairy on callosities near base; anthers 0.4–0.8 mm long, 0.1–0.5 mm wide. *Ovary* densely hairy; ovules (6–)8–12. *Style* flattened, tapering to apex, hairy at base just above ovary to (rarely) nearly 1/3 style length; stigma with short to moderately long hairs at base, linear. *Pods* linear, curved upwards just at apex, 41–52 × 3.5–5(–6) mm, turgid, stramineous to olivaceous at maturity; indumentum dense, patent, white, stramineous, ferruginous or brown; beak in line with the upper suture, straight to upcurved; white tissue present between seeds. *Seeds* (2–)6–12 per pod, (3–)3.5–5.0 mm between centres, transversely obloid, 1.9–3.2 × (1.8–)2.3–5.0 mm, finely to boldly

mottled in orange, brown, pale yellow and green, testa smooth, hilum excentric; rim-aril present, small, annular, white. (Figure 3)

Diagnostic features. *Tephrosia gardneri* can be recognised by the following combination of characters: leaves with (3–)5–13, flat, ovate through elliptic (incl. ±rhomboid) to obovate and narrowly obovate leaflets; calyx usually with patent, dark indumentum; long pseudoracemes of deep orange flowers with caducous inflorescence and floral bracts, prominent, hairy callosities on the staminal tube and vexillary filament, and (6–)8–12 ovules; long, slender, linear, turgid fruits that are upturned just before the apices with the beak in line with the upper suture and straight to upcurved; transversely obloid seeds that are variously mottled in orange, brown, pale yellow and green, and have an excentric hilum with a small, white, annular rim-aril.

Selected specimens examined. WESTERN AUSTRALIA: Northern form - Astron ESSC4-10, 12 km SW of Onslow, 29 Aug. 2009, *J. Alford* JJA 2009/02 (PERTH); Carnarvon, *s. dat.*, *G.B. Barnett s.n.* (PERTH, 2 sheets); North West Coastal Hwy, 18.5 km SSW of Onslow Rd, 11 Sep. 2011, *R. Butcher & R. Davis* RB 1559 (DNA, PERTH); dunes behind Onslow jetty, *c.* 50 m SW along track to 4 Mile Beach from Sunset Beach recreation area (along Simpson St), Onslow, 11 Sep. 2011, *R. Butcher & R. Davis* RB 1562 (BRI, MEL, PERTH); Tent Island Nature Reserve, 29 July 2015, *N. Godfrey* NG 149/15 (PERTH); site: WYW04, 34.2 km N of Mt Murray, 34.7 km WNW of Mt Amy, 39.8 km N of Nanutarra Roadhouse, Cane River Conservation Park, 4 Aug. 2004, *S. van Leeuwen et al.* PBS 0293 (AD, NSW, PERTH); *loc. cit.*, 11 Aug. 2005, *S. van Leeuwen et al.* PBS 0294 (CANB, PERTH); 4 km SW of Onslow, 28 July 1984, *K.R. Newbey* 10571 (BRI, CANB, DNA, PERTH); school Onslow, 6 July 1977, *S.P. Pfeiffer* 34 (PERTH); North West Coastal Hwy, 7.8 km S of the Onslow t/o, 12 July 2012, *K.R. Thiele* 4606 (PERTH); Southern form - 5.9 km W along Uendoo Creek Rd from North West Coastal Hwy, S side of road, S of Carnarvon, 8 Sep. 2011, *R. Butcher & R. Davis* RB 1547 (DNA, PERTH); Mardathuna Stn HS, dune behind old Mrs B's cottage, W of Kennedy Ra., SE of Carnarvon, 8 Sep. 2011, *R. Butcher & R. Davis* RB 1549 (DNA, PERTH); 42.2 km S of Minilya on North West Coastal Hwy, N of Boologooro Stn, E side of road, *c.* 92 km N of Carnarvon, 12 Sep. 2011, *R. Butcher & R. Davis* RB 1566 (BRI, MEL, NSW, PERTH, UWC); sand dunes, Carnarvon, 14 Aug. 1932, *C.A. Gardner* 3015 (PERTH, 2 sheets); Gascoyne Junction, Aug. 1984, *G. Gintzburger* 840814/5 (PERTH); 7.5 km S of Carnarvon on N[orth] W[est] Coastal Hwy, 19 Aug. 1986, *N.S. Lander* 1354 (CANB, MEL, PERTH); S of [Vlaming Head] Lighthouse, S[e]ismic track, 1 km N of area B boundary, Aug. 1978, *G. Perry* 862 (PERTH); Mangrove Point, Carnarvon, 29 Aug. 1982, *J.H. Ross* 2681 (AD, BRI, CANB, MEL, PERTH); Bibawarra Rd 1.9 km S of Blowholes Rd, *c.* 16 km direct line NNE of Carnarvon, 13 July 2012, *K.R. Thiele* 4611 (PERTH); North West Coastal Hwy, 10.3 km S of Carnarvon-Geraldton intersection, 16 July 2005, *J.E. Wajon* 1366 (PERTH).

Phenology. Flowering June to November with fruiting commencing from July; mature fruits with seed observed from August to November.

Distribution. Occurs in the Carnarvon, Gascoyne, Murchison and Pilbara bioregions of Western Australia in the area roughly bounded by Onslow in the north, inland towards Mileura Homestead in the south-east, and north-westward to Hamelin Pool, Shark Bay (Figure 4A). Also found offshore, with one collection from Tent Island, in the Pilbara bioregion.

Habitat. Grows in coastal and near-coastal dune habitats in pink-brown to red-brown sand, often adjacent to saline flats, extending inland to consolidated dunefields and Aeolian sandplains in pastoral country. Commonly occurs in tall, open *Acacia* spp. shrubland with *Crotalaria cunninghamii*, *Grevillea*

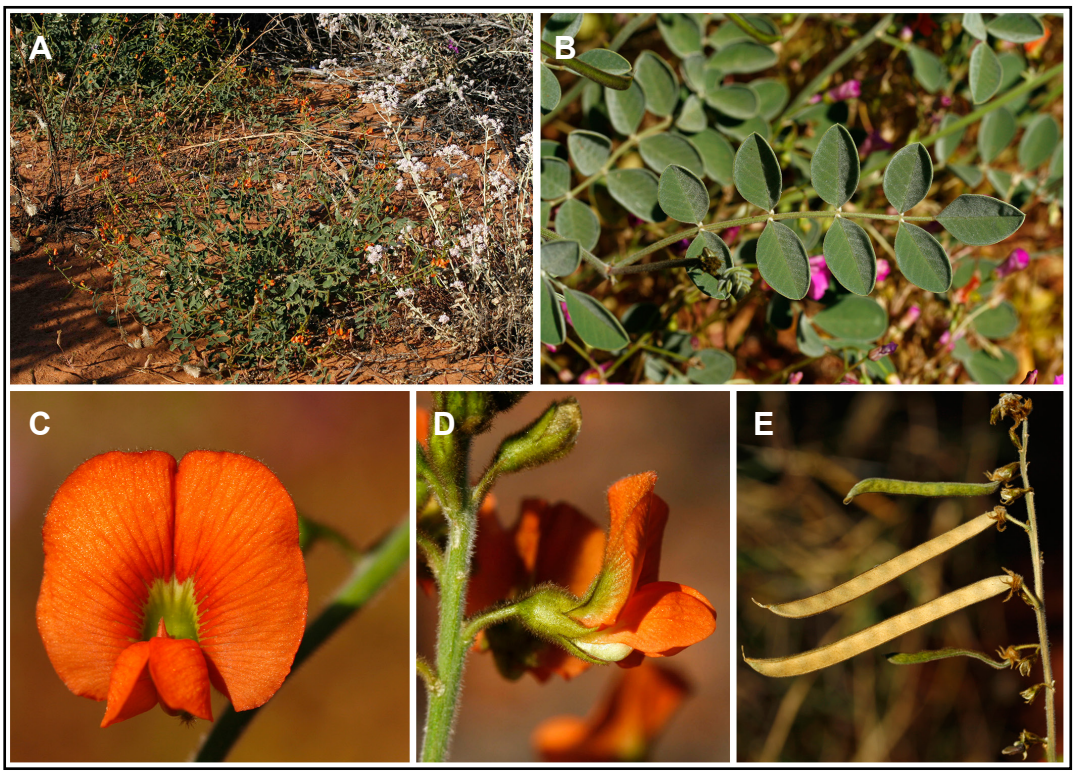

Figure 3. *Tephrosia gardneri*. A – spreading, low shrub habit, in near-coastal sand dune habitat; B – typical leaf, with ovate to elliptic leaflets; C – orange flower from front; D – orange flower from side, showing division and indumentum of the calyx; E – mature pods. Vouchers: *R. Butcher & R. Davis* RB 1544 (A, D); RB 1547 (B, C); RB 1566 (E). Photographer: R. Butcher.

stenobotrya and *Verticordia forrestii* over open *Triodia* spp. hummock grassland, on dunes and plains, with near-coastal vegetation comprising open *Acacia* spp. shrubland with mixed low shrubs and herbs.

Conservation status. This species is widespread and is currently not considered to be under threat; it does not have a conservation listing in Western Australia.

Etymology. The epithet was raised as a manuscript name by Les Pedley to honour botanist Charles Austin Gardner (1896–1970), former Curator of the Western Australian Herbarium (1929–1960), and the earliest collector of this species (in 1932) as indicated by PERTH specimens.

Affinities. In foliage morphology and flower colour, *T. gardneri* is similar to the Kimberley species *T. coriacea* Benth. and *T. flammea* Benth., and it is from the latter that Pedley first segregated mis-identified specimens of this taxon. *Tephrosia coriacea* has similarly shaped leaflets, but is readily distinguished from *T. gardneri* by its slender, erect habit, axillary clusters of flowers, and shortly petiolate, usually unifoliolate (sometimes trifoliolate) leaves, which are often held in a strongly ascending position, as well as its shorter, broader fruits with four to six seeds. *Tephrosia flammea* bears its flowers in elongate pseudoracemes, but is a taller shrub with a silvery to golden hue and has leaves with early caducous stipules and one to nine, larger, ovate to elliptic-oblong leaflets with prominent, reticulating intersecondary venation; both species have linear pods and seeds with an excentric hilum, but those of *T. flammea* have the hilum surrounded by an enlarged aril. Neither *T. coriacea* nor *T. flammea* have the patent, rufous to dark brown indumentum on inflorescence rachides and calyces that is commonly seen in *T. gardneri*.

Table 2. Specimens of *Tephrosia densa* studied that have hairs on the staminal tube or vexillary filament, indicating variable placement of hairs.

Specimen	Staminal tube with hairs on sides	Staminal tube fenestrae with hairs on margins	Vexillary filament patently hairy in front of callosity	Vexillary filament hairy from middle of callosity to 2/3 length
J.S. Beard 2869		+		+
A.C. Beauglehole 11456				+
G. Byrne 128		+		+
E.M. Goble-Garratt 98	+			+
S. Hopper 5037	+	+	+	
B.R. Maslin 4707		+		
A.A. Mitchell PRP 1299	+	+		+
K. Newbey 10670		+		
M.E. Trudgen 16176	+			+
J. Tyler & K. Gillen 291	+			
P.G. Wilson 10562		+		+

Notes. In December 1984, L. Pedley put determinavit slips on a number of PERTH specimens, marking some as *T. gardneri sp. nov.* and a smaller number as *T. morrisonii sp. nov.* In subsequent years all these specimens were amalgamated at PERTH under *T. gardneri* Pedley ms; the name was never published, later becoming *T.* sp. Carnarvon (J.H. Ross 2681) under APC naming protocols. Later study of the specimens bearing Pedley's 1984 determinavits (by the author and Ian Cowie) identified some subtle characters that appeared to distinguish his (*in sched.*) names. The name *T.* sp. Onslow (K.R. Newbey 10571) was then erected on the vascular plant census to account for those specimens matching Pedley's *T. morrisonii*, with the following text: 'Very closely allied to *T. gardneri* Pedley ms but differing in its shorter, denser stem indumentum; shorter, early-deciduous floral bracts; and caducous stipules. May represent a subspecific taxon with further research.' (R. Butcher *in sched.*).

Although two forms are more or less recognisable, detailed study of specimens placed in *T.* sp. Carnarvon and *T.* sp. Onslow, and targeted fieldwork, has since failed to find a consistent suite of characters by which these two putative taxa can be distinguished. There are certainly trends in morphology that are correlated with geographic distribution (e.g. southern collections frequently have longer, less-dense, darker indumentum on stems; smaller, more-numerous, finer-textured leaflets with a higher L:W ratio (1.2–3.1(–4.4)), the secondary venation scarcely raised and the intersecondary venation obscure; green, reflexed stipules; longer inflorescence and floral bracts; higher number (8–12) of ovules. Northern collections commonly have shorter, denser, paler indumentum on stems; larger, fewer, thicker, more-densely hairy leaflets with a lower L:W ratio (1–1.9(–2.3)), the secondary venation raised on both surfaces and often divaricating well-before the margin, and the intersecondary venation indistinctly reticulate; yellow-tan, spreading stipules that often fall; shorter inflorescence and floral bracts; fewer (6–10) ovules) and with habitat (e.g. plants from consolidated dunes tend to be taller, open, woody shrubs, with prominent leaflet venation and smaller flowers, while plants from near-coastal dunes and Aeolian plains are smaller and more lush, with longer inflorescences and larger flowers); however, there are also intermediate specimens (e.g. *J. Alford* JJA 2009/02, *J.S. Beard* 3623, *H. Demarz* 2490,

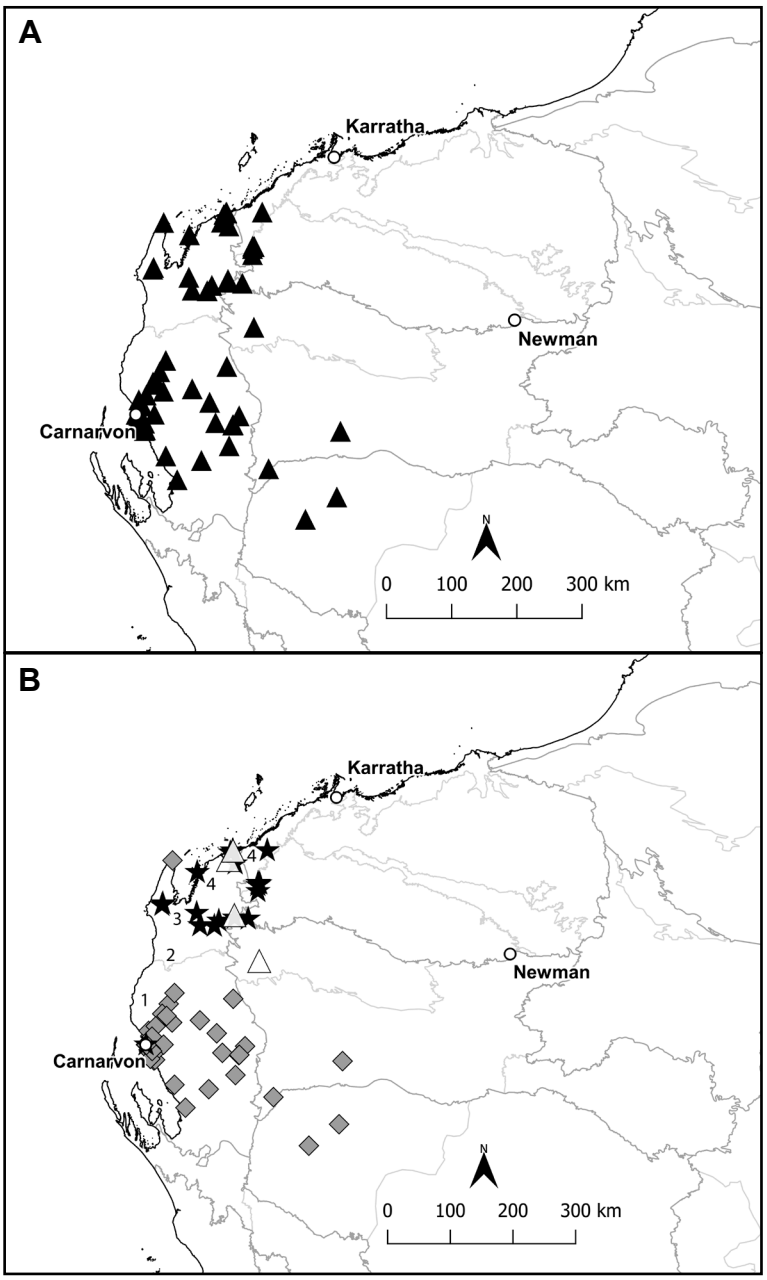

Figure 4. Distribution of *Tephrosia gardneri* in Western Australia, based on PERTH specimen data. A – all records of *T. gardneri* (black triangles); B – all records of *T. gardneri* by their *T.* sp. Carnarvon (grey diamonds) and *T.* sp. Onslow (black stars) morphological groupings, with intermediates also shown (white triangles); areas of unsuitable habitat contributing to disjunctions include Lake MacLeod and fringing samphire flats (1), Giralia Range (2), Rough Range (3), and extensive tidal flats (4). *Interim Biogeographic Regionalisation for Australia* v. 7 (Department of the Environment 2013) bioregions are shown in grey with subregions in light grey.

A. Morrison s.n. PERTH 02925354) that bring together the extremes of form recognised under each phrase name. Some specimens collected from the same or adjacent populations in different years have noticeably different-sized flowers and leaflets, and the influence of good and bad seasons on morphology cannot be ignored. The effect of environmental differences on phenotype has not been rigorously studied and common-garden experiments would be a useful means to investigate patterns of variation further. Until such a time, *T. gardneri* is recognised here as a single species that is variable across its range.

When these two general *T. gardneri* morphotypes are plotted out, their south/north distribution is striking (Figure 4B), as is the disjunction between them. Many of these disjunctions are attributable to large areas of unsuitable habitat, such as tidal flats, salt lakes and ranges of rocky hills, which may be creating barriers to gene flow, accentuating morphological differences. The majority of collections of *T. gardneri* have been made from track-accessible near-coastal habitats around Carnarvon and Onslow, and along Onslow Road and North West Coastal Highway; the absence of collections along the highway between Manberry and Marilla homesteads is curious and may reflect access issues to areas of suitable habitat. It is notable that at least one of the specimens from this intervening area has somewhat intermediate morphology and continued assessment of the morphological distinctness, or otherwise, of the south/north forms would benefit from additional collections from this area.

Two collections are interestingly placed geographically for their morphology: *G. Perry* 862, collected from the tip of North West Cape, has the same morphology as specimens from the Carnarvon area, and the two sheets of *G. Barnett s.n.* from Carnarvon are a good match for specimens from the Onslow area. In both cases there is some evidence that the specimens may not have been collected from the recorded localities. Perry made 76 collections in August–September 1978 from the North West Cape through to Carnarvon from ten different sites; seven of these are on the North West Cape, with two sites accounting for 37 and 25 records, respectively. While the majority of the collections are dated 'August 1978', 12 have dates recorded (23/08, 28/08, 30/08, 31/08 and 01/09) allowing a critical assessment of Perry's collection data over space and time, and showing that there is some minor discrepancy between the collection dates and the number series across the sites. Given that *G. Perry* 862 is a perfect match for specimens collected near Carnarvon, and one of Perry's collecting sites is from 40 km south of Minilya, near the collecting location for *R. Butcher & R. Davis* RB 1566, there is an outside possibility that the specimen was actually collected from there; revisiting the Vlaming Head area would be required to confirm this. Similarly, all of Barnett's collections at PERTH have non-specific locality statements (e.g. 'Kimberley', 'North West Coast', 'Roebourne' etc.), but there is an annotation on the holotype of *Dicrastylis cordifolia*, recorded as being from 'Carnarvon', that reads 'This specimen was probably collected N of Carnarvon, probably much closer to Onslow than Carnarvon' (B.L. Rye, 06/09/2006). Given that the Barnett collection matches material from near Onslow, it is felt that the locality statement is probably incorrect in this case also.

The sheets of *S. van Leeuwen et al.* PBS 0293 and PBS 0294 state on the specimen labels 'Shrub with purple flowers', but this appears to be a transcription error made during mass specimen processing post-survey, with the colour notes identical to, and attributable to, plants of *T. rosea* Benth. collected from the same site at the same times (i.e. *S. van Leeuwen et al.* PBS 0210 & PBS 0211). Indeed, a sterile collection of *T. gardneri* from this site, collected on a different date (*S. van Leeuwen et al.* PBS 0295), has the same flower colour notes. Later collections of *T. rosea* and *T. gardneri* from the same survey quadrat (*S. Dillon & A. Markey* CR 9002 & CR 9003, respectively) correctly note their flower colour as 'pink-mauve' and 'orange'.

Pedley based his manuscript name on *C.A. Gardner* 3015, one sheet of which (PERTH 02924552) has Gardner's illustrations of a flower, and dissected flower. The type of *T. gardneri* has therefore been selected from one of the southern populations of the species, to match Pedley's concept of the manuscript name.

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