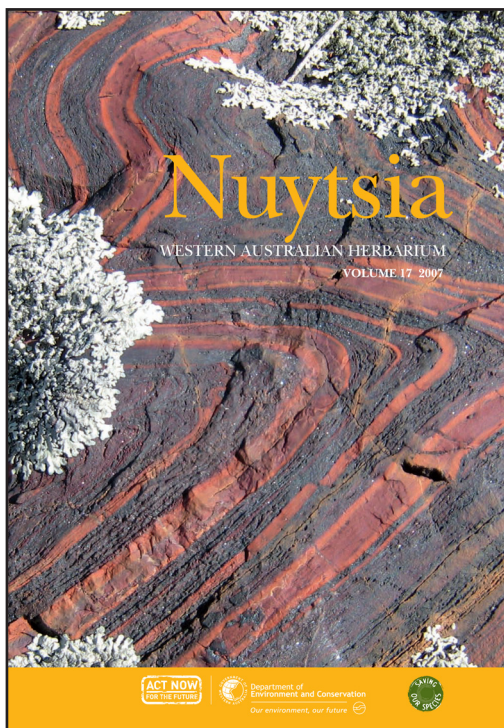


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***Tetratheca erubescens* (Elaeocarpaceae), a new and geographically restricted species from the Coolgardie Biogeographic Region of south-western Australia**

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Abstract

Bull, J.P. *Tetratheca erubescens* (Elaeocarpaceae), a new and geographically restricted species from the Coolgardie Biogeographic Region of south-western Australia. *Nuytsia* 17: 87–96 (2007). *Tetratheca erubescens* J.P.Bull, a rare species endemic to the remote and ironstone-rich Koolyanobbing Range, is described and photographically represented. To facilitate recognition, a table comparing relevant characters of morphologically and ecologically similar species of *Tetratheca* Sm. is provided.

Introduction

The genus *Tetratheca* Sm. (Elaeocarpaceae) comprises 45 species across southern temperate Australia, of which 26 are restricted to Western Australia (Thompson 1976; Keighery 1979; Ross & Walsh 2003; Western Australian Herbarium 1998–; Botanic Gardens Trust 2007; Butcher 2007). Although most Western Australian *Tetratheca* species are confined to the mesic south-western corner of the state, a number have isolated and highly restricted geographic distributions within the semi-arid and arid inland regions. At present, four taxa are known from small, remote banded ironstone ranges within the Coolgardie Biogeographic Region (Thackway & Cresswell 1995) some 350 km east of Perth, with two more in similar habitats 600 km and 1000 km to the north in the Little Sandy Desert and Pilbara Biogeographic Regions respectively (Thompson 1976; Alford 1995; Butcher & Sage 2005; Butcher 2007).

With the exception of the relatively common and sandplain-dwelling *T. efoliata* F.Muell., most species in the Coolgardie Biogeographic Region are restricted to sheer cliff ridges and upper rocky slopes on isolated ironstone ranges (Paczkowska & Chapman 2000). These ‘ironstone endemics’ appear to be biogeographic relics from the late Tertiary period when the climate was more temperate and the genus probably had a more widespread distribution. Despite the apparent similarities in both form and habitat type, recent molecular and morphological studies suggest that they have evolved along separate lineages (Butcher *et al.* 2007). As such, their similar morphologies (e.g. having a characteristic ‘leafless’ habit) and ecological preference for cliffs and steep slopes are most likely the result of adaptive convergence derived from sharing a similar climatic and ecological history (Thompson 1976; Butcher *et al.* 2007).

Due to the inherent rarity of ironstone ranges and the recent and rapid growth of iron ore mining interests in the Goldfields and Midwest regions, all *Tetrateca* species occupying this habitat type are listed as either Declared Rare Flora (DRF) under the Western Australian Wildlife Conservation Act 1950, or Priority One under the Department of Environment and Conservation's (DEC) Conservation Codes for Western Australian Flora (Atkins 2006; Table 1). The species described in this paper is the latest discovery for the area: it occurs on the Koolyanobbing Range, a similarly remote set of small hills within the Coolgardie Biogeographic Region. As with other *Tetrateca* species in the area, *T. erubescens* J.P.Bull is geographically restricted, 'leafless' and ecologically confined to cliffs and steep rocky slopes primarily composed of banded ironstone. Due to its isolation, low population numbers and proximity to mining interests, it is also certified DRF (Atkins 2006) and will most likely attract Vulnerable or Endangered status under national legislation once listed.

History of Discovery. Up until 1988, only two *Tetrateca* species were described for the Coolgardie Biogeographic Region: *T. aphylla* F.Muell. from the Helena and Aurora Ranges and *T. harperi* F.Muell. from the Jackson Range (Thompson 1976). In that year, a new species was discovered by Ms Ray Paynter on a small undisclosed range (now known colloquially as 'Windarling') 30 km north of Mt Jackson. *Tetrateca paynterae* Alford was subsequently named and described, along with *T. chapmanii* Alford from the Carnarvon Range (Alford 1995). Due to the expansion of mining interests in the wider Koolyanobbing region a number of environmental consultancies were commissioned by mining companies to investigate the location of Declared Rare and Priority Flora on, and in the vicinity of, small ironstone ranges (e.g. Mattiske Consulting Pty Ltd 2001; *ecologia* Environmental Consultants 2002a, 2002b). As a result of these searches a new subspecies, *T. paynterae* subsp. *cremnobata* R.Butcher, was discovered along cliff faces in the Die Hardy Range some 50 km north of Mt Jackson (Mattiske Consulting Pty Ltd 2001). On August 26th 2002, *ecologia* Environmental Consultants (on behalf of Portman Iron Ore Ltd) investigated a section of rocky outcrops and cliffs along the Koolyanobbing Range (*ecologia* Environmental Consultants 2002c). Here the author recognised and collected a species of *Tetrateca* not known to science. Subsequent collections of *T. erubescens* were made on June 4th 2003 and Western Botanical Ltd has since performed a number of unpublished surveys to determine the geographical extent and total population size of the new species.

Methods

The description of *Tetrateca erubescens* is based on the examination of fresh material and associated vouchers lodged at the Western Australian Herbarium (PERTH). Seed measurements were obtained from eight seeds obtained from Western Botanical Ltd in 2004. For comparative purposes, the following six specimens of *T. harperi* were also examined: *J.R. Tonkinson s.n.* (PERTH 1034898), *A.P. Brown* 702 (PERTH 07500874), *J.J. Alford* 1229 (PERTH 04610245), *T. Carlino* D3 - TC23 (PERTH 06351506), *Landcare Services* 9275 (PERTH 07270682), *Landcare Services* 9276 (PERTH 07270526).

Taxonomy

Tetrateca erubescens* J.P.Bull, *sp. nov.

Caules graciles, 1.2–1.7 mm lati, teretes, tuberculati; setae erectae, 0.05–0.3 mm longae. Folia sparsa, caduca, 1.6–3.8 mm longa, 0.7–1.1 mm lata, marginibus revolutis. Pedicellus 5.5–12 mm longus, retrorsus, leviter tuberculatus. Lobi calycis (4)5, 1.9–2.2 mm longi, 0.9–1.4 mm lati, ovati,

pubescentes, marginibus crassis. Petala (4)5, 10–12 mm longa, 2.0–4.2 mm lata, obovata ad elliptica, alba in maculis rubris sparsis vel ostrinis ornata. Stamina (8)10, 3.4–3.8 mm longa, rubri–purpurea, tuberculis acutis oblecta; filamentum 0.24–0.32 mm longum; corpus antherarum 2.1–2.6 mm longus; tubus antherarum 1.2–1.4 mm longus. Ovarium glabrum; ovula 4, in quoque loculo 2.

Typus: Koolyanobbing Range, north-east of Southern Cross, Western Australia [precise locality withheld for conservation purposes], 4 June 2003, *J.P. Bull* 8 (*holo*: PERTH 06787797; *iso*: CANB).

Tetradthea sp. (*J. Bull* 1), R. Butcher, *Australian Systematic Botany* 20: 141 (2007).

Low, tangled *shrub*, 0.15–0.5 m in height, 0.1–1.5 m wide, glaucous to greyish-green in overall appearance, decumbent to erect with a woody stock. *Stems* numerous with alternate-divaricate branching, straight to slightly curved, erect, terete, 1.2–1.7 mm wide, 1.4–1.9 mm wide in flowering region (generally 0.15–0.3 mm wider than non-flowering part of stem), apices indeterminate but senescing to form a blunt, brown, slender point; main stems 30–50 cm long, side stems 10–20 cm long, mature growth robust, grey to dull-green, irregularly and faintly longitudinally striate with dense tubercle-based setae; *tubercles* translucent to cream coloured, elliptic and arranged longitudinally along the stems, often protruding from striation ‘ridges’, 0.04–0.08 mm² in area, ± 10–13 per 1 mm² stem surface area, 0.05–0.16 mm raised from stem surface, terminating in broadly acuminate setae; *setae* short, patent, 0.05–0.3 mm long, red to dark red on juvenile stems, dark red to black on mature stems, intact setae uncommon on mature and old stems, probably deciduous with age; juvenile stems slender, green to dull green with scattered leaves. *Leaves* much reduced, alternate, sparse, sessile, early deciduous and often absent on mature stems; leaf scars present, ± erect; blade narrowly ovate, 1.6–3.8 mm long, 0.7–1.1 mm wide, light green to green, both surfaces with scattered translucent hairs, prominent central vein on abaxial surface, margins flat to slightly recurved, often appearing serrate due to scattered marginal hairs, acute apex; seedling and resprouting leaves larger than mature stem leaves, elliptic to ovate. *Flowers* occurring singly in axils of leaf bases, emerging along mid and upper sections of main stems, rarely near stem base; corolla openly splayed to half closed when mature, pendulous. *Bracts* 2–5, clustered, thick, 0.5–1.2 mm long, 0.2–0.4 mm wide, ovate to narrow ovate, ± scattered short clear hairs, ± scattered tubercles, margin entire or minutely serrated due to scattered hairs, reddish brown to translucent with black tips. *Pedicel* retrorse, light green to green, 5.5–12 mm long, 0.3–0.4 mm wide, terete, faintly longitudinally striate, glabrous to sparsely tuberculate with scattered short simple hairs, gently fluted at apex; *receptacle* 1.2–1.5 mm wide, thickened between each calyx segment. *Calyx* segments (4)5, deciduous, ovate, margins entire but sometimes appearing serrate due to scattered marginal hairs, apex acute to acuminate, truncate at receptacle attachment, inserted inside and appearing continuous with receptacle rim, slightly concave, 1.9–2.2 mm long, 0.9–1.4 mm wide, green to glossy green, scattered short clear patent hairs and tubercles on abaxial surface, thickened midvein with prominent parallel veins. *Petals* (4)5, narrowly obovate to elliptic, margins entire, apex obtuse, 10–12 mm long, 2.0–4.2 mm wide with the widest point near the middle to 2/3 length, deciduous, white with pink flecks and speckles, more rarely white, pink or mauve; if white, petals sometimes have a medium pink base with speckled pink bands radiating out through the mid-line and along the petal margins; if mauve, these petal markings are a darker shade of mauve. *Stamens* (8)10, free, 3.4–3.8 mm long; *filaments* continuous with anther body, dark red to reddish brown, 0.24–0.32 mm long, 0.16–0.24 mm wide; *anther body* narrow oblongoid, gently curved on outer edge, somewhat abruptly contracting into anther tube at apex, anther cells prominently separated by longitudinal indentations along body, cream to light brown on white flowers, flecked with pink to purplish-brown on white/pink flowers, red to purplish-brown on mauve flowers, 2.1–2.6 mm long, 0.48–0.56 mm wide, densely covered with minute tubercles; *anther tube* with a prominent though gently curved concave kink, smooth or with few tubercles at base, cream to white with reddish base,

Table 1. Key diagnostic characters for the 'leafless' *Tetralthea* taxa occurring on inland ranges in semi-arid and arid regions of Western Australia. All measurements are in mm.

	<i>T. aplylla</i> F.Muell. subsp. <i>aplylla</i>	<i>T. chapmanii</i> Alford	<i>T. erubescens</i> J.Bull	<i>T. harperi</i> F.Muell.	<i>T. paaynterae</i> subsp. <i>cremnobata</i> R.Butcher	<i>T. paaynterae</i> Alford subsp. <i>paaynterae</i>
Distribution	Helena and Aurora Ranges	Camarvon Range	Koolyanobbing Range	Jackson Range	Die Hardy Range	Windarling Range
Conservation Status (Atkins 2006)	DRF (Vulnerable)	Priority One	DRF (Vulnerable)	DRF (Vulnerable)	DRF (Vulnerable)	DRF (Endangered)
Stem vestiture	dense, slender, acute tubercles, appearing hispid	sparse minute tubercles + resin tipped hairs	dense, broad acuminate tubercles bearing short patent setae	dense, broad tubercles bearing long, stout, patent setae	minute tubercles + occasional glandular hairs	dense minute tubercles
Stem setae length	-	-	0.05–0.3	0.4–1.7 (2)	-	-
Pedicle length	2.0–4.5	2.3–4.4	5.5–12	3.7–6.3	0.8–8	1.5–11
Pedicle vestiture	hispid + scattered very small red glandular hairs	scattered resin-tipped hairs	simple hairs, ± sparse tubercles	glabrous	scattered glandular hairs	dense simple hairs + scattered glandular hairs
Receptacle diameter	0.8–1.8	0.7–1.0	1.2–1.5	1–1.5	1.0–1.7	1.0–1.9
Calyx length	2.1–3.2	1.9–2.3	1.9–2.2	2–2.5	2.2–4.6	2.1–5.5
Corolla colour	dark pink, base paler or yellowish	deep lilac pink	white with pink flecks to entirely mauve	dark pink	deep pink, yellow spot at base	deep pink, yellow spot at base
Stamen length	3.7–5.3	2.7–2.9	3.4–3.8	3.5–4.4	3.1–4.8	2.9–5.1
Anther body length	1.75–2.85	1.7–1.8	2.1–2.6	1.9–2.6	1.4–3.2	1.8–3.4
Anther tube length	0.8–1.8	0.6–0.7	1.2–1.4	1.4–1.9	0.6–1.5	0.7–1.2
Filament length	0.4–0.8	0.3–0.6	0.24–0.32	0.22–0.37	0.4–0.9	0.4–0.7
Filament fusion	free	fused	free	free	fused	fused
Ovary vestiture	dense, short, stiff hairs + scattered glandular hairs	resin-tipped hairs	glabrous or rarely with scattered simple hairs	glabrous	scattered glandular hairs	dense simple hairs + sparsely glandular-pilose
Ovule number	2	4	4	2	4	4
Data source	Thompson (1976); Butcher (2007)	Alford (1995)	Bull, this paper	Thompson (1976); Bull, this paper	Butcher (2007)	Alford (1995); Butcher (2007)

1.2–1.4 mm long, 0.24 mm wide, orifice distinctly 2-lipped, with the inner lip longer than the outer. *Ovary*, orbicular to broadly elliptic, tapered abruptly into the style, flattened in T.S., 1.5–1.9 mm long, 0.9–1.1 mm wide, green, glabrous or rarely with scattered and unevenly spread short clear hairs; *style* erect, gently tapering toward stigma, straight or occasionally gently kinked at apex, glabrous with faint striations, 2.7–2.8 mm long, 0.15–0.20 mm wide; *ovules* 4, 2 per locule, the upper ovule attached to the upper 1/4 of the septum, the lower ovule attached near the middle. *Fruits* not seen. *Seeds* cylindrical, tapering at the base, sometimes into a small, obtuse point, slightly flattened on the adaxial side (where compressed against the septum), gently curved on the abaxial side, 3.8–4.9 mm long, 1.5–2.0 mm wide, pale to medium brown, shiny, moderately to densely pubescent with patent to antrorse clear hairs *c.* 0.2 mm long; *elaiosome* prominent, 1/4–1/5 of total seed length, compact, apparently coiled once, 1–1.2 mm long in coiled state, cream coloured, surface appearing somewhat reticulate due to numerous small pits and small tubercles, sparsely to moderately pubescent with patent clear hairs, \pm terete at point of attachment, becoming ellipsoid in coiled state. (Figures 1, 2)

Other specimens examined. WESTERN AUSTRALIA: [localities withheld] 26 Aug. 2002, *J. Bull s.n.* (PERTH 06589294); 4 June 2003, *J. Bull* 1 (PERTH 06789412); 4 June 2003, *J. Bull* 2 A (PERTH 06789404); 4 June 2003, *J. Bull* 2 B (MEL); 4 June 2003, *J. Bull* 4 A (CANB); 4 June 2003, *J. Bull* 4 B (PERTH 06789463); 4 June 2003, *J. Bull* 7 (AD); 28 Nov. 2003, *Landcare Services* 11832 (PERTH 07313330).

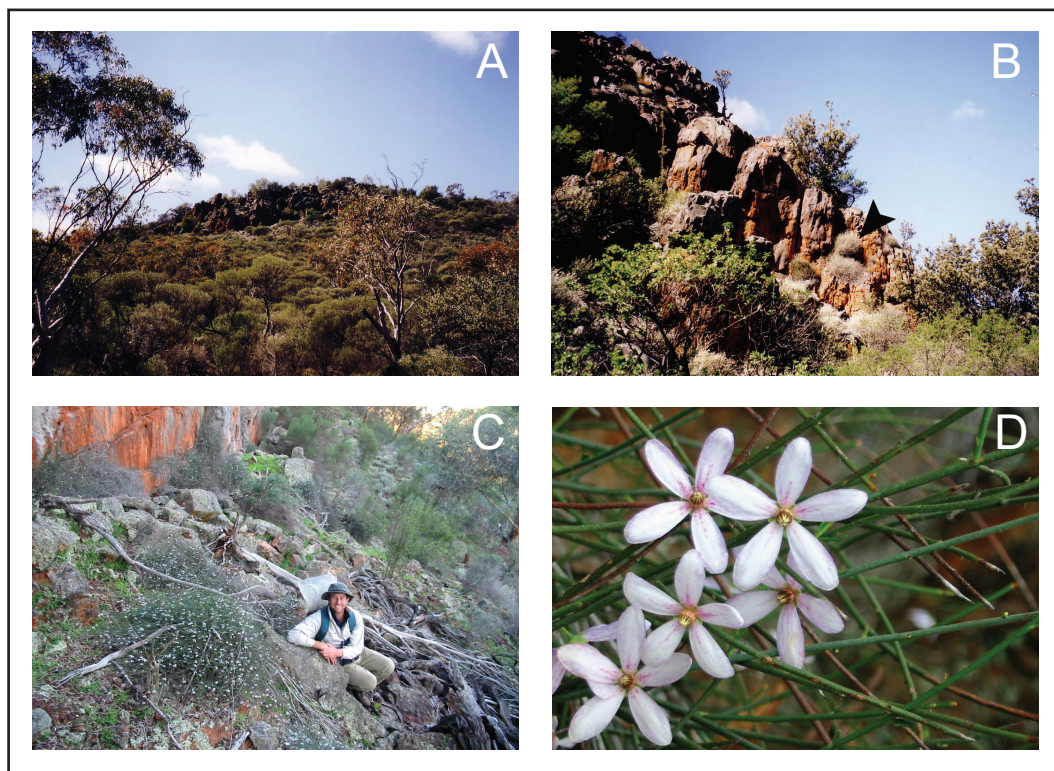


Figure 1. *Tetrateca erubescens*. A – habitat along a rocky cliff line; B – growing out of cliffs composed of banded ironstone (arrow indicates a plant); C – a sprawling individual at base of cliff line, with author pictured to the right; D – predominately white flowers. Photographs: A, B & D by J. Bull, C by Brian Vincent; all taken on 4 June 2003.

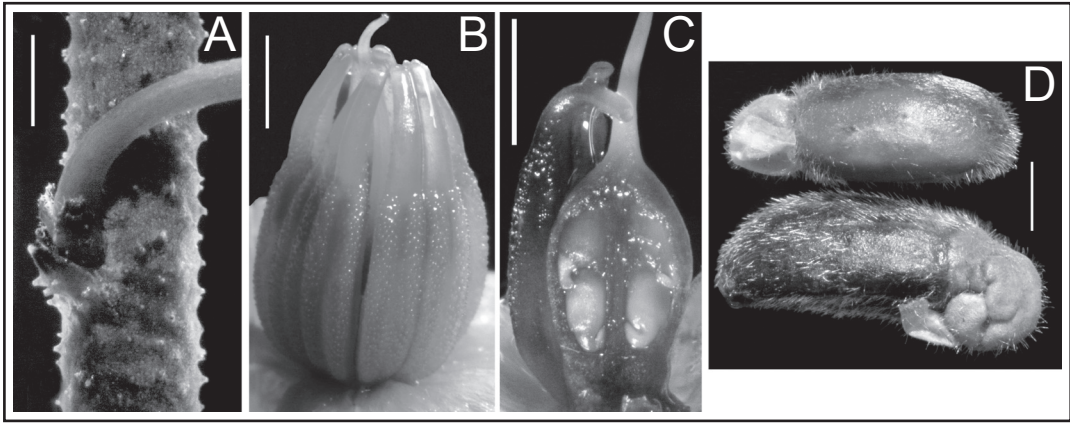


Figure 2. *Tetralthea erubescens*. A – stem of mature plant with bracts subtending the retrorsely curved pedicel. Note the dense cover of tubercles and patent short setae along the stem; B – side view of stamen arrangement around the ovary. Note the tuberculate anther bodies connected to the glabrous and slightly kinked anther tubes; C – dissected ovary showing 4 ovules, 2 in each locule; D – seeds, abaxial (upper) and lateral (lower) views. Note the moderate pubescence of the testa and the coiled elaiosome. Scale = 1 mm. Photographs from material collected on 4 June 2003.

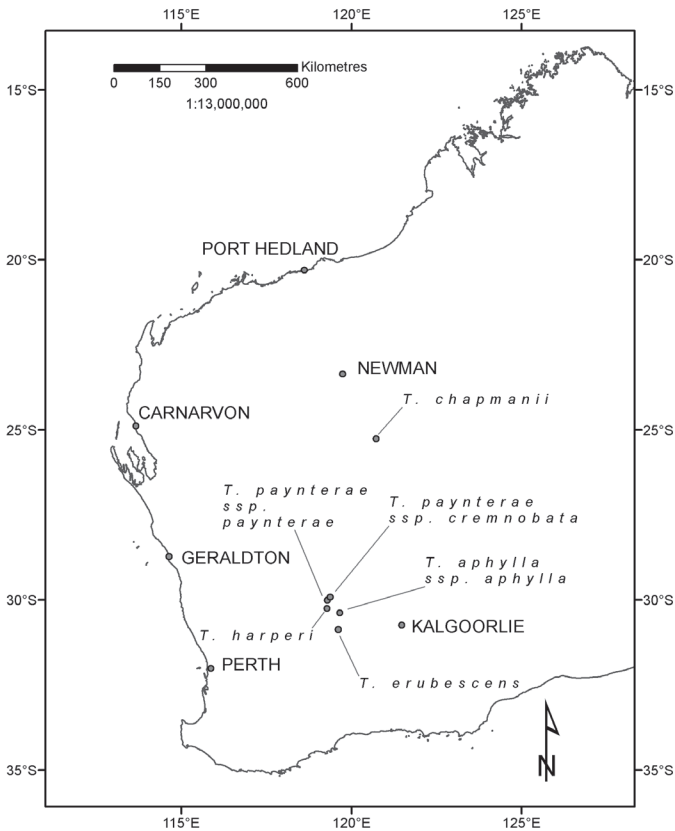


Figure 3. Distribution of 'leafless' *Tetralthea* species endemic to isolated disjunct ranges in semi-arid and arid regions of Western Australia.

Distribution. This species is endemic to the Koolyanobbing Range in the Coolgardie Biogeographic Region of south-western Australia (Figure 3). Portman Iron Ore Ltd currently operates an iron ore mine within the range and owns a number of exploration leases over the remaining parts as well as throughout the surrounding region.

Habitat. *Tetralthea erubescens* inhabits rock crevices containing red sandy loam soils amongst hill crests, steep slopes, cliffs and associated rocky monoliths within certain sections of the Koolyanobbing Range. The main spine of the range is aligned north-west to south-east and is largely composed of a geological unit called the Banded Iron Formation (BIF), a hard resistant rock type that is exposed as cliff lines in the area (Chin & Smith 1983). Unlike other ironstone hills in the region, extensive vertical cliff faces are rare within the Koolyanobbing Range (*ecologia* Environmental Consultants 2002c). Instead, cliff lines are comprised of small vertical faces (i.e. less than 5 m) interrupted by rocky ledges, boulders and short steep slopes (Figures 1A, B). Since its distribution is determined by the location of prominent exposed ridges, *T. erubescens* is confined to the upper reaches of the range and thus reaches altitudes of 445–500 m AMSL.

Associated vegetation consists of scattered low trees or low open woodlands of *Dryandra aborea* over scattered tall shrubs or tall open shrublands of *Allocasuarina acutivalvis*, *Alyxia buxifolia*, *Calycopeplus paucifolius* and *Acacia quadrimarginea*. The shrub layer is generally open to scattered with common species including *Beyeria brevifolia*, *Dodonaea viscosa*, *Exocarpos aphyllus* and *Philotheca brucei* subsp. *brucei* while *Xerolirion divaricata* and *Ptilotus obovatus* subsp. *obovatus* are common low shrubs. *Isotoma petraea* and *Cheilanthes tenuifolia* are scattered herb components.

Phenology. *Tetralthea erubescens* was flowering during both collection times in August 2002 and June 2003. This indicates that it is probably a winter and spring flowering species, which is consistent with other *Tetralthea* species in the region (Western Australian Herbarium 1998–). It is also likely that it flowers opportunistically in response to erratic summer rainfall events, a common trait exhibited by plants adapted to semi-arid and arid conditions in the Ereman Province.

Conservation status. *Tetralthea erubescens* has attracted Declared Rare Flora (DRF) status under the Western Australian Wildlife Conservation Act 1950 due to a number of biogeographical, ecological and social factors:

- It is geographically restricted to a small, isolated ironstone range, which are uncommon landscape features in the Coolgardie Biogeographic Region and the southern half of Western Australia in general.
- It is ecologically restricted to steep cliffs and associated rocky slopes, which are rare habitat types in the region and are generally confined to the upper slopes of prominent ironstone ranges.
- As a result of the above two factors, the total population size is naturally low (approximately 4000–6000 individuals) and its distribution is limited to only a few kilometres (McNee & Cockerton pers. comm.).
- The total geographic distribution of the species is currently covered by a mining exploration lease, and may therefore be impacted by future mining activities.
- None of the known populations are currently represented within a conservation reserve.
- Due to its habitat specificity, it is unlikely to survive elsewhere in the wild since similar habitats are nonexistent or are occupied by other species of *Tetralthea*.

Etymology. The specific epithet *erubescens* (derived from the Latin *erubesco*) means ‘blushing’ or ‘becoming red’. The presence of pink flecks and speckles upon the predominantly white, nodding flowers, give them the appearance of blushing.

Spotting features. The following combination of morphological features distinguish *T. erubescens* from other 'leafless' taxa within the genus: the predominantly white flower colour, the profusion of broad, translucent to cream coloured tubercles (10–13 per 1 mm²) and short (0.05–0.3 mm long) setae on the stems, a glabrous ovary (rarely with scattered and unevenly distributed hairs), two ovules per locule and free stamens.

Affinities. *Tetralthea erubescens* appears most similar to *T. harperi*, a species endemic to the Mt Jackson area 70 km to the north. Both species have glaucous stems with stout patent setae arising from broad cream-coloured tubercles, free stamens, comparable stamen attributes (dimensions, colour and vestiture), a glabrous ovary, slender and largely glabrous pedicels and a similar receptacle morphology (1–1.5 mm wide with calyces attached inside the rim). Although the flowers are predominantly white in *T. erubescens* and dark pink in *T. harperi*, both species possess distinctive darker markings that radiate out from the base of the petals along the major veins. In addition to flower colour, *T. harperi* differs from *T. erubescens* in having fewer (1–3 per 1 mm²) and broader tubercles along the stems, more prominent (0.4–2 mm long) stem setae (see Butcher 2007: Figure 1C), shorter pedicels (3.7–6.3 mm long) and only 1 ovule per locule.

Table 1 shows the distinguishing morphological characteristics of 'leafless' *Tetralthea* species endemic to ironstone ranges of inland Western Australia. A taxonomic key for 'leafless' *Tetralthea* species in Western Australia is given in Butcher (2007), with *T. erubescens* represented by the informal name *Tetralthea* sp. (J. Bull 1).

Notes. The predominantly white colour of the petals of *Tetralthea erubescens* (Figure 1D) appears to be unique in the genus, as most species display pink, deep pink or purple flowers (Thompson 1976; Alford 1995; Paczkowska & Chapman 2000). White colour variants have been observed in both Western and eastern Australian species (i.e. *T. ciliata* Lindl., *T. confertifolia* Steetz, *T. efoliata*, *T. halmaturina* J.M.Black, *T. nuda* Lindl., *T. pilosa* Labill., *T. pubescens* Turcz. and *T. thymifolia* Sm.), but it has never been recorded as a dominant trait (Thompson 1976; Botanic Gardens Trust 2007). In the Coolgardie Biogeographic Region, only *T. efoliata* exhibits a white flower variant (Paczowska & Chapman 2000) and, on current knowledge, none of the other cliff dependant taxa in Western Australia display white or partly white flowers (Western Australian Herbarium 1998–). *Tetralthea erubescens* exhibits a remarkable array of flower colour within its known populations and this also appears unique for the genus. Both white and mauve flowered plants were observed during June and August, as well as a range of plants with flowers of intermediate coloration. White flowers are more common and the petals are generally pink speckled, with the degree of speckling varying between different individuals. The adaptive significance of variable flower colour within this taxon remains an intriguing avenue for further research.

The reproductive biology of the species is unknown, however, flower morphology and presentation indicate that species of *Tetralthea* are likely to be 'buzz' pollinated by small native bees (e.g. Hingston 1999, Gross *et al.* 2003). Seed dispersal is likely to be myrmecochorous due to the presence of a large elaiosome on the seed (see Berg 1975). Furthermore, the observation of many individual plants growing out of narrow rock crevices on vertical cliff faces supports the hypothesis of seed dispersal by a small biotic vector (see Jasper & Braimbridge 2002).

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