

***Triodia pisoliticola* (Poaceae), a new species from the Pilbara region,
Western Australia, and a description for *T.* sp. Mt Ella (M.E. Trudgen
MET 12739)**

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Abstract

Barrett, M.D. & Trudgen, M.E. *Triodia pisoliticola*, a new species from the Pilbara region, Western Australia, and description for *T.* sp. Mt Ella (M.E. Trudgen 12739). *Nuytsia* 29: 271–281 (2018). The genus *Triodia* R.Br. is currently undergoing taxonomic revision in the light of intensive botanical survey in remote Australia and molecular phylogenetic data. Several *Triodia* species have been known by phrase names in Western Australia for about 20 years. This paper deals with two of these names, *Triodia* sp. Mt Ella (M.E. Trudgen 12739) and *T.* sp. Robe River (M.E. Trudgen et al. MET 12367), that were first recognised as distinct taxa by one of us. Both species are ‘soft’ spinifexes with awned lemmas, and are known only from the Pilbara region in Western Australia. *Triodia* sp. Robe River is formally described as *T. pisoliticola* Trudgen & M.D.Barrett. This species is restricted to the western part of the Pilbara bioregion and has flowers morphologically similar to *T. melvillei* (C.E.Hubb.) Lazarides. *Triodia* sp. Mt Ella has floral parts morphologically similar to *T. bitextura* Lazarides; a full description of this entity is given, but it is not formally named pending further revision of the *T. bitextura* complex across northern Australia. Both taxa are currently given a conservation ranking of Priority Three. Both taxa are illustrated, and diagnostic character combinations are given to allow discrimination from all other Pilbara *Triodia* species.

Introduction

Triodia R.Br. (Poaceae) hummock grasses are restricted to mainland Australia, where they are characteristic components of many arid and semi-arid communities. As at late 2017 the genus *Triodia* consisted of 81 described and accepted species (Lazarides 1997; Barrett *et al.* 2005; Armstrong 2008; Barrett & Barrett 2011; Hurry *et al.* 2012; Barrett & Barrett 2015; Crisp *et al.* 2015; Anderson *et al.* 2017a). The genus is being revised by one of us (MB) in the light of material collected during botanical surveys in remote parts of Australia, and molecular phylogenetic data dissecting species complexes (e.g. Anderson *et al.* 2016, 2017a, 2017b for the *T. basedowii* E.Pritz. complex). Several *Triodia* species have been known by phrase names in Western Australia for some years. This paper discusses two of these names, *Triodia* sp. Mt Ella (M.E. Trudgen 12739) and *T.* sp. Robe River (M.E. Trudgen et al. MET 12367), that were first recognised as distinct taxa by one of us (MET) in the 1990s.

Both species are known only from the Pilbara administrative region in Western Australia (which includes the Pilbara bioregion), and currently have a Western Australian conservation ranking of Priority Three. Diagnostic character combinations are given for both species, but a revised key to *Triodia* is postponed pending description of additional species.

Triodia pisoliticola Trudgen & M.D.Barrett is described as a new species restricted to the far western Hamersley sub-bioregion of the Pilbara bioregion and has flower morphology similar to *T. melvillei* (C.E.Hubb.) Lazarides, but much longer, lax and non-resinous leaves, which give it a distinctly different appearance in the field. It also differs in habitat, growing on the edges and tops of mesas, rather than on alluvial plains as is typical of Pilbara *T. melvillei* (although populations outside the Pilbara are typically restricted to rocky sites).

Triodia sp. Mt Ella (M.E. Trudgen 12739) is mainly restricted to open gullies and slopes in the eastern Hamersley Range, with a disjunct occurrence near the Rudall River, but is morphologically ill-defined against the widespread *T. bitextura* Lazarides *sens. lat.* The latter species occurs from the Kimberley to Queensland, and is morphologically and genetically complex; the diversity and existence of co-occurring discrete forms suggests that multiple taxa exist within *T. bitextura*, but a detailed genetic and morphological study is required for precise definition of these taxa, and to determine whether *T. sp. Mt Ella* may be conspecific with one of the Kimberley or Northern Territory forms. Despite the variation further north, *T. sp. Mt Ella* in the Pilbara is morphologically (and genetically) uniform and geographically discrete, and we have no doubt that it represents a single taxon, although that taxon may ultimately include additional variation from other regions. Consequently, we do not formally name *T. sp. Mt Ella* here, but provide a detailed description of the disjunct Pilbara entity to aid discrimination from other species locally, and as a contribution to the resolution of the *T. bitextura* complex. In the field, *T. sp. Mt. Ella* can be easily separated from co-occurring species by its spreading form, extremely resinous surfaces and very strong smell of resin.

The two taxa discussed in this paper were originally recognised as distinct from then-accepted Pilbara *Triodia* taxa on form, habitat preference and abundance of resin on the leaves. These differences were found to be supported by differences in spikelet morphology when specimens were examined microscopically and compared to other taxa.

Methods and terminology

Descriptions and terminology are based on Lazarides (1997) and Barrett and Barrett (2015).

Leaf anatomy in section was examined by placing a leaf blade in boiling water with a drop of detergent, and manually sectioning with a razor blade. Sections were made primarily to confirm the distribution and number of stomatal grooves on the abaxial and adaxial surfaces, to distinguish epistomatous from amphistomatous anatomy (Toon *et al.* 2015; *cf.* amphistomatous). The term epistomatous is accepted for the soft-type leaf anatomy in which stomatal grooves are lacking on the lateral faces of the abaxial leaf blade, and corresponding increase in lateral colourless mesophyll tissue in section to fill the space. The term epistomatous is synonymous with the term ‘soft-type leaf anatomy’ that is sometimes used in literature on *Triodia*. The term epistomatous is slightly misleading, since stomatal *grooves* are still present on the lower surface (in a median band), and so there is only a tendency toward a truly epistomatous condition. Although Toon *et al.* (2015) claim that stomata are not present in the few grooves on the abaxial surface in ‘soft’ *Triodia* species, transections of the leaf blades of most such species show chlorenchyma and ‘photosynthetic carbon reduction’ (PCR) cells extending all the way

to the lower epidermis at least either side of the central vascular bundle (see supplementary images in Toon *et al.* 2015), which indicates that photosynthesis still occurs there, and by extension stomata must occur in the proximity for efficient gas exchange. The presence of stomata within these grooves is very difficult to observe, in both ‘hard’ and ‘soft’ species alike; stomata have been confirmed for very few species. Consequently the term ‘stomatal groove’ is used here to indicate an abrupt longitudinal fold in the epidermis, homologous in position with the grooves that typically contain stomata, but not necessarily implying that stomata are always present or abundant in the groove.

Glume widths are difficult to measure, the glumes having a curved or folded structure in most species, and even when boiled cannot always be flattened without breaking. To avoid this, widths are measured from the margin to the midrib on both sides and added to give a total width.

The conclusions made here are based on morphological data, but some notes are made on relationships inferred from phylogenetic analyses of sequence alignments from ITS and ETS (Internal Transcribed Spacer and External Transcribed Spacer respectively of the nuclear ribosomal DNA region). Full results of these analyses will be presented elsewhere.

Taxonomy

Triodia pisolitica Trudgen & M.D.Barrett, *sp. nov.*

Type: near Pannawonica, Western Australia [precise locality withheld for conservation reasons], 19 March 2017, *S. Reiffer s.n.* (*holo:* PERTH 08776296; *iso:* BRI, CANB, DNA, K, MEL).

Triodia sp. Robe River (M.E. Trudgen et al. MET 12367), Western Australian Herbarium, in *FloraBase*, <https://florabase.dpaw.wa.gov.au/> [accessed 19 December 2016].

Tussock-forming *perennial*, not resinous, not obviously stoloniferous; *tussocks* compact with lax to sprawling leaves, (10)40–90 cm high, 50–200 cm wide; flowering culms 60–100 cm high. *Culm internodes* all short (never elongated as in *T. claytonii* Lazarides), 0.2–4.2 cm long, and obscured by subtending foliage, red-brown, glabrous or sparsely and patchily appressed-hairy, fastigiated branching absent; aerial roots absent. *Leaf sheaths* 80–155 mm long, 3.5–4.0 mm wide near apex, broader and often papery at base, glabrous or with thin hairs 2–5 mm long on surface, not resinous, straw-coloured, moderately to strongly *c.* 14–16-nerved in central part, becoming chartaceous to almost membranous toward the margins; margins glabrous to densely pilose (often glabrous on one margin, pilose on the other); margins of *orifice* oblique to truncate but not auriculate, with a sparse to dense fringe of straight, becoming woolly-tangled, hairs, the longest hairs 0.6–7.0 mm long. *Ligule* a dense fringe of hairs *c.* 0.5–1.0 mm long; pseudopetiole not distinct. *Leaf blades* flattened-V-shaped when fresh, conduplicate and tightly in-rolled when dry, initially straight but sometimes becoming curled in older and dead leaves, 24–59 cm long, 0.6–1.0 mm wide when rolled (unrolled leaves not seen), when fresh relatively soft and lax, flexible, weakly pungent, glabrous abaxially, adaxial surface densely papillose and sometimes densely woolly-hairy at base, non-resinous, pale to mid-green, drying pale green, stomatal grooves on abaxial surface confined to central part, 4 (2 either side of midline), closely spaced either side of the midline, grooves absent on marginal *c.* 1/3 but finely obscurely ribbed, stomatal grooves on adaxial surface 7 each side of midrib; margins obscurely and minutely scaberulous with prickle hairs *c.* 0.04 mm long. *Panicle* 8.0–23.5 cm long, 0.8–4.5 cm wide, with 26–178 spikelets in total, lanceolate, with branches racemose or more usually ternate on longest branches at least near the base, moderately dense to loose; primary axis angular to ribbed, glabrous or with minute tufts of hairs

0.1–0.4 mm long in branch axils, weakly scaberulous, non-resinous; longest basal panicle branches (1.7–)3.8–8.5 cm long, terete to angular or weakly flattened, with 3–13 loosely arranged, ±uniform-sized spikelets, which are 3.6–12.2 mm apart (measured from base of pedicels) with adjacent glumes partly overlapping; *longest basal pedicels* (lateral on longest lower panicle branches, excluding the terminal pedicels on secondary and ternate branches) 0.9–3.5 mm long, 0.15–0.25 mm wide, becoming slightly thicker just below spikelet, angular to flattened, minutely scabrous; distal lateral pedicels on branch (i.e. excluding terminal one) only slightly shorter than proximal ones; terminal pedicels (including on ternate branches) 4.5–8.0 mm long. *Spikelet* 7.5–21 mm long, 0.8–2.8 mm wide (excluding awns), loosely 5–12-flowered with 4–11 fertile florets and apparently 0–2 sterile florets at apex (but these possibly merely immature), linear, subterete or compressed; lowest rachilla internode 1.0–1.7 mm long, *c.* 0.15–0.25 mm diam., minutely scabrous; spikelets disarticulating above glumes and at rachilla internodes at maturity. *Lower glume* 6.2–8.8 mm long, 0.9–1.6 mm wide, narrowly lanceolate, L:W 5.0–7.2, sharply acute to acuminate, shorter than the combined spikelet florets (excluding awns), chartaceous, scarious, lacking differentiated membranous margins, with minute scabrosities less than 0.05 mm long over whole surface, 3–5-nerved, the midnerve scarcely raised, lateral nerves scarcely raised, margins glabrous. *Upper glume* inserted *c.* 0.3–0.5 mm above lower glume, 6.5–8.5 mm long, 3–5-nerved, similar to and subequal to lower glume, shorter than the combined florets. *Lowest lemma* 8.0–13.0 mm long including awns, lanceolate, not bitextured, uniformly stiffly chartaceous to weakly indurated except for narrow membranous margin, deeply 3-lobed, 3-awned; body 3.7–5 mm long including callus, *c.* 1–1.2 mm wide, basal 1/4–2/3 with dense, appressed to ascending hairs 0.15–0.6 mm long in 1–5 rows either side of the midnerve and also along submargins or frequently almost glabrous except for 2 rows of dense hairs either side of midnerve, nerves 9, the upper part with 3 groups of 3 obscure nerves radiating into lobes; midlobe 4.2–9.0 mm long including awn, triangular at base abruptly narrowing into awn, slightly to distinctly narrower to slightly broader than lateral lobes; lateral lobes 2.8–5.7 mm long including awn, narrowly triangular at base soon narrowing into an awn, margins with a very narrow membranous wing; *callus* 0.4–0.6 mm long, straight to slightly curved, attached obliquely, acute to abruptly blunt in face view, acute in profile, white-bearded on lateral margins leaving narrow to broad glabrous midline, the longest hairs 0.15–0.7 mm long. *Upper lemmas* similar to but smaller than lowest lemma. *Palea* of basal lemma distinctly longer than lemma body, 4.2–6.0 mm long, 0.7–1.0 mm wide, lanceolate, 2-keeled, not bitextured, membranous to chartaceous, glabrous but with dense tiny tubercles (the bases of tiny trichomes) in the lower half, apex acute; keels raised and not winged or with a narrow wing up to *c.* 0.1 mm wide, keel margin scabrous in basal 1/4–2/3, becoming shortly ciliate with cilia *c.* 0.1–0.2 mm long near apex; flaps 0.1–0.4 mm wide, broadest in central part, narrower than 1/2 width of the palea body and not overlapping, entire. *Lodicules* 2, 0.3–0.8 mm long, apex truncate, undulate, glabrous. *Anthers* 3, 2.5–2.9 mm long, exerted at maturity. *Styles* 2, 1.3–1.6 mm long. *Caryopsis* 1.8–2.0 mm long, *c.* 0.5 mm wide. (Figure 1)

Diagnostic features. Foliage non-resinous. Leaf blades epistomatous (soft-type), 24–59 cm long. Spikelets 5–12-flowered, with 4–11 fertile florets and 0–2 sterile florets. Glumes narrowly lanceolate, 3–5-nerved. Lemmas deeply 3-lobed and 3-awned, body uniformly textured, with appressed hairs arranged in many longitudinal lines (or sometimes glabrous in the central zone). Palea minutely tuberculate in lower half, glabrous, not winged.

Selected specimens examined. WESTERNAUSTRALIA: [localities withheld for conservation reasons] 10 Feb. 2015, *M.D. Barrett & B.M. Anderson* MDB 4546 (PERTH); 8 Aug. 2008, *A. Douglas & R. Graham* LCH 24930 (PERTH); 12 Feb. 2008, *R. Graham* LCH 24929 (PERTH); 14 Aug. 2010, *N. Krawczyk* NK/03 (PERTH); 15 Aug. 2015, *S. van Leeuwen et al.* PBS 0406 (PERTH); 14 Aug. 2005, *S. van Leeuwen et al.* PBS 0406 (PERTH); 31 Aug. 2006, *S. van Leeuwen* PBS 3623 (PERTH); 25 Mar. 2010, *B. Mathews* BM 50 (PERTH); 1 Sep. 2010, *B. Mathews* BM 53 (PERTH); 16 June

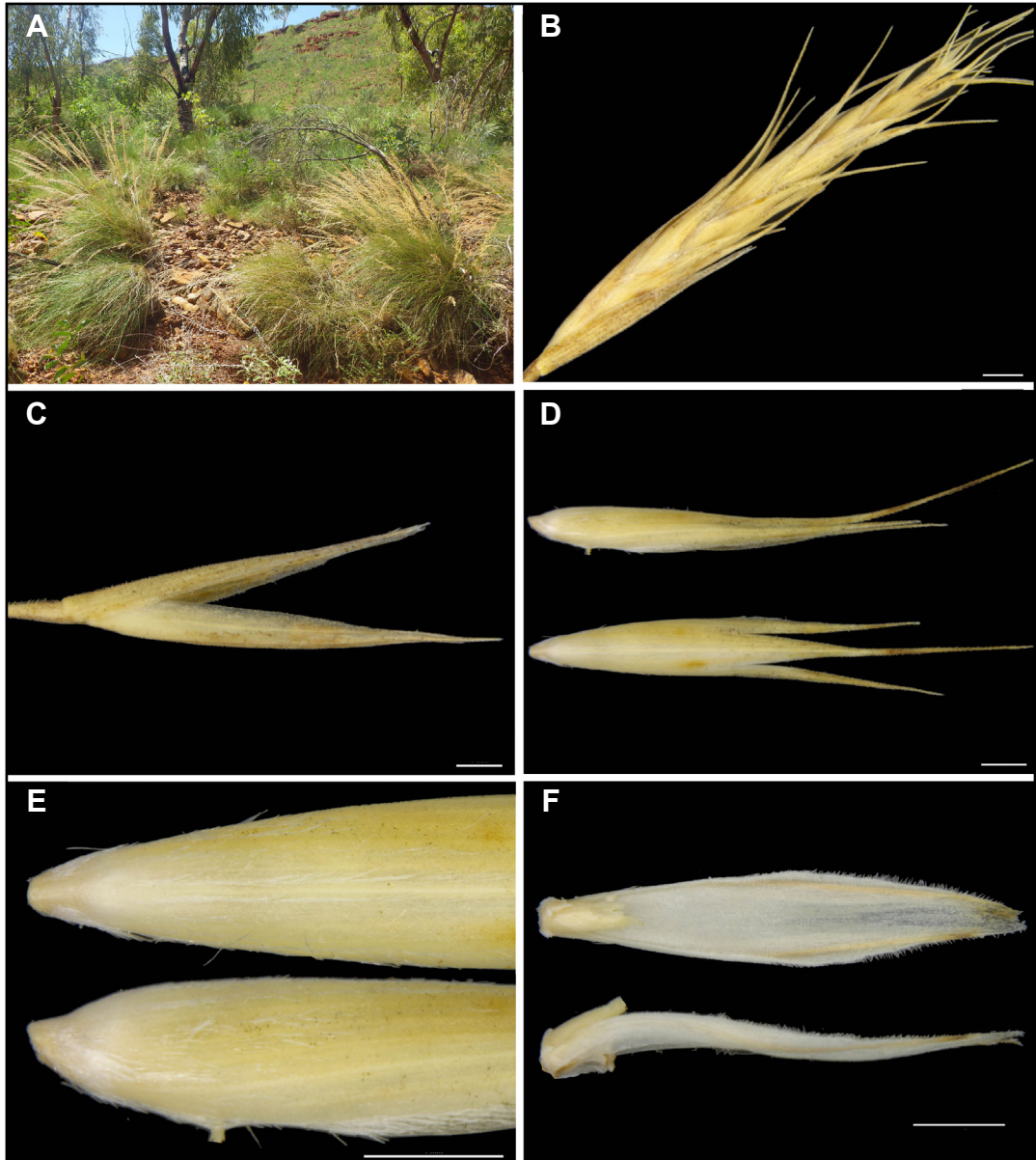


Figure 1. *Triodia pisoliticola*. A – flowering plant *in situ* showing long, lax leaf blades; B – spikelet, showing the awned lemmas and the glumes shorter than combined florets; C – glumes, showing chartaceous texture; D – lemmas of basal floret in side and face view showing relative proportions of body and lobes; E – base of lemmas of basal floret in side and face view, showing hairs in longitudinal rows becoming glabrous in some areas, and callus shape; F – paleas in side and face view showing lack of hairs and minute tubercles in basal half, and very shortly winged lemma keels. Scale bars = 1 mm. Images from S. Reiffer *s.n.* (9/3/2017). Photographs by S. Reiffer (A) and M. Barrett (B–F).

2011, B. Mathews BM 71 (PERTH); 14 Mar. 2011, B. Mathews BM 83 (PERTH); 31 Mar. 1994, A.A. Mitchell PRP 200 (PERTH); 11 July 1991, M.E. Trudgen & S.M. Maley MET 10114 (PERTH); 2 May 1995, M.E. Trudgen, M. Trudgen & S. Deluca MET 12367 (PERTH); 23 Aug. 2009, M.S. Trudgen MST 366 (PERTH); 18 Feb. 2008, D. True LCH 24931 (PERTH); 15 June 2007, D. True, S. Kern & K. McMaster LCH 14701 (PERTH).

Phenology. Fertile collections have been made between February and August, but seed has dropped from almost all plants by late March in most years.

Distribution and habitat. All known locations of *T. pisoliticola* are in the western part of the Pilbara bioregion, with a range of about 200 km. The main areas of occurrence are in the Robe River Valley and the headwaters of the Cane River, with smaller occurrences to the north of the Robe River and east of the Cane River, and in the western Hamersley Range. Most of the known locations are either on the edges of mesas capped with Robe Pisolite or on the tops of the mesas of that geology. In the Robe River Valley *T. pisoliticola* is usually on the edges of the mesas, while the Cane River occurrences are partly on the edges of the mesas and partly on the flat tops of the mesas. A few of the eastern occurrences are on other iron-rich geology.

Conservation status. *Triodia pisoliticola* is listed by Smith and Jones (2018) as Priority Three under Conservation Codes for Western Australian Flora, under the name *T. sp.* Robe River (M.E. Trudgen et al. MET 12367). It is known from nearly 50 collections in herbaria, with heavy representation from the area south of Pannawonica, but sterile material from more locations has been seen by one of us (MET) who has also seen more locations in the Robe River Valley. At many locations it is dominant in the ground layer of the vegetation, but occurrences vary in size from quite small to fairly large. There are no known records of this taxon in the conservation estate and all occur within live mining and exploration tenements in the Pilbara. *Triodia sp.* Robe River assemblages of mesas of the West Pilbara are also listed as a Priority Ecological Community (PEC). The western part of the distribution extends for about 120 km from north to south, the area of occurrence then extends very patchily from the southern end to the east.

Etymology. The epithet is from pisolite, a geological term for a conglomerate of pea-sized pieces such as gravel (in turn derived from Latin *pisum*, pea), and Latin *-cola*, dweller.

Notes. Using the subgeneric groups of Lazarides *et al.* (2005), *T. pisoliticola* belongs to the ‘Schinzii group’, closest morphologically to *T. melvillei*; both share awned lemma lobes and hairs arranged in lines on the lemma body. *Triodia pisoliticola* was treated under *T. melvillei* by Lazarides (1997) and Lazarides *et al.* (2005). The two species are easily distinguished, since *T. pisoliticola* is non-resinous and the leaf blades are slender, long and lax, while *T. melvillei* is copiously resinous on the foliage and the leaves are stiffer and usually shorter [15–35(–46) mm long in *T. melvillei*; 24–59 cm long in *T. pisoliticola*]. *Triodia melvillei* differs further from *T. pisoliticola* by having three or four reduced infertile florets at the apex of spikelets (only 0–2 reduced infertile florets terminating spikelets in *T. pisoliticola*). Nuclear ribosomal and chloroplast genes (data not shown) suggest that *T. melvillei* and *T. pisoliticola* are not sister taxa, despite their floral similarities.

The closest phylogenetic relative to *T. pisoliticola* appears to be *T. sp.* Karijini (S. van Leeuwen 4111), a plant of high mountains (>900 m) in the eastern Hamersley Range. *Triodia sp.* Karijini is similar to *T. pisoliticola*, but forms smaller, denser tussocks, has lobed lemmas with midlobe 2–3 mm long, (prominently awned and 4.2–9.0 mm long in *T. pisoliticola*), resinous to non-resinous foliage (always non-resinous in *T. pisoliticola*), and leaf blades generally shorter (19.0–33.5 mm long, compared to 25–59 mm long in *T. pisoliticola*).

Other than *T. melvillei* discussed above, four species with epistomatous (soft-type) leaf anatomy with long-awned but not bitextured lemmas have been described: *T. bunglensis* (S.W.L.Jacobs) Lazarides, *T. bynoei* (C.E.Hubb.) Lazarides (*sens. lat.*), *T. salina* Lazarides and *T. prona* Lazarides. All four occur

in the Kimberley or central deserts or the Top End region of the Northern Territory, disjunct from *T. pisolitica* in the western Pilbara. The first three species differ in having copiously resinous foliage (non-resinous in *T. pisolitica*) and hairs scattered over the lower lemma body (arranged in 2–many longitudinal rows in *T. pisolitica*). *Triodia bunglensis* differs further in having very compact, dense inflorescences (loose in *T. pisolitica*). *Triodia bynoei* (*sens. lat.*) differs further in frequently having reduced awns on the lateral lobes on the lowest lemma. *Triodia salina* differs further in having a distinctly stoloniferous habit (tightly clumping, with stolons not exceeding the parent tussock in *T. pisolitica*). *Triodia prona* is an enigmatic taxon that has not been relocated since the type collection in 1963 (Gibson 2016), and is unique in its decumbent inflorescence.

Triodia triaristata Lazarides was also considered part of the awned ‘Schinzii group’ by Lazarides *et al.* (2005), but has acuminate to short-awned lemma lobes, with the awns 1–3 mm long when present (4.2–9 mm long in *T. pisolitica*).

The vernacular name Mesa Spinifex is suggested.

Triodia sp. **Mt Ella (M.E. Trudgen 12739)**, Western Australian Herbarium, in *FloraBase*, <https://florabase.dpaw.wa.gov.au/> [accessed 15 May 2017].

Hummock-forming *perennial*, very resinous, sometimes conspicuously stoloniferous (e.g. *M.E. Trudgen & M. Trudgen* MET 12774); hummocks loose, 30–60 cm high, 40–80 cm wide; flowering culms 70–100 cm high. *Culm internodes* short to long, 0.3–15.3 cm long, some exerted from subtending foliage, red-brown, glabrous, fastigiated branching absent; aerial roots not seen. *Leaf sheaths* 2.5–3.5 mm wide near apex, glabrous on surface, resinous, green to straw-coloured, prominently nerved; margins glabrous or more usually ciliate with hairs 0.5–2.0 mm long; margins of orifice truncate, with a dense fringe of hairs matted in resin, the longest hairs 2.5–5.0 mm long. *Ligule* a dense fringe of hairs *c.* 1.0 mm long; pseudopetiole not distinct. *Leaf blades* flattened-V-shaped when fresh, conduplicate and tightly in-rolled when dry, initially straight becoming curved in older and dead leaves, 8–19 cm long, 0.7–0.8 mm wide when rolled (unrolled leaves 2.4–2.6 mm wide), when fresh relatively flexible, weakly pungent, glabrous abaxially, adaxial surface densely papillose, resinous over abaxial surface, bright green, drying dull green, stomatal grooves on abaxial surface confined to central part, 2–4, (1 or 2 either side of small midrib), unequally spaced, grooves absent on marginal *c.* 1/3 but finely obscurely ribbed, stomatal grooves on abaxial surface 6–7 each side of midrib; margins minutely scaberulous with prickle hairs 0.05–0.15 mm long. *Panicle* 7.5–20.0 cm long, 1.5–5.0 cm wide, with 28–84 spikelets, lanceolate to narrowly lanceolate, with branches openly racemose or basal-most ones sometimes ternate at the base, moderately dense to loose; primary axis angular and ribbed, glabrous or with minute tufts of hairs 0.5–1.7 mm long in branch axils, resinous or non-resinous; longest basal panicle branches 3.8–7.0 cm long, terete to angular or weakly flattened, with 4–8 loosely arranged, ±uniform-sized spikelets, which are 2.8–10.0 mm apart (measured from base of pedicels) with adjacent glumes shortly separated or partly overlapping; *longest basal pedicels* (lateral on the longest lower panicle branches) 5.0–15.5 mm long, 0.1–0.2 mm wide, ±filiform, becoming distinctly thicker just below spikelet, subterete to angular, minutely scabrous; upper lateral pedicels on branch only slightly shorter than lower one; terminal pedicel 6.5–11.0 mm long. *Spikelet* 6.3–12.0 mm long, 1.5–3.5 mm wide (including glumes but excluding awns), spikelet excluding glumes and awns 4.0–10.0 mm long, loosely 4–6-flowered with 2–4 fertile florets (apparently 1 or 2 sterile florets at apex, but these possibly merely immature), linear to narrowly lanceolate, not or only slightly compressed at maturity; lowest rachilla internode *c.* 1.3–2.0 mm long, *c.* 0.1 mm diam., minutely scabrous; spikelets disarticulating above glumes and at rachilla internodes at maturity. *Lower glume* 6.3–10.5(–12) mm long, 1.1–2.0 mm wide, L:W 5.0–6.6, narrowly lanceolate, acute to shortly acuminate, shortly to distinctly longer than the combined spikelet florets (excluding

the awns), submembranous and subtranslucent, with undifferentiated margins, smooth or with very fine, minute and obscure scabrosities to *c.* 0.05 mm long mostly in marginal areas, 3–5-nerved, the midnerve only slightly raised, lateral nerves slightly raised, margins glabrous. *Upper glume* inserted 0.2–0.4 mm above lower glume, 6.1–10.3 mm long, 3–5-nerved, similar to or slightly shorter or longer than lower glume, distinctly longer than the combined florets (excluding awns). *Lowest lemma* 11.3–15.0 mm long including awns, linear to lanceolate, uniformly textured when immature becoming bitextured with a transverse demarcation line (lower part indurated, upper part membranous-chartaceous, underside developing a thickened transverse callosity at the junction of the texture change) developing by anthesis, deeply 3-lobed and 3-awned; body 3.1–4.2 mm long including callus, the indurated part 1.8–2.7 mm long with dense, appressed hairs 0.3–0.5 mm long reaching to apex of indurated part and apparently nerveless, the membranous part 0.6–1.0 mm long and glabrous with 3 groups of 3 obscure nerves radiating into lobes; midlobe including awn 6.4–10.5 mm long, narrowly triangular at base narrowing into an awn, equal in width to lateral lobes; lateral lobes including awn 4.0–7.6 mm long, narrowly triangular at base narrowing into an awn, margins with a very narrow membranous wing; *callus* 0.2–0.35 mm long, slightly curved in profile, attached obliquely, acute to blunt in face view, acute in profile, white-bearded except in midline, the longest hairs 0.4–0.8 mm long. *Upper lemmas* similar to but smaller than lowest lemma. *Palea* of basal lemma longer than lemma body, 3.9–4.7 mm long, 0.6–1.0 mm wide, oblanceolate, not keeled, obscurely 2-nerved with nerves only partly running into membranous part, distinctly bitextured, lower part indurated and hairy in upper 1/2–2/3 or lower half, upper part translucent-membranous and glabrous, apex acute to truncate; keels obscured in indurated part and not winged (a brief wing *c.* 0.1–0.2 mm wide at the nerved base of membranous part of palea); flaps *c.* 0.1–0.2 mm wide, broadest in central part, narrower than 1/2 width of the palea body and not overlapping, entire. *Lodicules* 0.5–0.7 mm long, obtriangular, apex \pm truncate, glabrous or ciliate. *Anthers* 3, 2.3–2.5 mm long, exerted at maturity. *Styles* 2, *c.* 1.5–1.6 mm long. *Caryopsis* not seen. (Figure 2)

Diagnostic features. Foliage copiously resinous. Leaf sheaths glabrous on surfaces, margins ciliate or sometimes glabrous. Leaves epistomatous (soft-type), lacking stomatal grooves on the lateral margins of the abaxial surface. Spikelets 4–6-flowered with 2–4 fertile florets. Glumes 6.3–10.5(–12) mm long, longer than the combined florets. Lemmas with short callus 0.2–0.35 mm long, body bitextured with upper membranous part sharply demarcated from lower indurated part by a transverse line, lobes awned. Palea bitextured, the lower indurated part hairy.

Selected specimens. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 8 Mar. 2012, *M.D. Barrett & W. Lewandrowski* MDB 3910 (CANB, DNA, K, PERTH); 1 Feb 2011, *J. Bull & G. Hopkinson* ONS JIN 2 (PERTH); 4 Feb. 2011, *J. Bull & G. Hopkinson* ONS M 4 (PERTH); 9 Aug. 2011, *J. Bull & D. Roberts* ONS wp 046.01 (PERTH); 26 Apr. 2013, *J. Bull & D. Roberts* ONS A 81 (PERTH); 6 May 2002, *D.J. Edinger & G. Marsh* DJE 3461 (PERTH); 22 May 1971, *A.S. George* 10783 (PERTH); 20 Mar. 2010, *K. McCann* ENV 6 (PERTH); 27 Mar. 2013, *S. Reiffer* SRe 208 (PERTH); 19 May 1995, *M.E. Trudgen* MET 12739 (PERTH); 29 May 1997, *M.E. Trudgen* MET 15705 (PERTH); 22 May 1995, *M.E. Trudgen & M. Trudgen* MET 12778 (PERTH).

Phenology. Fertile collections have been made in February and March.

Distribution and habitat. *Triodia* sp. Mt Ella is restricted to a small area mainly in the central to eastern Hamersley Range but extends to the south of the range, and also has disjunct occurrences east of Newman (*J. Bull & D. Roberts* ONS 19jb 143.01) and south of the Rudall River (*A.S. George* 10783). The Hamersley Range populations mainly occur in the Mt Meharry, Mt Robinson, and Mt Ella areas and south from there to the Angelo River area and to near Turee Creek Station (*D.J. Edinger & G. Marsh* DJE 3461). Individual occurrences in the Hamersley Range are small in area, mainly occurring at the

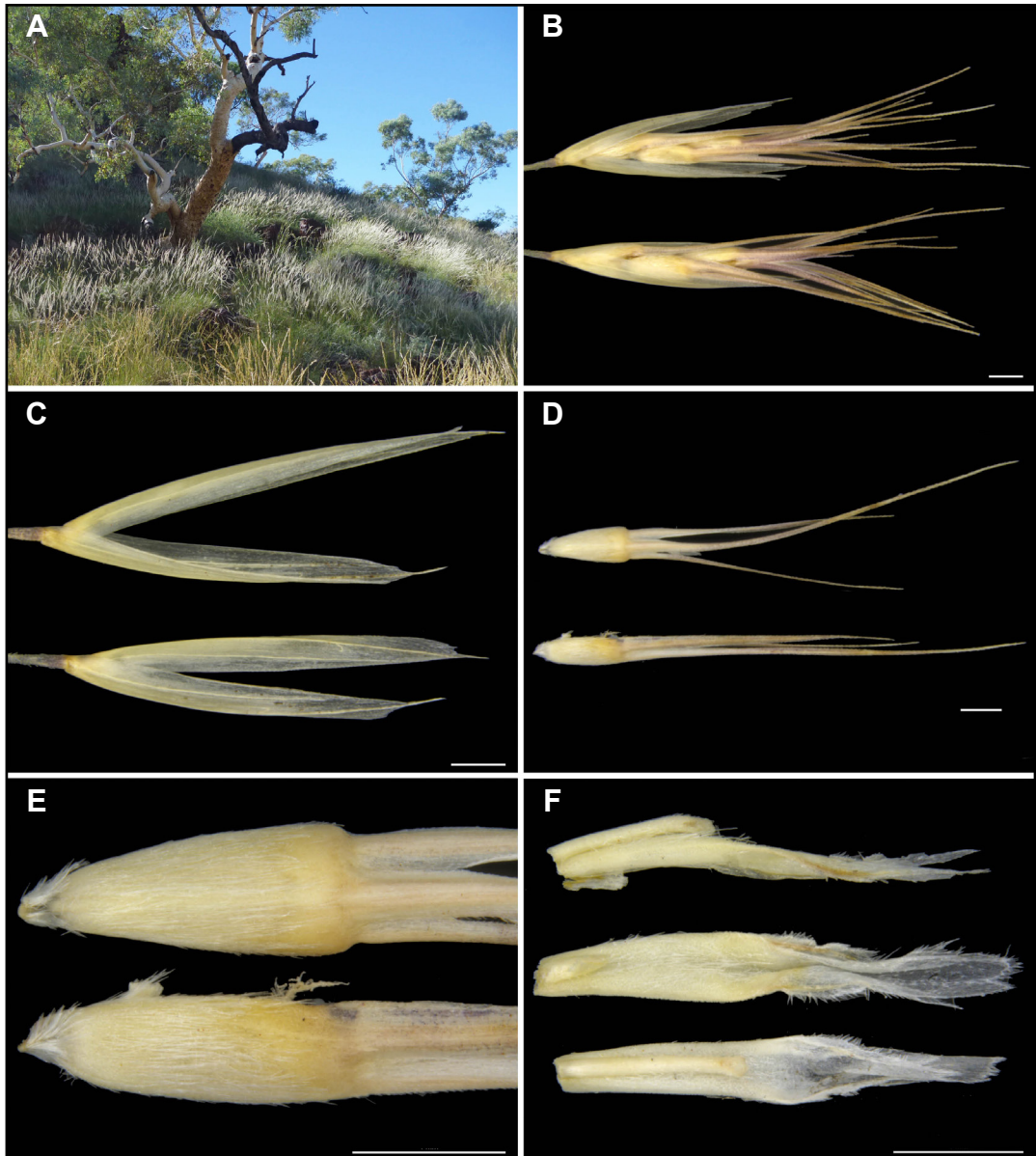


Figure 2. *Triodia* sp. Mt Ella. A – flowering plants *in situ* at base of steep ironstone slope, with *T. pungens* R.Br. in foreground; B – spikelets, showing glumes longer than the combined florets (excluding awns); C – glumes, showing membranous texture and three nerves; D – lemma of basal floret in side and face view showing awns; E – lemma of basal floret, detail of base in side and face view, showing indurated lower part separated from membranous upper part with a sharp demarcation line, uniformly distributed hairs over indurated part, and short callus; F – palea of basal floret (partially crumpled) in side and face view showing indurated base and membranous apex, with hairs over the indurated part. Scale bars = 1 mm. Images from M.D. Barrett & W. Lewandrowski MDB 3910. Photographs by M. Barrett.

bases of open to slight gullies on the mid- to upper slopes of large hills; however, some records are from gorges and ridges. Some occurrences are associated with iron-rich substrate in the West Angelas mining area, but the main factor affecting distribution is likely to be the deeper (moisture retaining) soils at the bases of gullies. Most records are from outcropping ironstone or ironstone gravel; the Rudall River occurrence is from creek beds on unknown geology.

Conservation status. *Triodia* sp. Mt Ella (M.E. Trudgen 12739) is listed by Smith and Jones (2018) as Priority Three under Conservation Codes for Western Australian Flora. It is mostly known from 33 collections from an area about 100 km north to south and about 40 km at its widest point in the West Angelas area. In this area *T.* sp. Mt Ella is usually dominant in the grass layer where it occurs; however, the individual occurrences are quite small, often being only a few tens of metres across. The size of the disjunct populations east of the Pilbara bioregion are not known.

Notes. The Rudall River specimens of *T.* sp. Mt Ella were cited as part of a broad concept of *T. bitextura* by Lazarides (1997) and Lazarides *et al.* (2005), while Hamersley Range specimens were not seen for those treatments. *Triodia bitextura* as treated by Lazarides (*loc. cit.*) is a complex of morphologically similar but apparently genetically divergent variants, some of which can co-occur, indicative of reproductive isolation despite subtle morphological differences. One of these variants, mentioned as a form of *T. bitextura* with hirsute sheath surfaces by Lazarides (1997), has already been described as the Pilbara endemic *T. basitricha* M.D.Barrett (Barrett & Barrett 2015). *Triodia* sp. Mt Ella accounts for the majority of remaining Pilbara collections formerly included under *T. bitextura*. Two additional unusual Pilbara '*T. bitextura*' forms are known: *P.J. Davidson* 2026 (CANB) from near Pannawonica should perhaps be included under *T. basitricha*, but lacks the diagnostic sheath hairs, and requires additional study, while another variant east of Port Hedland has longer glumes and more glume nerves than any member of *T. bitextura sens. lat.*, and appears to have more affinity to *T. schinzii* (with which it co-occurs) rather than any member of the *T. bitextura* complex; this form is to be described elsewhere (Barrett, in prep.).

Several described species share with *T.* sp. Mt Ella the distinctive bitextured mature lemma, where the indurated lower part is sharply demarcated from the upper membranous part by a transverse line that is usually thickened on the inner surface, and can eventually become an abscission line: these are *T. acutispicula* Lazarides, *T. basitricha*, *T. caelestialis* G.Armstrong, *T. helmsii* C.E.Hubb.) Lazarides and *T. schinzii* (Henrard) Lazarides. *Triodia* sp. Mt Ella can be distinguished from *T. basitricha* in being copiously resinous and lacking hairs on the leaf sheath surfaces (not or weakly resinous and with hairy leaf sheath surfaces in *T. basitricha*). *Triodia* sp. Mt Ella is distinguished from *T. acutispicula* and *T. caelestialis* in having numerous appressed hairs all over the lemma surfaces (glabrous, or with minute hairs only along the midline in *T. acutispicula* and *T. caelestialis* respectively). *Triodia* sp. Mt Ella is distinguished from *T. schinzii* (and *T. helmsii* which appears to be synonymous with *T. schinzii*; Barrett, in prep.) in having a shorter, blunt to broadly acute callus and shorter glumes 6.3–10.5(–12) mm long (callus sharply pungent and 0.8–1.5 mm long, and glumes (12.7–)15.5–26.0 mm long in *T. schinzii*).

Triodia bitextura sens. lat. is morphologically variable, covering the range of variation in *T.* sp. Mt Ella. While this latter taxon has the unusual combination of copiously resinous foliage, usually ciliate leaf sheath margins, a combined floret length of 6.3–10.0 mm, and glumes that are 6.3–10.5(–12) mm long and longer than the combined florets, it is not necessarily unique within the *T. bitextura sens. lat.* assemblage (foliage most commonly non-resinous to weakly resinous, but sometimes strongly resinous; sheath margin glabrous or ciliate; combined florets 9–20 mm long; glumes 7–17 mm long and shorter to longer than combined florets). Of note, however, is that the short spikelets, and corresponding combination of relatively short glumes and glumes longer than combined florets are especially unusual, and potentially diagnostic.

Immature lemmas can lack any evidence of a transverse line, and *T.* sp. Mt Ella could then be mistaken for *T. melvillei*. This species, however, has hairs aligned in distinct rows on the lemma body, compared with a more or less uniform distribution over the surface in *T.* sp. Mt Ella.

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References

- Anderson, B.M., Barrett, M.D., Krauss, S.L. & Thiele, K. (2016). Untangling a species complex of arid zone grasses (*Triodia*) reveals patterns congruent with co-occurring animals. *Molecular Phylogenetics and Evolution* 101: 142–162. doi:10.1016/j.ympev.2016.05.014.
- Anderson, B.M., Thiele, K.R. & Barrett, M.D. (2017a). A revision of the *Triodia basedowii* species complex and close relatives (Poaceae: Chloridoideae). *Australian Systematic Botany* 30: 117–229.
- Anderson, B.M., Thiele, K.R., Krauss, S.L. & Barrett, M.D. (2017b). Genotyping-by-sequencing in a species complex of Australian hummock grasses (*Triodia*): methodological insights and phylogenetic resolution. *PLoS One* 12(1): e0171053. doi:10.1371/journal.pone.0171053.
- Armstrong, G. (2008). *Triodia caelestialis* (Triodieae: Chloridoideae: Poaceae), a new species from the central Kimberley, Western Australia. *Journal of the Royal Society of Western Australia* 91: 313–317.
- Barrett, R.L., Wells, G.B. & Dixon, K.W. (2005). New taxa and combinations: Subfam. Chloridoideae, Trib. Triodieae, *Triodia*. In: Mallett, K. (ed.). *Flora of Australia* Vol. 44B. pp. 458–459. (CSIRO Publishing: Melbourne.)
- Barrett, R.L. & Barrett, M.D. (2011). Two new species of *Triodia* (Poaceae: Triodieae) from the Kimberley region of Western Australia. *Telopea* 13: 57–67.
- Barrett, R.L. & Barrett, M.D. (2015). Twenty-seven new species of vascular plants from Western Australia. *Nuytsia* 26: 21–87.
- Crisp, M.D., Mant, J., Toon, A. & Cook, L.G. (2015). Australian spinifex grasses: new names in *Triodia* for *Monodia* and *Symplectrodia*. *Phytotaxa* 230: 293–296.
- Gibson, N. (2016). Western Australian plant taxa not collected for more than 50 years. *Nuytsia* 27: 139–164.
- Hurry, C.R., Walsh, N.G. & Murphy, D.J. (2012). A taxonomic review of *Triodia bunicola* and *T. scariosa* (Poaceae: Chloridoideae), based on morphological and molecular data. *Australian Systematic Botany* 25: 304–312. doi:10.1071/SB10044.
- Lazarides, M. (1997). A revision of *Triodia* including *Plectrachne* (Poaceae, Eragrostideae, Triodiinae). *Australian Systematic Botany* 10: 381–489. doi:10.1071/SB96012.
- Lazarides, M., Weiller, C. & McCusker, A. (2005). *Triodia*. In: Mallett, K. (ed.). *Flora of Australia* Vol. 44B. pp. 203–256.
- Smith, M.G. & Jones, A. (2018). *Threatened and Priority Flora list 16 January 2018*. Department of Biodiversity, Conservation and Attractions. <https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-plants> [accessed 29 October 2018].
- Toon, A., Crisp, M.D., Gamage H., Mant, J., Morris, D.C., Schmidt, S., Cook, L.G. (2015). Key innovation or adaptive change? A test of leaf traits using Triodiinae in Australia. *Scientific Reports* 5: 12398.

