

***Amphipogon indutus* (Poaceae), a new conservation-listed species from south-west Western Australia**

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Abstract

Karunakaram, M. & Macfarlane, T.D. *Amphipogon indutus* (Poaceae), a new conservation-listed species from south-west Western Australia. *Nuytsia* 37: 85–93 (2026). *Amphipogon indutus* Karunakar. & T.Macfarlane from south-west Western Australia is described and the morphology and leaf cross-sectional anatomy are illustrated with photographs. The new species is currently known from two localities in the Southern Cross area, one of which is under threat.

Introduction

Amphipogon R.Br. is an endemic Australian grass genus (Poaceae subfam. Arundinoideae, a member of the PACMAD clade; Soreng *et al.* 2022) comprised of 11 taxa (Council of Heads of Australasian Herbaria 2006). The members of this genus are perennial grasses characterised by ligules consisting of a fringe of hairs, compact spike-like or capitate panicles often with one or more basal reduced spikelets that can resemble an involucre, 1-flowered spikelets dehiscent above the glumes, rachilla not prolonged, both lemma and palea lobed, the lobes sometimes awned, leaf epidermal cells papillate, microhairs present at least adaxially, and C₃ photosynthesis (Watson *et al.* 1992–; Kellogg 2015).

Most species of *Amphipogon* have a strict south-west Western Australian distribution except for three species: *A. caricinus* F.Muell. and *A. strictus* R.Br. that extend to other regions in Australia, and another species *A. sericeus* (Vickery) T.Macfarlane exclusive to the arid zone from Western Australia to Queensland. The genus occurs in all mainland states and territories but is absent from Tasmania. The modern taxonomy of *Amphipogon* follows a revision by Vickery (1950) and a later review by Macfarlane (2005), where *Diplopogon* R.Br. was included and a few taxonomic changes were made. No further additions or changes have been made until now.

A new species described here, *A. indutus* Karunakar. & T.Macfarlane, was discovered by chance during fieldwork and recognised as distinct from known *Amphipogon* species. Subsequently, it was matched to an earlier collection (*J. Dodd* 238, PERTH 00804401) with senescent inflorescences that, somewhat hesitantly, had been assigned to *A. caricinus* var. *caricinus*. The new species is thus known from two locations in south-west Western Australia. A field survey raised concerns about disturbance at one location while the other location could not be confirmed and no additional populations were found, so the new species was conservation listed as Priority One under the name *A. sp.* Southern Cross (T.D. Macfarlane *et al.* TDM 7193) (Western Australian Herbarium 1998–).

Although no species with C₄ photosynthesis have been identified so far within the subfamily Arundinoideae, previous research findings indicated a need for further investigation in *Amphipogon*. Statistical modelling of leaf anatomical traits within species in the PACMAD clade revealed an increase in evolvability of C₄

photosynthesis in lineages where the proportion of outer vascular sheath tissue (OS %) to mesophyll tissue was higher than 15% (Christin *et al.* 2013). During that leaf anatomical trait survey, *A. caricinus* was reported to have an OS % of 19.5% (Christin *et al.* 2013). As the high OS % was detected in an *Amphipogon* species, the leaf anatomy of *A. indutus* was examined to explore the possibility of detecting C₄ or C₃-C₄ intermediate phenotypes within *Amphipogon*.

Methods

The measurements and descriptions of features were prepared by examination of dried herbarium specimens, except for spikelets which were rehydrated from dried specimens. Indumentum concepts follow Hewson (1988). Lemma and palea lobes are measured from the base of the sinus between lobes to the estimated point where the flat lobe changes to the terete awn. Leaf anatomy was investigated using herbarium material rehydrated as per Christin *et al.* (2013), then sectioned by hand with a double-sided razor blade. The sections were mounted in glycerine followed by imaging using a Nikon Ti2 Eclipse microscope. Leaf anatomical measurements were calculated as per Christin *et al.* (2013) using ImageJ software.

Key to the taxa of *Amphipogon*

This key is based on that of Macfarlane (2005).

1. Glumes distinctly 3-lobed **A. debilis**
- 1: Glumes entire, not 3-lobed although apex sometimes a little torn
 2. Lemma with the central lobe much more strongly developed than the two lateral lobes and twisted when fully mature, often bent to one side **A. setaceus**
 - 2: Lemma with equal or sub-equal lobes
 3. Lemma lobes acute to acuminate, lacking an awn or short awn-tip; floret shorter than glumes by at least 1 mm and usually virtually concealed **A. amphipogonoides**
 - 3: Lemma lobes with a short awn-tip or well-developed awn; floret distinctly longer than glumes (sometimes equal to glumes in *A. avenaceus*, but then floret conspicuous)
 4. Lemma lobes with a well-developed awn; awns scabrous
 5. Inflorescences turbinate to spherical
 6. Glume hairs with conspicuously tuberculate bases; lemma callus less than 1 mm long and blunt **A. laguroides**
 - 6: Glume hairs lacking tuberculate bases; lemma callus at least 2 mm long and pungent **A. turbinatus**
 - 5: Inflorescences elongated, narrowly ovoid to cylindrical or linear to ellipsoidal
 7. Spikelets with lemma awns about equal to the longer glume (slightly shorter to 1.5 mm longer); lemma callus 1.7–2.1 mm long; lemma awns 3–4 mm long; rhizomes ascending at a shallow angle, with new shoots arising at successively higher levels **A. avenaceus**
 - 7: Spikelets with lemma awns well exerted beyond the longer glume (7.5–8.2 mm longer); lemma callus up to 1 mm long; lemma awns 8.5–9 mm long; rhizomes horizontal, with new shoots arising at the same level as the preceding ones **A. indutus**
 - 4: Lemma lobes gradually tapering to a short awn-tip; most of the length of the awn-tips plumose
 8. Lemma back uniformly covered in hairs, sericeous
 9. Leaves flat both when fresh and dried; lemma lobes plumose, with stiff spreading hairs on inner surface **A. sericeus**

- 9: Leaves inrolled or folded both when fresh and dried; lemma lobes scabrous.... **A. caricinus** var. **scaber**
- 8: Lemma back with hairs mainly in two longitudinal bands
- 10: Rhizomes very short and ascending; new shoots arising within the leaf sheaths of existing shoots, the shoot bud often emerging from within the sheath (intravaginal); glume backs often bearing prickles but rarely large tubercle-based setae **A. caricinus** var. **caricinus**
- 10: Rhizomes elongated and horizontal; new shoots arising outside the leaf sheaths of existing shoots, the shoot bud developing from a new rhizome segment (extravaginal); glume backs often bearing large tubercle-based setae in upper lateral region **A. strictus**

Taxonomy

Amphipogon indutus Karunakar. & T. Macfarlane, *sp. nov.*

Type: east of Southern Cross, Western Australia [precise locality withheld for conservation reasons], 9 November 2020, T.D. Macfarlane, C.J. French & M. Ludwig TDM 7193 (*holo:* PERTH 09645020; *iso:* CANB, MEL, NSW).

Amphipogon sp. Southern Cross (T.D. Macfarlane et al. TDM 7193), Western Australian Herbarium, in *Florabase*, <https://florabase.dbca.wa.gov.au/> [accessed 18 February 2026].

Perennial, 30–65 cm tall, caespitose, erect. *Rhizome* short, horizontal or descending. *Culms* erect, unbranched, shallowly grooved or striate, microscaberulous; new shoots extravaginal, closely packed; cataphylls and lowest sheath brown and contrasting with the green sheaths and blades above. Cataphylls always partly to entirely silky-haired, sometimes hairs fallen from outer sheaths. *Lower leaf sheaths* moderately grooved, hirsute along grooves. *Ligule* a fringe of hairs 0.1–0.2 mm long. *Lower leaf blades* 12–31 cm long, erect, convolute, 0.6–0.9 mm in diameter, rolled, usually only the abaxial surface visible; abaxial surface papillose, striate with broad, low longitudinal ribs; adaxial surface hidden but sometimes visible in lower 0.5–1 cm of leaf, shallowly grooved, hirsute. *Uppermost leaf* modified; *sheath* 20–65 mm long, the lower part narrow and green, the upper 1/3–2/3 expanded and pale brown to yellowish, enclosing the lower part of the flowering panicle (in older plants the panicle is exerted with up to 15 mm of exposed peduncle); *blade* absent or 1–6 mm or up to 35 mm long, curved, erect, reaching to 1/3–2/3 the length of the panicle, often yellowish. *Inflorescence* a dense, linear to ellipsoidal spike-like panicle, 2.5–5 cm long. *Spikelets* 14–29 per inflorescence, yellowish brown, 13–20 mm long excluding awns, fertile except for 1 or 2 occasionally reduced at base of inflorescence; floret 1; rachilla not prolonged. *Glumes* 2, green to straw, usually subequal with the upper glume slightly longer. *Lower glume* pale yellowish brown, 6.8–7.3 mm long, 3-nerved, more or less elliptical but narrowing rather abruptly in the upper third, acuminate, the lower two-thirds flattened with lateral rounded shoulders or keels, the broad outer flaps clasping the lemma and upper glume, scabrous to shortly puberulous with an additional hirsute region lateral to the keels in the middle third; hairs 1.3–1.5 mm long, soft, with or without tuberculate bases; apical point flattened and scaberulous. *Upper glume* pale green becoming pale brownish in upper third, 7.4–8 mm long, 3-nerved, ellipsoid, attenuate, rounded on the back, not keeled but folded on to the lemma in the outer third and wrapped around base of floret, glabrous near the base and hirsute in the upper two-thirds; awn-like apical point up to 1.5 mm long, surface puberulous, scabrous to shortly pubescent on margins. *Floret* with lemma body shorter than glumes by *c.* 4 mm, awns protruding from glumes by 10–13 mm. *Lemma* 17–17.5 mm long including awns; body 4.75–5 mm long including the callus, 3-nerved, rounded on the back, uniformly pubescent with antrorse hairs; *callus* 0.8–1 mm long, acuminate, covered by silky hairs 0.1–0.2 mm long, the hairs equalling to shortly exceeding top of callus, distinct from those of the lemma body; *lobes* 3, 3.5–4 mm long, broad and flat in lower part, narrowing upwards and passing into an awn, outer surface uniformly pubescent on the lower part, transitioning to shorter more rigid antrorse hairs in upper part, inner surface plumose with stiff spreading hairs *c.* 0.1–0.2 mm long; lobe margins thickened, yellowish, touching in lower part with a deep cleft between them; outer margins of the lateral

lobes with a broad membranous flap continuous with the lemma body, tapering upwards to the base of the awn; *awns* well-developed, equal, somewhat recurved when mature, 8.5–9 mm long when straightened, circular in cross-section, plumose with stiff spreading hairs *c.* 0.1–0.2 mm long becoming scabrous in apical 4–5 mm of awn. *Palea* 13–14.5 mm long including awns; body 3–3.4 mm long with rounded back and two closely spaced veins continuing into lobes; *lobes* 2, *c.* 3 mm long, awned; *awns* *c.* 6.5 mm long, similar to lemma awns except shorter and less curved when mature. *Lodicules* 2, 0.4–0.5 mm long, cuneate, thick, white, without visible veins, not lobed, glabrous. *Anthems* 3, 4 mm long, brown at maturity. *Ovary* ellipsoidal, transitioning into two closely adjacent styles; stigma colour unknown. *Fruit* not seen. (Figures 1–3)

Diagnostic features. *Amphipogon indutus* may be distinguished from all other members of the genus by the following combination of characters: rhizomes horizontal with unbranched shoots; linear to ellipsoidal inflorescences; panicle basally enclosed by sheath of uppermost leaf at anthesis; lemma body pubescent all over; well-developed curved lemma awns, 8.5–9 mm when straightened (Figure 2).

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 4 Nov. 1985, J. Dodd 238 (CANB, PERTH); 22 Oct. 2020, T.D. Macfarlane & C.J. French TDM 7169 (AD, BRI, CANB, K, PERTH, US); 18 Oct. 2023, T.D. Macfarlane & C.J. French TDM 7497 (CANB, PERTH); 18 Oct. 2023, T.D. Macfarlane & C.J. French TDM 7498 (BRI, CANB, NSW, PERTH); 18 Oct. 2023, T.D. Macfarlane & C.J. French TDM 7499 (PERTH); 18 Oct. 2023, T.D. Macfarlane & C.J. French TDM 7500 (PERTH).

Phenology. Flowering in late October to November. Most collections lack flowering material or have old inflorescences.

Distribution and habitat. Western Australia, Coolgardie IBRA Bioregion, known from only two locations. Currently known from patchy occurrences along a 12 km stretch of road and another location 70 km away in Jilbadji Nature Reserve. Grows on yellow sand in low to tall shrublands dominated by species of mallee *Eucalyptus*, *Allocasuarina*, *Callitris*, and *Grevillea*, accompanied by grasses including *A. caricinus* var. *caricinus*, *A. turbinatus* and *Neurachne alopecuroidea*.

Conservation status. Listed as Priority One under Conservation Codes for Western Australian Flora (Western Australian Herbarium 1998–) as *A. sp.* Southern Cross (T.D. Macfarlane et al. TDM 7193). This species apparently has a restricted distribution and has been observed at only two locations, one of them in a conservation reserve. At the latter location, plants were not found during a field visit and at the other, on a road reserve, there were signs of disturbance (see *Notes*). The two locations range from the very eastern edge of the cleared agricultural region (the Wheatbelt) to 50 km eastward into the uncleared region.

Etymology. The epithet is from the Latin *indutus* (cloaked, clothed, covered), referring to the partial enclosure of the flowering inflorescence by the uppermost leaf sheath.

Leaf anatomy. **Adaxial surface:** with prominent ribs of varying sizes relating to vascular bundle size, accompanied by slight to moderate furrows. **Epidermis:** stomata and unicellular papillae on abaxial and adaxial epidermes. **Sclerenchyma:** vascular bundles accompanied by abaxial and adaxial sclerenchyma girders except the two near-marginal bundles which have no associated sclerenchyma; non-bundle associated sclerenchyma in abaxial groups and at each margin. **Mesophyll:** with non-radiate chlorenchyma. **Bulliform cells:** absent. **Bundle sheaths:** XyMs⁺; bundles surrounded by two sheath layers; mestome sheath complete; parenchymatous sheath interrupted adaxially and abaxially by girders when present (Figure 3).

Photosynthetic pathway. The leaf anatomy of *A. indutus* is classified as C₃ given a high lateral cell count (> 4 mesophyll cells between vascular bundles) and few to no visible chloroplasts in the vascular sheath layers. *Amphipogon indutus* has an OS % measurement of 11%.



Figure 1. *Amphipogon indutus*. A – inflorescence at anthesis showing conspicuous, spreading awns and sheathed by upper leaf with, in this case, a short brown blade; B – immature inflorescence with erect awns and sheathed by upper leaf with, in this case, a long green blade; C – rhizome showing separately arising (extravaginal) shoots; D – plants in open habitat, site disturbed by mechanical ripping, parts of clump dead from damage and with fresh shoots present; E – base of plant showing new separately arising shoots; F – habitat showing undisturbed vegetation adjacent to site shown in D; G – plants in a shaded, long-unburnt site. Images from T.D. Macfarlane *et al.* TDM 7193 (A), T.D. Macfarlane & C.J. French TDM 7169 (B–F) and T.D. Macfarlane & C.J. French TDM 7500 (G). Photographs by T.D. Macfarlane.

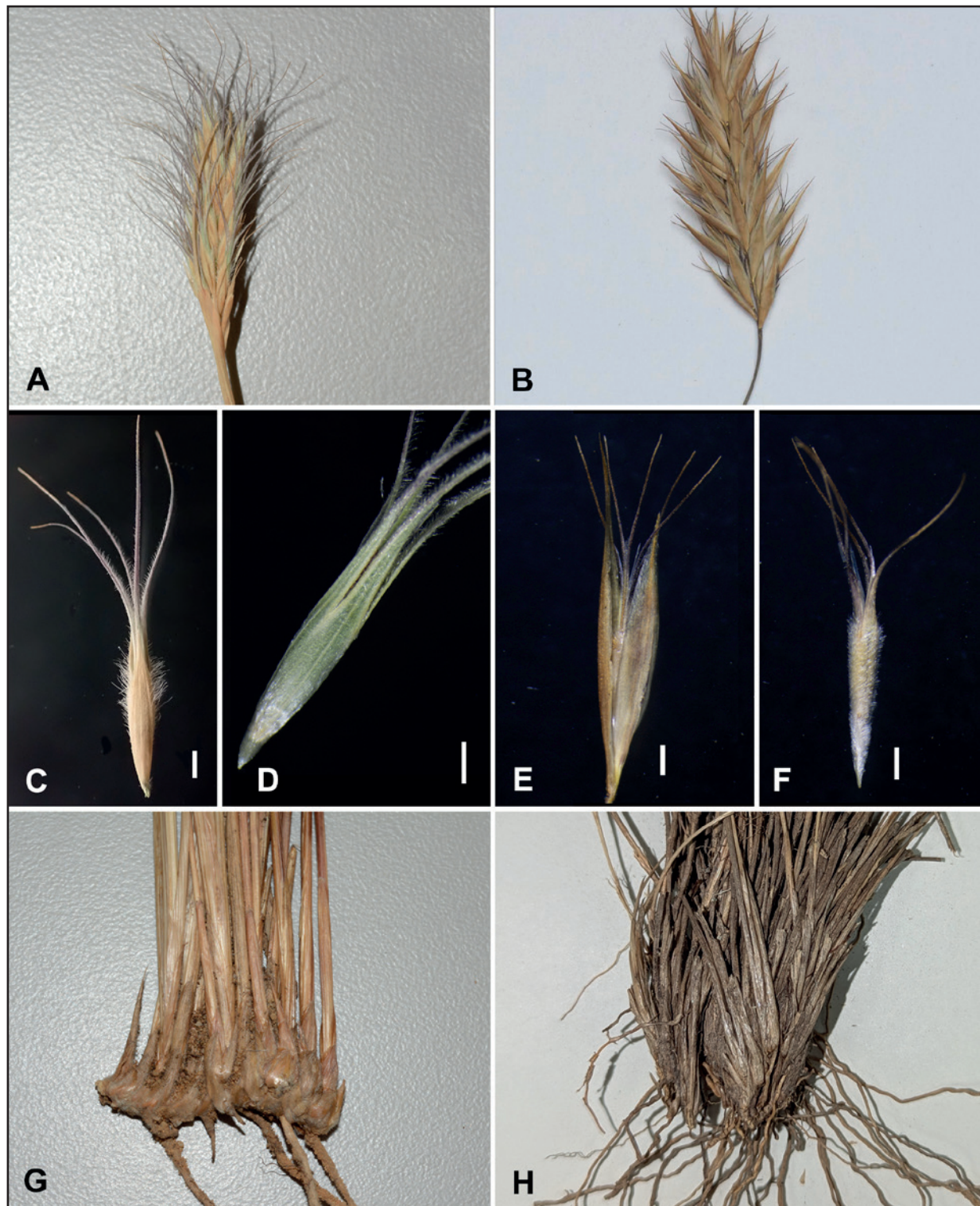


Figure 2. Comparison of species. *Amhipogon indutus*. A – inflorescence; C – spikelet; D – floret (awns truncated); G – base of plant showing extravaginal new shoots. *Amhipogon avenaceus*. B – inflorescence; E – spikelet; F – floret; H – base of plant showing intravaginal new shoots. Images from T.D. Macfarlane *et al.* TDM 7193 (A, C, D), L.J.P. [Pen] 364 (B), M.D. Crisp 4919 (E, F), T.D. Macfarlane & C.J. French TDM 7500 (G) and K. Newbey 4600 (H). Scale bars = 1 mm. Photographs by T.D. Macfarlane.

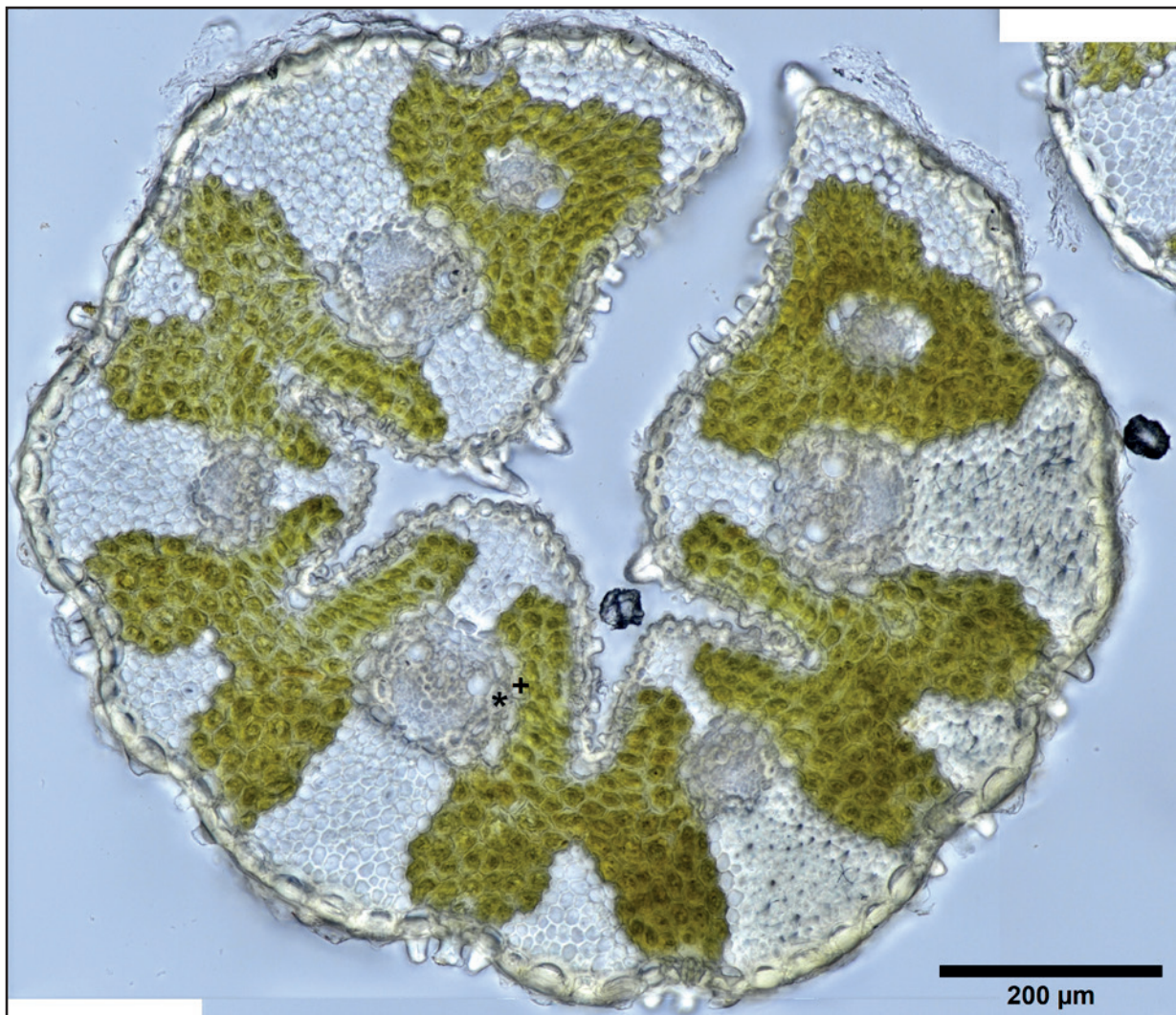


Figure 3. *Amphipogon indutus* leaf in cross-section showing typical C_3 anatomy with > 4 mesophyll (chlorophyll-containing) cells between vascular bundles. Vascular bundles are $XyMs+$ with few to no chloroplasts in the parenchymatous sheath cells (marked with +) and mestome sheath cells (marked with *). Image from T.D. Macfarlane *et al.* TDM 7193. Photograph by Madhoolika Karunakaram.

Notes. Several south-west WA species of *Amphipogon* have well-developed scabrous awns: *A. avenaceus* R.Br., *A. indutus*, *A. laguroides* R.Br., *A. setaceus* (R.Br.) T.Macfarlane and *A. turbinatus* R.Br. Three of these (*A. laguroides*, *A. setaceus* and *A. turbinatus*) have compact and rounded, turbinate, or hemispherical to spherical inflorescences. In contrast, those of *A. avenaceus* and *A. indutus* are elongate and cylindrical and narrowly ovoid to ellipsoidal in outline. As well as inflorescence shape, *A. indutus* is most similar to *A. avenaceus* in having well-developed long scabrous awns as well as the uppermost leaf covering the base of the immature inflorescence. In *A. indutus*, the base of the mature inflorescence is almost always enclosed by the uppermost leaf sheath, only occasionally being exerted by 10–20 mm, whereas in *A. avenaceus* mature inflorescences may be similarly enclosed or, on more than half the available specimens, exerted by 40–140 mm. *Amphipogon indutus* differs most strikingly from *A. avenaceus* (Figure 2) by having horizontal rhizomes and unbranched shoots, lemma body moderately densely pubescent with antrorse hairs rather than densely hairy with short white erect hairs, spikelets with lemma awns well exerted beyond the longer glume (7.5–8.2 mm longer) rather than with awns about equal to the longer glume (slightly shorter to 1.5 mm longer), and lemma awns 8.5–9 mm rather than 3–4 mm long. They also differ by *A. indutus* having glumes straw-coloured instead of pale brown (and often purple-tinged), glumes with a conspicuous hirsute area rather than hirsute area lacking and lemma callus acuminate and 0.8–1 mm long instead of pungent and 2–2.4 mm long. The distributions of *A. indutus* and *A. avenaceus* are separated by approximately 200 km, with the former known only from two sites east

and southeast of Southern Cross, at least 230 km inland while the latter grows in the south coastal region from Denmark to c. 80 km east of Esperance, extending up to 50 km inland.

The leaf anatomy of *A. indutus* is consistent with that of other species in the genus (Macfarlane & Watson 1980; Watson *et al.* 1992–; Karunakaram unpubl.), with differences between species mainly concerning the extent and distribution of sclerenchyma, the number of ribs and associated vascular bundles, and the presence/absence of bulliform cells. Notably, the epidermal papillae characteristic of *Amphipogon* are present in *A. indutus*. During our investigation of *Amphipogon* leaf anatomy, we examined an image of the leaf anatomy from the *A. caricinus* specimen used in the study by Christin *et al.* (2013). We determined the specimen to be *A. sericeus* given the presence of bulliform cells. This specimen, cited as *Blake 3597*, was originally cited for anatomy by Renvoize (1986) and is presumed to be held at the Kew Herbarium. To confirm this re-identification, we sought a duplicate of *Blake 3597* from the Queensland Herbarium (BRI), home of the original collections of S.T. Blake, but BRI had no such Blake number. It was determined that the collector was instead M. Lazarides and that the identifier S.T. Blake had been mistakenly interpreted as the collector at Kew. Examination of overall and close-up images of *Lazarides 3597* (BRI-AQ227453) confirmed it as *A. sericeus*.

The first collection of *A. indutus*, *J. Dodd 238*, was made in 1985 along the State Vermin Fence No. 7 south-east of Southern Cross. It was initially identified as *A. strictus*, presumably based on the compact linear to ellipsoidal inflorescences and the extravaginal shoots. Further diagnostic characteristics could not be observed as the inflorescences were senescent year-old remnants carrying only glumes. Subsequently, it was re-identified by T.D.M. as *A. caricinus* var. *caricinus* based on the large plant size and geographic location, despite that taxon being characterised by intravaginal shoots. The Dodd specimen was collected from a broad region of contact or overlap in the ranges of *A. caricinus* var. *caricinus* and *A. strictus* where specimens sometimes exhibit mixed features of those taxa (Macfarlane 2005). The inclusion of *Dodd 238* in *A. caricinus* var. *caricinus* was consequently not unreasonable given the lack of mature spikelets, although its unusual appearance, notably its robust habit and shoot origin, were noted. Following the 2020 discovery of the fertile plants described here as *A. indutus*, *Dodd 238* was matched to that species, providing a second location for it. During research on *A. indutus*, the approximate original Dodd site was visited in the hopes of collecting flowering specimens and to investigate the population size and extent, but no plants were found despite the highly specific location information ‘locally very common at base of fence’. Either the correct point along the fence was not identified or conditions had changed at that location in the ensuing 38 years.

In 2023, a survey was conducted by T.D. Macfarlane and C.J. French in the area surrounding the new population (*T.D. Macfarlane & C.J. French* TDM 7169, south-east of Southern Cross), c. 70 km from the Dodd site. Four sub-populations of the new *A. indutus* were found along 12 km of road, sometimes co-occurring with either or both *A. caricinus* var. *caricinus* and *A. turbinatus*. Most sub-populations were found on the eastern road verge where a broad strip of vegetation between road and fence had been largely cleared by slashing and ripping. In one place, plants were also found in a more natural situation on the western road verge in long-undisturbed vegetation. There the plants grew under tall shrubs, were vegetative without inflorescence remnants and had a more unkempt appearance, having less erect stems and leaves and plentiful retained old leaves (Figure 1G). The vegetation treatment on the eastern verge enabled some plants to survive despite damage and it may have been this disturbance that resulted in some plants flowering. Nevertheless, this vegetation treatment must be considered a threat to the populations. So far, general searches along roads in the area have not revealed populations in the undisturbed vegetation east of the fence. The area is poorly accessible but future searches may locate more plants east of the road and fence, improving knowledge of the geographic extent.

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