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Five new species and a new combination in Cyperaceae from the Kimberley region of Western Australia

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Abstract

Rye, B.L., Barrett, R.L., Barrett, M.D., Bruhl, J.J., Clarke, K.L. & Wilson, K.L. Five new species and a new combination in Cyperaceae from the Kimberley region of Western Australia. *Nuytsia* 26: 167–184 (2015). Four new species of *Actinoschoenus* Benth. and one new species of *Fimbristylis* Vahl are described from the north Kimberley region of Western Australia: *A. glabrispiculus* Rye, R.L.Barrett & M.D.Barrett, *A. pentagonus* Rye, R.L.Barrett & M.D.Barrett, *A. quadricostatus* Rye, R.L.Barrett & M.D.Barrett, *A. ramosus* Rye, R.L.Barrett & M.D.Barrett, and *F. helicophylla* Rye, R.L.Barrett & M.D.Barrett. One new combination is made: *A. arthrostyloides* (W.Fitzg.) K.L.Clarke, K.L.Wilson & J.J.Bruhl. Several of these species have very restricted distributions and are of conservation concern. Two species also occur in the western Northern Territory. All of these taxa have previously been listed on Western Australia's plant census under phrase names. All species are illustrated. A revised key to species of *Actinoschoenus* in the Kimberley region is provided.

Introduction

Cyperaceae are well represented in the Kimberley region with about 17 genera and 190 species currently recorded. Several genera in the regional flora treatment by Rye (1992) contained informally named species, indicative of the extent of taxonomic uncertainties for the sedges of this region. Further collecting, field study and examination of type specimens has enabled us to establish formal names for the species of *Actinoschoenus* Benth. and one distinctive species of *Fimbristylis* Vahl.

Full descriptions for the five new species named here—*A. glabrispiculus* Rye, R.L.Barrett & M.D.Barrett, *A. pentagonus* Rye, R.L.Barrett & M.D.Barrett, *A. quadricostatus* Rye, R.L.Barrett & M.D.Barrett, *A. ramosus* Rye, R.L.Barrett & M.D.Barrett and *F. helicophylla* Rye, R.L.Barrett & M.D.Barrett—were published previously by Rye (1992) under informal names. A new combination is provided for *A. arthrostyloides* (W.Fitzg.) K.L.Clarke, K.L.Wilson & J.J.Bruhl based on *F. arthrostyloides* W.Fitzg. (Fitzgerald 1918). Four species are endemic to the Kimberley region of Western Australia, while

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two extend into the adjacent Northern Territory. All of these species have previously been known by informal phrase names in Western Australia and four of them have conservation priority (Western Australian Herbarium 1998–).

Methods

All measurements are based on dried herbarium material. Most species newly described here have been examined in the field by R.L. and M.D. Barrett. Dry leaves, culms and seeds were mounted on stubs using double-sided carbon tape with conductive carbon paint, coated with gold using an EMITECH K550X Sputter Coater and imaged at high vacuum and high voltage (15 KVa) using a Jeol JCM 6000 NeoScope bench-top Scanning Electron Microscope at Kings Park and Botanic Garden.

Photosynthetic pathway prediction was based on the 'one cell distant criterion' of Hattersley and Watson (1975) where 1) mesophyll chlorenchyma cells are not more than one chlorenchyma cell distant from the nearest vascular bundle, which predicts C_4, or 2) a count of more than one indicates C_3 status (see Bruhl *et al.* 1987 for a more detailed explanation and application to Cyperaceae). Observations here were of culm anatomy (*cf.* Bruhl *et al.* 1987; Bruhl & Wilson 2008) for two to four collections of each species of *Actinoschoenus* treated in this paper (Table 1). Hand-cut transverse sections from the rehydrated mid-third region of culms were double-stained with 0.5% acidified Astra Blue and 0.125% Basic Fuchsin in 50% ethanol for *c.* 1–2 min and 2 s respectively. Sections were rinsed between stains and mounted in 50% glycerol for photomicroscopy. Images were captured with a Nikon DS-Ri1 digital camera on a motorised Nikon Eclipse 90i microscope using the 'large image' feature of NIS Elements AR3.22.00 software to capture and stitch multiple images.

Table 1. Vouchers used for photosynthetic pathway anatomical observations in *Actinoschoenus*. Asterisked (*) specimens under *A. ramosus* are from the East Alligator River area, Northern Territory, and require further taxonomic study (see text).

***Actinoschoenus* species**	**Vouchers**
A. arthrostyloides	*C.R. Dunlop* 5238 (PERTH 01345354)
	K.F. Kenneally 9948 (PERTH 01428888)
	J. Russell-Smith 7584 *& D. Lucas* (DNA 0037927)
A. glabrispiculus	*K.F. Kenneally* 4474 (CANB 292219)
	K.F. Kenneally 4789 (PERTH 01489054)
	J.H. Willis s.n. (PERTH 01489070)
A. pentagonus	*C.R. Dunlop* 5309 (CANB 293319)
	K.F. Kenneally 11266 (PERTH 02249154)
A. quadricostatus	*G.W. Holmes s.n.* (MEL 204869)
	P.G. Wilson 11426 (PERTH 01489011)
A. ramosus	*C.R. Dunlop* 4403 (DNA 0010763)*
	C.R. Dunlop 5303 (DNA 0017460)
	R. Fensham 872 (DNA 0054914)*
	J. Russell-Smith 8423 *& J. Brock* (DNA 0055610)*

Anatomy and photosynthetic pathway

A detailed database of photosynthetic pathway in the family Cyperaceae has been developed covering almost all genera and around 25% of all species (Bruhl & Wilson 2008), including one out of about ten species of *Actinoschoenus*. All samples of *Actinoschoenus* examined in this study (Table 1) consistently exhibited a maximum cells-distant count of more than one, indicative of C_3 photosynthetic pathway (Figure 1). Bruhl *et al.* (1987) and Bruhl and Wilson (2008) assessed a variety of methods for determining whether Cyperaceae species had C_3 or C_4 photosynthetic pathways, including anatomical (using the 'one cell distant criterion'), CO_2 compensation point analyses and $\delta^{13}C$ values. Anatomical assessment accurately predicted photosynthetic pathways for all Cyperaceae, except in some species of *Eleocharis* R.Br. The results of the present anatomical study are consistent with such findings and, with 60% of species in the genus now having been studied, make it likely that all species of *Actinoschoenus* will have C_3 anatomy.

Taxonomy

Actinoschoenus Benth.

The circumscription of genera in Abildgaardieae Lye and 'Arthrostylideae' is under investigation. *Actinoschoenus* is a member of the 'Arthrostylideae' which is embedded within the tribe Abildgaardieae and sister to *Fimbristylis* (Hinchliff & Roalson 2013). *Actinoschoenus* was included in a more broadly circumscribed *Fimbristylis* by Latz (1990). Revision of the other Australian species distributed in the Northern Territory and possibly Queensland, will follow separately (Clarke *et al.*, unpubl. data). The treatment presented here is adapted from Rye (1992).

Key to *Actinoschoenus* species in the Kimberley region of Western Australia based on Rye (1992)

1. Inflorescence of 3 or more spikelets, with 2–4 primary rays and often also secondary rays each bearing 1 spikelet. Uppermost 2 glumes 4.5–5 mm long ..... **A. ramosus**

1: Inflorescence a solitary spikelet or a head of 2–7 spikelets. Uppermost 2 glumes 6–9 mm long

2. Inflorescence bracts 2–5, obvious, the basal bract longest. Culms densely hairy, with two types of hairs, most of the hairs short but some much longer ones scattered along the ridges

3. Culms obtusely 5(6)-ridged. Spikelets (1–)2–7. Upper glumes distally minutely hairy on sides as well as midvein..... **A. arthrostyloides**

3: Culms acutely 4-ridged. Spikelets 1–3. Upper glumes appearing glabrous at 10× or with a few hairs on midvein..... **A. quadricostatus**

2: Inflorescence bracts many, not obvious, intergrading with the glumes, the uppermost bract longest. Culms nearly glabrous to densely hairy, the hairs all short

4. Culms 0.2–0.35 mm in diam., 4-ridged. Inflorescence of 1 spikelet; bracts and glumes glabrous except for 2 basal bracts..... **A. glabrispiculus**

4: Culms 0.5–1.0 mm in diam., 5-ridged. Inflorescence of 3–6 spikelets; bracts and glumes densely minutely hairy. ..... **A. pentagonus**

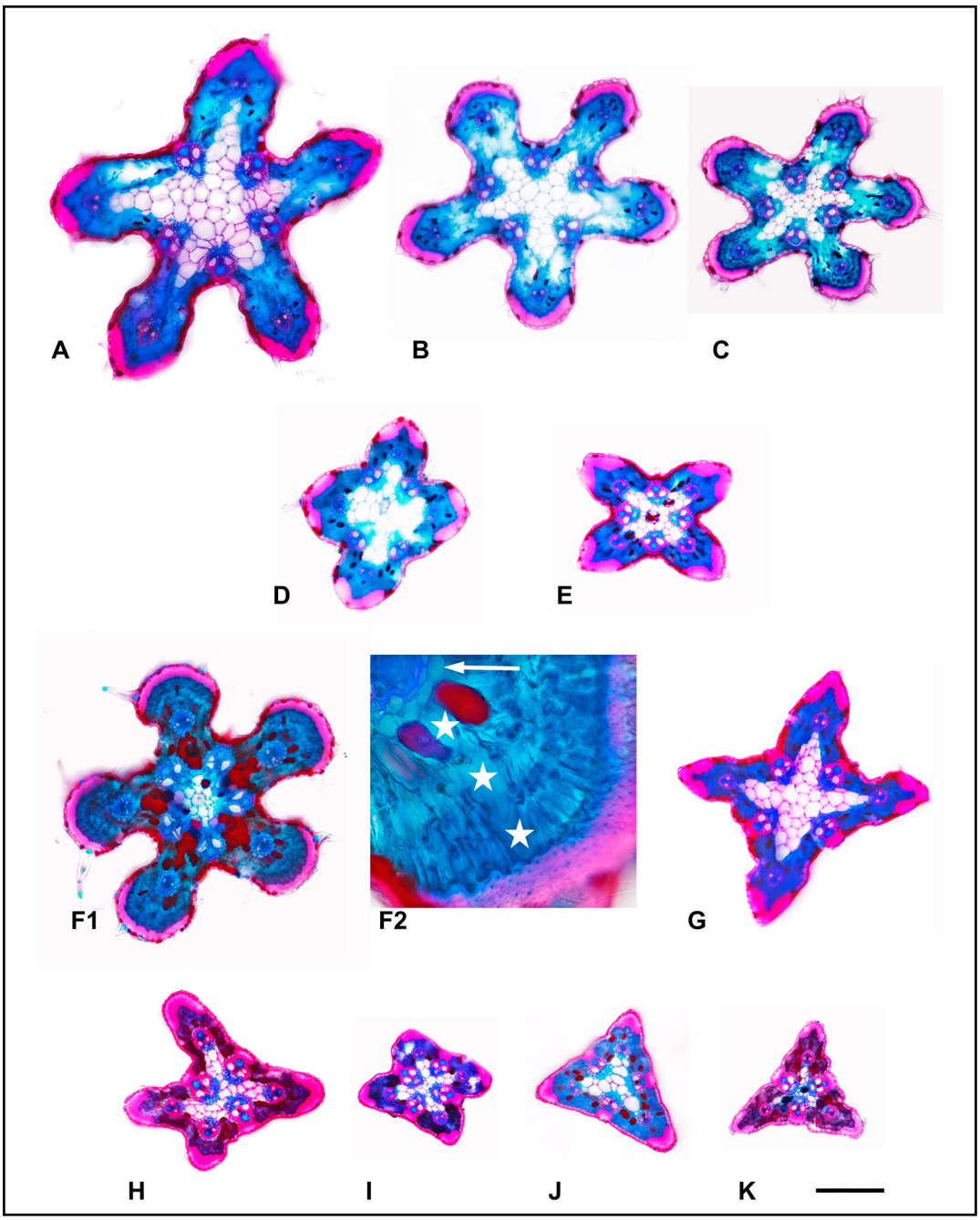

Figure 1. Astra Blue-Basic Fuchsin stained culm cross-sections of *Actinoschoenus* species showing culm features and C_3 photosynthetic pathway anatomy. A–C – *A. arthrostyloides*; D, E – *A. glabrispiculus*; F – *A. pentagonus*, showing (in F2) typical C_3 anatomy with parenchymatous bundle sheath cells without chloroplasts (arrow), and three cell layers of palisade parenchyma (i.e. a maximum cells-distant count of 2; stars); G – *A. quadricostatus*; H – *A. ramosus*; I–K – *A.* aff. *ramosus*. Scale bar = 200 µm (A–F1, G–K); 40 µm (F2). Images from *C.R. Dunlop* 5238 (A), *K.F. Kenneally* 9948 (B), *J. Russell-Smith* 7584 *& D. Lucas* (C), *K.F. Kenneally* 4474 (D), *J.H. Willis s.n.* (E), *K.F. Kenneally* 11266 (F), *P.G. Wilson* 11426 (G), *C.R. Dunlop* 5303 (H), *C.R. Dunlop* 4403 (I), *J. Russell-Smith* 8423 *& J. Brock* (J) and *R. Fensham* 872 (K). Photomicrographs by K.L. Clarke.

Actinoschoenus arthrostyloides (W.Fitzg.) K.L.Clarke, K.L.Wilson & J.J.Bruhl, *comb. nov.*

Basionym: *Fimbristylis arthrostyloides* W.Fitzg., *J. & Proc. Roy. Soc. West. Austral.* 3: 121 (1918). *Lectotype* (designated here): Artesian Range, near Walcott Inlet, Western Australia, August 1905, *W.V. Fitzgerald* 1368 (*lecto*: PERTH 01031120; *isolecto*: BM 000990865 image seen, BRI AQ0340989 image seen, NSW 696918, NSW 696919, PERTH 01031104, PERTH 01031112).

Actinoschoenus sp. B, B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1037 (1992).

Actinoschoenus sp. B Kimberley Flora (G.J. Keighery 2649), G. Paczkowska & A.R. Chapman, *West. Austral. Fl.: Descr. Cat.*, p. 41 (2000); Western Australian Herbarium, in *FloraBase*, http://florabase.dpaw.wa.gov.au/ [accessed 1 March 2014].

Perennial, caespitose sedge, 0.3–0.8 m high. *Culms* 0.5–1 mm diam., overall shape in TS ± terete but strongly and obtusely 5(6)-ridged, densely covered by short hairs and with much longer hairs scattered along the ridges. *Leaves* densely covered by short and long hairs; uppermost leaf 35–100 mm long, with a blade 6–11 mm long. *Inflorescence* a head of (1)2–7 somewhat spreading spikelets. *Bracts* 2–5, hairy, the longest bract basal; basal bract 7–10 mm long, with a blade 6–8 mm long. *Spikelets* strongly compressed, narrowly ovate in outline, 7–9 mm long, 1.5–3 mm wide. *Glumes* 5–7, distichous, with a green keel and pale brown sides; upper glumes narrowly ovate, 6–8 mm long, distally minutely hairy, acute, often apiculate. *Stamens* 3; anther 3.5–4 mm long. *Style* undivided for 4.3–5.5 mm; base narrowly triangular to triangular in outline, *c.* 1 mm long, 0.5 mm wide; stigmatic branches 3, about as long as undivided portion of style. *Nut* with a stipe or contracted base 0.6–1 mm long; body whitish to grey-brown, 2–2.5 mm long, 1.5–2 mm wide, transversely tuberculate-ridged. C_3 photosynthetic pathway inferred from anatomy. (Figures 1A–C, 2)

Diagnostic characters. *Culms* densely hairy, displaying 2 hair types, obtusely 5(6)-ridged. *Inflorescence* (1–)2–7 spikelets; bracts 2–5, the basal bract longest. *Upper glumes* 6–8 mm long, distally minutely hairy on sides as well as midvein.

Other specimens examined. WESTERN AUSTRALIA: 9 km NNW of Mt Agnes, 9 Jan. 2001, *M.D. Barrett* MDB 1175 (NSW, PERTH); large gully, 10.8 km NE of junction of Youwanjela Creek and Prince Regent River, Prince Regent Nature Reserve, 20 Jan. 2007, *R.L. Barrett & M.D. Barrett* RLB 3670 (CANB, PERTH); Youwanjela pavement 1, 26.7 km E of Kings Cascades; 12.4 km NNE of junction of Youwanjela Creek and Prince Regent River, Prince Regent Nature Reserve, 25 Jan. 2007, *R.L. Barrett & M.D. Barrett* RLB 3840 (CANB, NSW, PERTH); HR1 Site, Harding Range, 20 km WNW of Munja, N of Walcott Inlet, 13 Jan. 2010, *R.L. Barrett, M. Maier & P. Kendrick* RLB 6008 (NE, NSW, PERTH); Cypress Valley, on W side of Morgan River, 3 km E of Theda Station Homestead, 9 Mar. 2014, *R.L. Barrett* RLB 8866 (BM, BRI, CANB, DNA, K, MEL, NE, NSW, PERTH); Mitchell River, 22 Feb. 1980, *C.R. Dunlop* 5238 (DNA, NT, PERTH); near Gariyeli Creek, Prince Regent River Reserve, 24 Aug. 1974, *A.S. George* 12594 (CANB, PERTH); overlooking AAB pitline and along last section of trapline 2, Hidden Island, Buccaneer Archipelago, 18 June 1982, *A.J.M. Hopkins* BA 0243 (PERTH); track to Mitchell Falls, Mitchell Plateau, 31 May 1988, *S.W.L. Jacobs* 5804 *& P.G. Wilson* (NSW); Surveyors Pool, Mitchell Plateau, 17 Feb. 1980, *G.J. Keighery* 2649 (PERTH); Mt Daglish vine thicket, 19 June 1987, *G.J. Keighery & J.J. Alford s.n.* (NSW, PERTH); Hunter River, W Kimberley, 26 May 1987, *K.F. Kenneally* 9948 (PERTH); Boongaree Island, Prince Frederick Harbour, 5 July 1973, *P.G. Wilson* 11374 (PERTH). NORTHERN TERRITORY: headwaters of Lalngang Creek, 16 May 1994, *I.D. Cowie* 5066 *& N.G. Walsh* (CANB, DNA, MEL *n.v.*, NT); Spirit Hills Conservation Area,

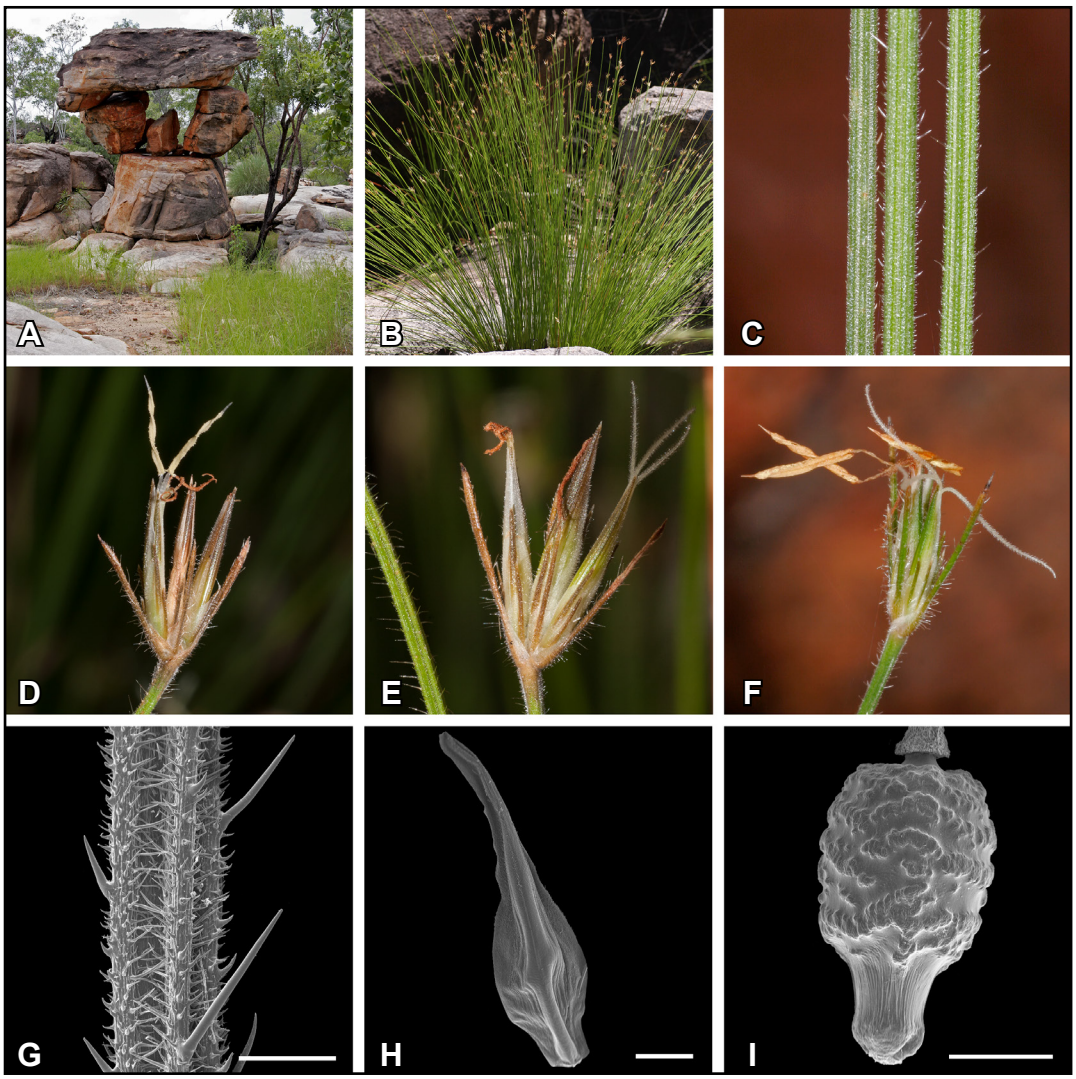

Figure 2. *Actinoschoenus arthrostyloides*. A – habitat on sand over sandstone; B – habit; C – culms; D–F – inflorescences showing anthers and/or style branches; G – SEM of culm; H – SEM of glume; I – SEM of nut. Scale bars = 500 µm (G); 1 mm (H, I). Images from *R.L. Barrett* RLB 8866 (A–F) and *R.L. Barrett* RLB 3840 (G–I). Photographs by R.L. Barrett.

Nancys Gorge, 17 Aug. 1996, *I.D. Cowie* 7114 (DNA, NSW); Keep River National Park, Spirit Hills area, *c.* 35 km SW of Bullo River Homestead, 23 Mar. 2009, *I.D. Cowie* 12307 (DNA, NSW); 44 km SE of Oenpelli, 13 June 1978, *P.K. Latz* 7764 (NT); 11 km S Legune Station, 5 Mar. 1989, *J. Russell-Smith* 7584 *& D. Lucas* (DNA); Bradshaw Military Training Area, *c.* 80 km NW Timber Creek, 2 Apr. 2007, *B.M. Stuckey & I.D. Cowie* 56 (DNA, PERTH).

Phenology. Flowers and fruits recorded in February and from May to August.

Distribution and habitat. Occurs in open woodland with shrubs on sand associated with sandstone, sometimes occurring on the edges of pools. From the Kimberley region, extending from Mitchell Plateau and Boongaree Island south to near Walcott Inlet, east to Bullo River in the Northern Territory.

Conservation status. Currently known from thirteen locations in Western Australia and six in the adjacent Northern Territory, and sufficiently widespread not to require listing as a priority species.

Etymology. The epithet is from the genus *Arthrostylis* R.Br. with the Greek termination *-oides* (like), in reference to the similar appearance of this species to that genus.

Typification. The lectotype is selected from seven duplicate sheets located by us. The primary sets of Fitzgerald's collections from names published by him in 1918 are usually duplicated at NSW and PERTH, so it is customary to choose a lectotype from one of these herbaria. The set at PERTH is stated to be the main material by Maiden (in Fitzgerald 1918), so this material is given preference. PERTH 01031120 is chosen as it contains mature material with nuts and has a label in Fitzgerald's script.

Notes. While this taxon has been known for some time to belong in *Actinoschoenus*, the relevant combination has not previously been made.

Most similar to *A. quadricostatus* and readily distinguished by the obtusely 5(6)-ridged culms (*vs* acutely 4-ridged) and (1)2–7 spikelets per head (*vs* 1–3).

The vernacular name of Hairy Actinoschoenus is suggested.

Actinoschoenus glabrispiculus Rye, R.L.Barrett & M.D.Barrett, *sp. nov.*

Type: west of Drysdale River, Drysdale River National Park, Western Australia [precise locality withheld for conservation reasons], 29 April 2008, *R.L. Barrett & M.D. Barrett* RLB 4895 (*holo*: PERTH 08046808; *iso*: CANB, DNA, K, NE, NSW).

Actinoschoenus sp. D, B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1039, Figure 310C (1992).

Actinoschoenus sp. D Kimberley Flora (K.F. Kenneally 4789), G. Paczkowska & A.R. Chapman, *West. Austral. Fl.: Descr. Cat.*, p. 41 (2000); Western Australian Herbarium, in *FloraBase*, http://florabase.dpaw.wa.gov.au/ [accessed 1 March 2014].

Illustration. B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1038, Figure 310C (1992) [as *Actinoschoenus* sp. D].

Perennial, caespitose sedge, 0.3–0.6 m high. *Culms* 0.2–0.3 mm diam, obtusely 4-ridged, shortly hairy throughout or glabrescent especially along the ridges. *Leaves* densely shortly hairy to partially glabrous; uppermost leaf 30–40 mm long, with a blade up to 3 mm long. *Inflorescence* of 1 spikelet. *Bracts* 2–many but not clearly differentiated from the glumes, gradually increasing in size from base upwards; basal bracts 2–2.5 mm long, with a point or short blade 0.5–1 mm long, slightly hairy; upper bracts glabrous. *Spikelet* narrowly ovoid, 9–11 mm long, 1–2 mm diam. *Glumes* (and all but basal 2 inflorescence bracts) 10–12, 4-ranked or nearly so, with a green keel and whitish sides, becoming medium brown, glabrous; upper glumes narrowly ovate, 7–9 mm long, apiculate. *Stamens* 3; anther not seen. *Style* undivided for *c.* 7.3 mm; base narrowly triangular in outline, *c.* 1 mm long, 0.5 mm wide; stigmatic branches 3, apparently shorter than undivided part. *Nut* with a stipe or contracted base 1–1.6 mm long; body whitish to grey-brown, 2–2.5 mm long, 1.4–1.8 mm wide, transversely tuberculate-rugose or somewhat tuberculate-ridged. C_3 photosynthetic pathway inferred from anatomy. (Figures 1D, E, 3)

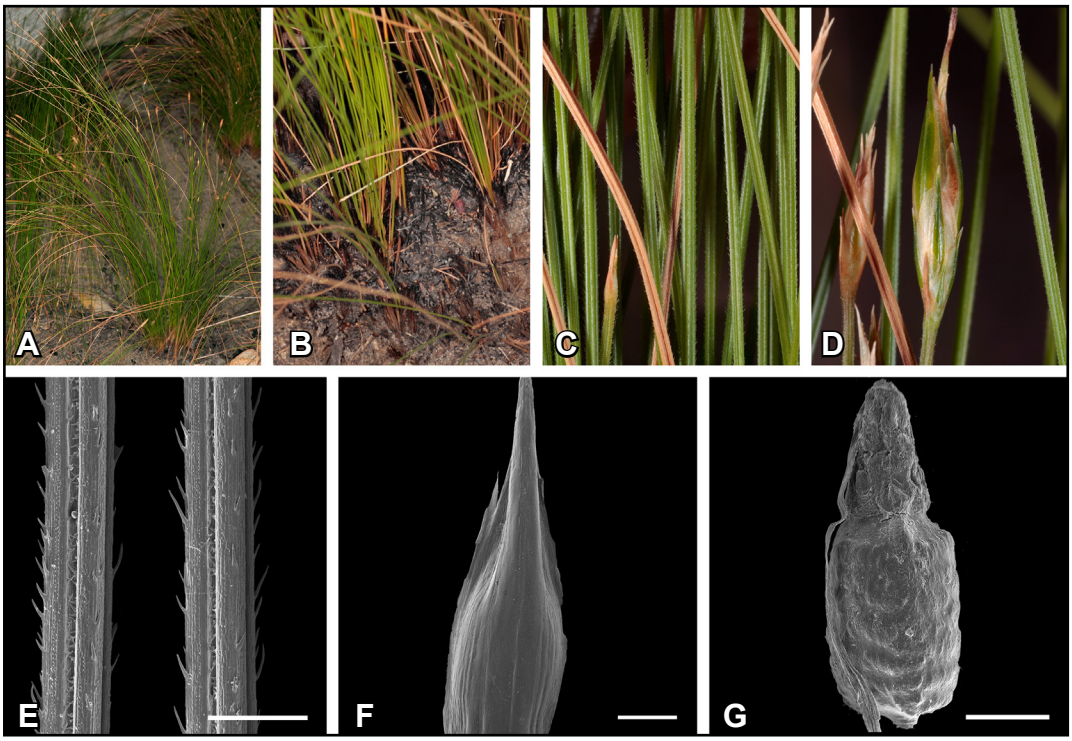

Figure 3. *Actinoschoenus glabrispiculus*. A – habit; B – compact plant base resprouting following fire; C – culms; D – inflorescence; E – SEM of culm; F – SEM of glume; G – SEM of nut. Scale bars = 500 µm (E); 1 mm (F, G). Images from *R.L. Barrett & M.D. Barrett* RLB 4895. Photographs by R.L. Barrett.

Diagnostic characters. *Culms* 0.2–0.3 mm diam., 4-ridged, nearly glabrous to densely hairy, the hairs all short. *Inflorescence* of 1 spikelet; bracts many or intergrading with the glumes, the uppermost bract longest; glabrous except for 2 basal bracts. *Upper glumes* 7–9 mm long, glabrous.

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 22 May 1984, *E.A. Chesterfield, S.J. Forbes & J.H. Willis* EAC 319 (CANB, K *n.v.*, L *n.v.*, MO *n.v.*, NSW, NT, PERTH); 19 May 2003, *K. Coate* 676 (PERTH); 22 Feb. 1980, *C.R. Dunlop* 5239 (DNA, NT, PERTH); 19 Aug. 1975, *K.F. Kenneally* 4474 (CANB, NT, PERTH); 13 June 1976, *K.F. Kenneally* 4789 (NT, PERTH 4 sheets); 28 May 1987, *K.F. Kenneally* 10017 (PERTH); 10 May 1986, *P.K. Latz* 10290 (DNA, NSW, NT); 11 Aug. 2008, *C. Sgherza* 8 (PERTH); 22 May 1984, *J.H. Willis s.n.* (MEL *n.v.*, NSW, NT, PERTH).

Phenology. Flowers and fruits recorded in February and from May to August.

Distribution and habitat. Occurs on sandstone in open woodland and shrubland. Endemic to the Kimberley region, extending from Bigge Island and the Mitchell Plateau east to Napier Broome Bay and Drysdale River National Park.

Conservation status. *Actinoschoenus glabrispiculus* is listed by Jones (2014) as Priority Three under Department of Parks and Wildlife Conservation Codes for Western Australian Flora, under the name *A.* sp. D Kimberley Flora (K.F. Kenneally 4789). Known from nine collections from four broad locations in the north-west Kimberley. Probably more widespread but poorly collected.

Etymology. The epithet is from the Latin *glabri-* (glabrous-) and *spicula* (spikelet), in reference to the glabrous spikelets in this species.

Notes. Most similar to *A. pentagonus* and readily distinguished by the inflorescence having only a single spikelet (*vs* 3–6), 4-ridged culms (*vs* 5-ridged), and glabrous upper bracts and glumes (*vs* densely minutely hairy).

The vernacular name of Smooth Actinoschoenus is suggested.

Actinoschoenus pentagonus Rye, R.L.Barrett & M.D.Barrett, *sp. nov.*

Type: Carson Escarpment, 41 km south-east of new Theda Station Homestead, Drysdale River National Park, Western Australia, 29 April 2008, *R.L. Barrett & M.D. Barrett* RLB 4890 (*holo*: PERTH 08046727; *iso*: NE, NSW).

Actinoschoenus sp. E, B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1039, Figure 310D (1992).

Actinoschoenus sp. E Kimberley Flora (C.R. Dunlop 5309), G. Paczkowska & A.R. Chapman, *West. Austral. Fl.: Descr. Cat.*, p. 41 (2000); Western Australian Herbarium, in *FloraBase*, http://florabase.dpaw.wa.gov.au/ [accessed 1 March 2014].

Illustration. B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1038, Figure 310D (1992) [as *Actinoschoenus* sp. E].

Perennial, caespitose sedge, 0.4–1 m high. *Culms* 0.5–0.8 mm diam., obtusely 5-ridged (rarely a few culms 4-ridged), densely shortly hairy throughout or glabrescent especially on the ridges. *Leaves* densely hairy; uppermost leaf 35–70 mm long, the blade 2–5 mm long. *Inflorescence* of 3–6 scarcely spreading spikelets, often resembling a solitary spikelet. *Bracts* many, greenish, gradually increasing in size from base upwards, densely shortly hairy; basal bract 3–5 mm long; uppermost bract *c.* 6 mm long, with a point or short blade up to 1.7 mm long. *Spikelets* compressed, narrowly ovate in outline, 7–11 mm long, *c.* 2 mm wide. *Glumes* 4–6, distichous to almost spirally arranged, pale to medium brown, densely minutely hairy; uppermost glumes narrowly ovate, 7–9 mm long, acute, often apiculate. *Stamens* 3; anther *c.* 4 mm long. *Style* undivided for 5.3–7 mm; base triangular or narrowly triangular in outline, 0.8–1.5 mm long, 0.5–0.8 mm wide; stigmatic branches 3, about as long as or somewhat longer than remainder of style. *Nut* with a stipe or basal contraction 0.8–1.5 mm long; body whitish or pale brown, *c.* 3 mm long, 1.6–2 mm wide, smooth to slightly tuberculate-rugose between the angles. C_3 photosynthetic pathway inferred from anatomy. (Figures 1F, 4)

Diagnostic characters. *Culms* 0.5–0.8 mm diam., 5-ridged, nearly glabrous to densely hairy, the hairs all short. *Inflorescence* of 3–6 spikelets; bracts many or intergrading with the glumes, the uppermost bract longest; minutely hairy. *Uppermost glumes* 7–9 mm long, densely minutely hairy.

Other specimens examined. WESTERN AUSTRALIA: near creek on Kalumburu road, 174.4 km by road N from junction with Gibb River to Ellenbrae road, 30 Apr. 1985, *T.E.H. Aplin et al.* 817 (PERTH); *c.* 10 km E of Purulba Massif, Prince Regent Nature Reserve, 2 Feb. 1999, *M.D. Barrett* 710 (PERTH); 6.7 km NE of Bachsten Creek campsite, Prince Regent Nature Reserve, 3 Feb. 1999, *M.D. Barrett* 747 (PERTH); Roe River [pavement 1] on mainland, 3 km ESE of Gertrude Cove, Kiska Island, 23 Apr. 2008, *R.L. Barrett & M.D. Barrett* RLB 4597 (PERTH); HR1 Site, Harding Range,

Figure 4. *Actinoschoenus pentagonus*. A – plant base with sand-binding roots; B – culms; C – inflorescence; D – SEM of culm; E – SEM of glume; F – SEM of nut. Scale bars = 500 µm (D); 1 mm (E, F). Images from *R.L. Barrett & M.D. Barrett* RLB 4597 (A–C) and *R.L. Barrett & M.D. Barrett* RLB 3776 (D–E). Photographs by R.L. Barrett.

20 km WNW of Munja, N of Walcott Inlet, 13 Jan. 2010, *R.L. Barrett, M. Maier & P. Kendrick* RLB 6009 (BRI, CANB, MEL, NE, NSW, PERTH); Governor Island, Napier Broome Bay, 19 May 1986, *E.A. Chesterfield, S.J. Forbes & J.H. Willis* EAC 247 (MEL, NSW, NT *n.v.*, PERTH); Mitchell Plateau, 26 Feb. 1980, *C.R. Dunlop* 5309 [distributed as 5306] (BRI *n.v.*, CANB, DNA, K *n.v.*, NSW, NT *n.v.*, PERTH); *c.* 1.4 km S of Ila Point, West Governor Island, Napier Broome Bay, 19 May 1984, *S.J. Forbes* 2061 (MEL *n.v.*, NT *n.v.*, PERTH); base of Anjo Peninsula (between Napier Broome Bay and Vansittart Bay), 5 km N of West Bay landing, 22 May 1984, *S.J. Forbes* 2114 (CANB, L *n.v.*, MEL, NSW, NT *n.v.*, PERTH); Blyxa Creek, Prince Regent River Reserve, 19 Aug. 1974, *A.S. George* 12454 (NT *n.v.*, PERTH 2 sheets); Mertens Creek, Mitchell Plateau, 31 May 1988, *S.W.L. Jacobs & Peter G. Wilson* SWLJ 5813 (DNA *n.v.*, NSW, PERTH); adjacent to King George River above Falls, 7 June 1992, *K.F. Kenneally* 11266 (NSW, PERTH); Mitchell Falls walking track, Mitchell Plateau, 20 July 1988, *M. Parris* 9392 (CANB, PERTH); *c.* 1 km SW of Mitchell Plateau track on western side of King Edward River crossing, 2 July 2002, *K.L. Wilson* 10096 (EIU, GENT, NSW, NY, PERTH, PRE); 6 km N of Kalumburu on Pago road, 3 July 2002, *K.L. Wilson* 10103 (NE, NSW, PERTH); parking area at start of path to Mitchell Falls, 1 July 2002, *K.L. Wilson* 10092 (L, NSW, PERTH). NORTHERN TERRITORY: Keep River National Park, Spirit Hills section, 10 May 2008, *I.D. Cowie* 12099 (B *n.v.*, DNA *n.v.*, MO *n.v.*, NSW); Spirit Hills section, Keep River National Park, 10 May 2008, *I.D. Cowie* 12104 (DNA *n.v.*, NSW, PERTH); *c.* 19 km NNW of Bullo River homestead, Spirit Hills, Keep River National Park, 22 Mar. 2009, *I.D. Cowie* 12291 (DNA *n.v.*, MO *n.v.*, NSW, PERTH); Spirit Hills Conservation Reserve, *c.* 100 km N of Ranger Station, 13 May 2011, *D.L. Lewis* 1720 (CANB, DNA *n.v.*, NSW).

Phenology. Flowers and fruits from February to May, also recorded in August.

Distribution and habitat. Grows in sand or gravelly soil on sandstone in open woodland with *Triodia* spp. From the north Kimberley region, between Mitchell Plateau, Prince Regent River Reserve, Governor Island and King Edward River, and just into the western Northern Territory near Keep River.

Conservation status. *Actinoschoenus pentagonus* appears to be widespread and is not currently threatened.

Etymology. The epithet is from the Greek *penta-* (five-) and *-gonus* (angled), in reference to the five-ridged culms in this species.

Notes. The base of the plant seems to be more resinous than in the other species of *Actinoschoenus* described here. Because the spikelets are closely associated and the inflorescence bracts are numerous, the head can easily be mistaken for a single spikelet.

Actinoschoenus pentagonus appears to be similar to the species referred to as *Fimbristylis* sp. G in Latz (1990) [= *A.* sp. Mount Brockman (R.C. Hinz 362); CHAH 2007–] but with fewer culm ribs (5 *vs* 5–9), larger spikelets (7–11 *vs* 4.5–7 mm long) and fewer of them per head (3–6 *vs* 3–10 per head). It is most similar to *A. glabrispiculus* and readily distinguished by the inflorescence having 3–6 spikelets (*vs* solitary), 5-ridged culms (*vs* 4-ridged), and densely minutely hairy upper bracts and glumes (*vs* glabrous).

There appear to be two variants of this species, the typical variant with densely hairy culms (Figure 4B), and a second variant with glabrous to sparsely hairy culms (e.g. *R.L. Barrett & M.D. Barrett* RLB 3776; Figure 4D). Further investigation is required to determine whether there are other differences that may justify the recognition of two taxa.

The vernacular name of Five-angled Actinoschoenus is suggested.

Actinoschoenus quadricostatus Rye, R.L.Barrett & M.D.Barrett, *sp. nov.*

Type: Uwins Island, Bonaparte Archipelago, Western Australia [precise locality withheld for conservation reasons], 6 June 2008, *M.N. Lyons* 6020 (*holo*: PERTH 08615497; *iso*: CANB, NE, NSW).

Actinoschoenus sp. C, B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1037, Figure 310B (1992).

Actinoschoenus sp. C Kimberley Flora (P.G. Wilson s.n. 12/5/72), G. Paczkowska & A.R. Chapman, *West. Austral. Fl.: Descr. Cat.*, p. 41 (2000); Western Australian Herbarium, in *FloraBase*, http://florabase.dpaw.wa.gov.au/ [accessed 1 March 2014].

Illustration. B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1038, Figure 310B (1992) [as *Actinoschoenus* sp. C].

Perennial, caespitose sedge, 0.2–0.6 m high. *Culms* 0.5–0.75 mm diam., acutely 4-ridged, densely shortly hairy and with scattered much longer hairs to 0.6 mm long. *Leaves* densely covered by short and long hairs; uppermost leaf 25–65 mm long, with a blade 6–10 mm long. *Inflorescence* of 1 spikelet or a head of 2 or 3 somewhat spreading spikelets. *Bracts* 2 or 3, hairy, the longest bract basal; basal bract 6–10 mm long, with a blade 5–8 mm long. *Spikelets* strongly compressed, narrowly ovate in outline, 7–9 mm long, 1.5–3 mm wide. *Glumes* 4–6, distichous, with a green keel and brown sides;

upper glumes narrowly ovate, 6–8 mm long, glabrous or with a few hairs on midvein, apiculate. *Stamens* 3; anther not seen. *Style* undivided for 5–6 mm; base narrowly triangular in outline, 1.5–2 mm long, *c.* 0.5 mm wide; stigmatic branches 3, about as long as remainder of style. *Nut* with a stipe or contracted base 0.7–1 mm long; body 2.2–2.5 mm long, 1.8–2 mm wide, transversely tuberculate-ridged. C_3 photosynthetic pathway inferred from anatomy. (Figures 1G, 5)

Diagnostic characters. *Culms* acutely 4-ridged, densely hairy, most of the hairs short but some much longer ones scattered along the ridges. *Inflorescence* of 1–3 spikelets; bracts 2 or 3, the basal bract longest. *Upper glumes* 6–8 mm long, glabrous or with a few hairs on midvein.

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] May 1943, *Rev. G.W. Holmes s.n.* (MEL, PERTH); 13 Feb. 2009, *G.J. Keighery s.n.* (NSW, PERTH); 8 June 2008, *M.N. Lyons* 6068 (PERTH); 12 May 1972, *P.G. Wilson s.n.* (PERTH); 7 July 1973, *P.G. Wilson* 11426 (PERTH).

Phenology. Flowers and fruits from February to July.

Distribution and habitat. Recorded in woodland, sometimes associated with pools on sandstone. Endemic to the Kimberley region and known only from the Bonaparte Archipelago on Augustus Island, Uwins Island, St Andrews Island (Lyons *et al.* 2013) and the adjacent mainland near Kunmunya Hill.

Conservation status. *Actinoschoenus quadricostatus* is listed by Jones (2014) as Priority One under Department of Parks and Wildlife Conservation Codes for Western Australian Flora, under the name *A.* sp. C Kimberley Flora (P.G. Wilson s.n. 12/5/72).

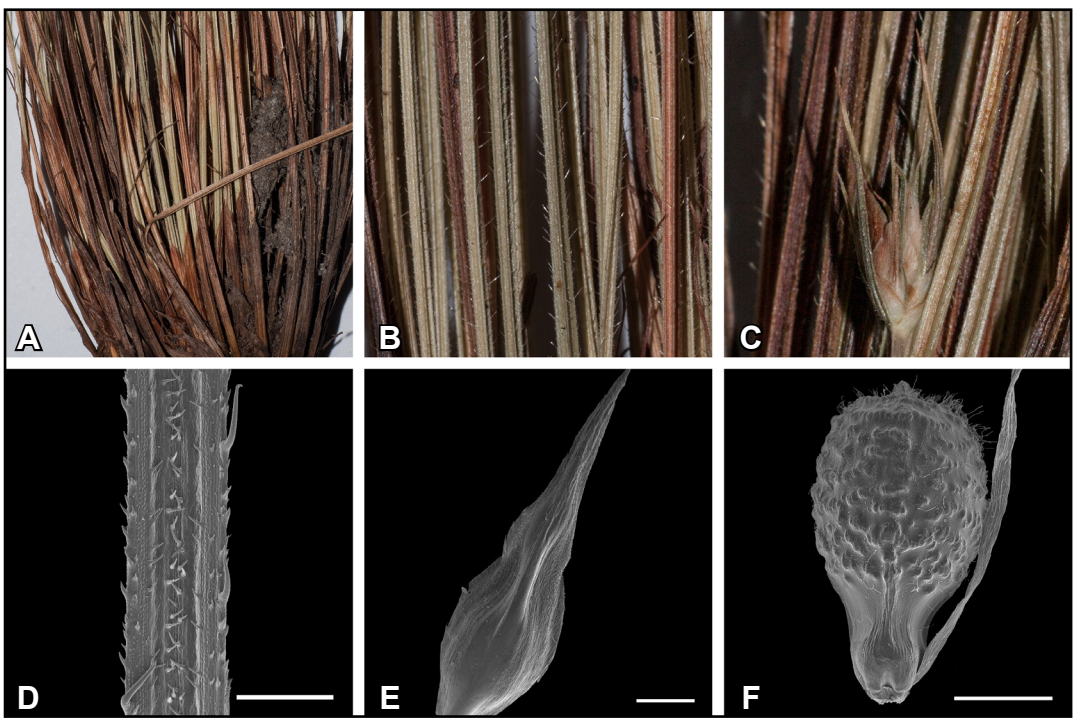

Figure 5. *Actinoschoenus quadricostatus*. A – plant base; B – culms; C – inflorescence; D – SEM of culm; E – SEM of glume; F – SEM of nut. Scale bars = 500 μm (D); 1 mm (E, F). Images from *M.N. Lyons* 6020. Photographs by R.L. Barrett.

Etymology. The epithet is from the Latin *quadri-* (four-) and *costatus* (ribbed), in reference to the four-ribbed culms.

Notes. Morphologically similar to *A. arthrostyloides* but differing in having very slender, 4-ribbed culms (*vs* 5(6)-ridged), 1–3 spikelets per head (*vs* (1)2–7), and with upper glumes glabrous or nearly so (*vs* minutely hairy distally on sides and midvein).

The vernacular name of Four-ribbed Actinoschoenus is suggested.

Actinoschoenus ramosus Rye, R.L.Barrett & M.D.Barrett, *sp. nov.*

Type: upper Lawley River, Lawley River National Park, Western Australia [precise locality withheld for conservation reasons], 12 March 2014, *R.L. Barrett* RLB 8988 (*holo*: PERTH 08614911; *iso*: BRI, DNA, K, NE, NSW).

Actinoschoenus sp. A, B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1037, Figure 310A (1992).

Actinoschoenus sp. A Kimberley Flora (C.R. Dunlop 5303), G. Paczkowska & A.R. Chapman, *West. Austral. Fl.: Descr. Cat.*, p. 41 (2000); Western Australian Herbarium, in *FloraBase*, http://florabase.dpaw.wa.gov.au/ [accessed 1 March 2014].

Illustration. B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1038, Figure 310A (1992) [as *Actinoschoenus* sp. A].

Perennial, caespitose sedge, 0.3–0.6 m high. *Culms* 0.3–0.4 mm diam., lax, obtusely 3- or 4-ridged, scabridulous immediately below inflorescence, elsewhere glabrous or nearly so. *Leaves* usually with short hairs on blade and orifice of sheath, glabrous or slightly shortly hairy below; uppermost leaf 45–85 mm long, with a blade 1–7 mm long. *Inflorescence* a loose simple or compound arrangement of 3 or more spikelets, the peduncle and each ray bearing 1 spikelet; primary rays 2–4, 3–8 mm long; secondary rays 0–2. *Bracts* 2 or 3, ciliate to almost glabrous on sheath, shortly hairy on blade, the longest bract basal, the basal bract 4–7 mm long, with a blade 3–5 mm long. *Spikelets* not very compressed, narrowly ovate in outline, 5.5–7 mm long, 1–1.5 mm wide. *Glumes c.* 6, 4-ranked to slightly spirally arranged, green on keel and ferruginous on sides, glabrous; upper glumes narrowly ovate, 4.5–5 mm long, usually slightly apiculate. *Stamens* 3; anther 3–4 mm long. *Style* undivided for 2–4 mm; base triangular in outline, *c.* 0.5 mm long, *c.* 0.3 mm wide; stigmatic branches 3, about as long as or longer than remainder of style. *Nut* with a stipe or basal contraction 0.3–0.5 mm long; body whitish, 1.3–1.4 mm long, 0.9–1.1 mm wide, transversely tuberculate-ridged. C_3 photosynthetic pathway inferred from anatomy. (Figures 1H, 6)

Diagnostic characters. *Inflorescence* of 3 or more spikelets, with 2–4 primary rays and often also secondary rays, each bearing 1 spikelet, the basal bract longest. *Upper glumes* 4.5–5 mm long.

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 25 Jan. 2007, *R.L. Barrett & M.D. Barrett* RLB 3860 (K, NSW, PERTH); 25 Jan. 2007, *R.L. Barrett & M.D. Barrett* RLB 3955 A (NSW, PERTH); 22 Apr. 2008, *R.L. Barrett & M.D. Barrett* RLB 4529 (PERTH); 15 Jan. 2010, *R.L. Barrett & M. Maier* RLB 6046 (NE, NSW, PERTH); 19 Jan. 2010, *R.L. Barrett, M. Maier & P. Kendrick* RLB 6263 (CANB, PERTH); 25 Jan. 2010, *R.L. Barrett & M.D. Barrett* RLB 6431 (PERTH); 24 Feb. 1980, *C.R. Dunlop* 5303 (BRI, *n.v.*, CANB, DNA, NSW, NT, PERTH); 19 Jan. 1982, *K.F. Kenneally* 7796 (NSW, PERTH).

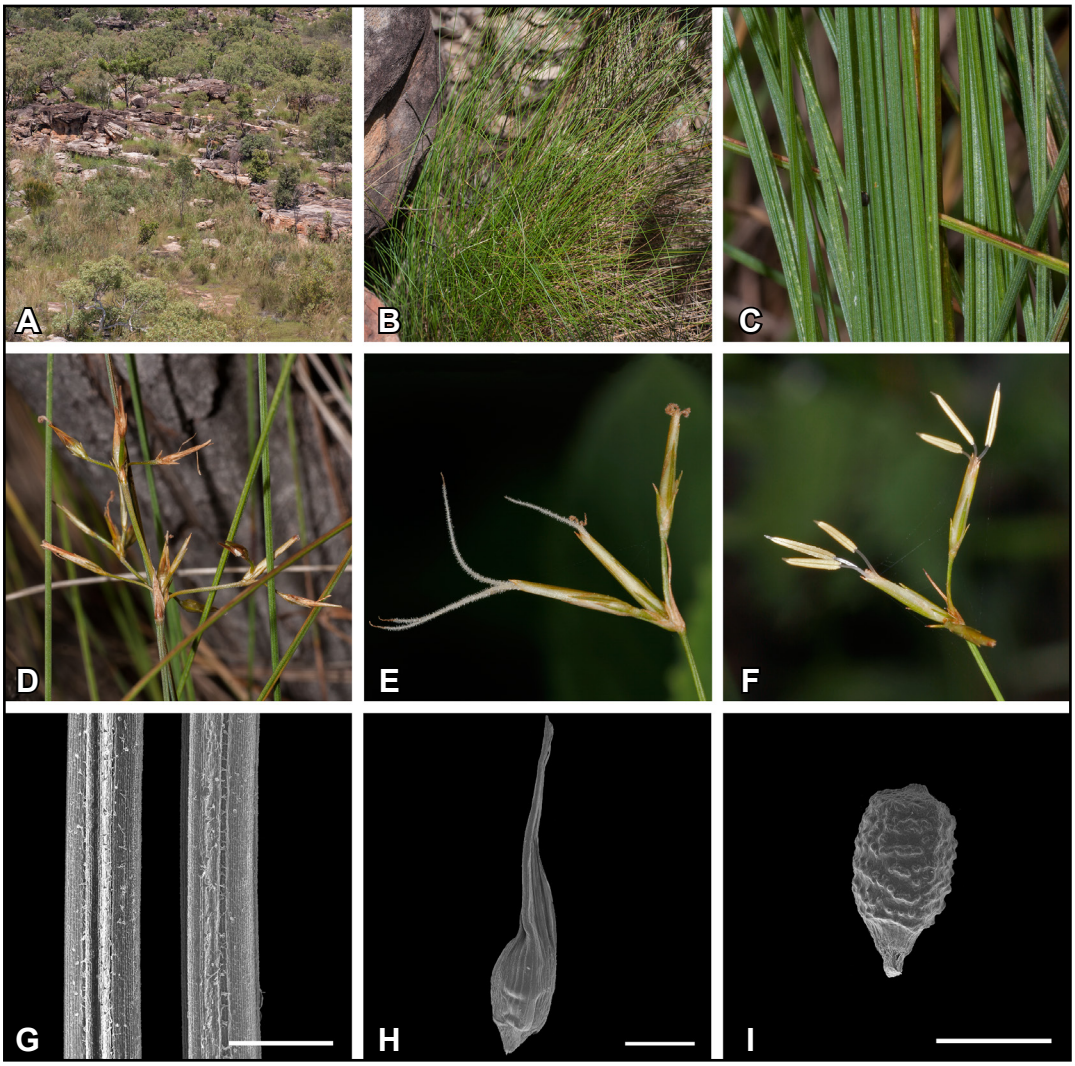

Figure 6. *Actinoschoenus ramosus*. A – habitat on sand over broken sandstone; B – lax habit; C – culms; D – openly branching inflorescence; E – spikelets showing style branches; F – spikelets showing anthers; G – SEM of culm; H – SEM of glume; I – SEM of nut. Scale bars = 500 μm (G); 1 mm (H, I). Images from *R.L. Barrett* RLB 8988 (A–F) and *R.L. Barrett* RLB 3860 (G–I). Photographs by R.L. Barrett.

Phenology. Flowers and fruits recorded from January to February.

Distribution and habitat. Apparently endemic to the Kimberley region where it is known between the Lawley River, Mitchell Plateau and the Prince Regent River. Recorded in sand amongst sandstone rocks or in skeletal sand on sandstone in open woodland, often between boulders that offer a degree of shading; one record is 'adjacent to a watercourse'.

Conservation status. Recently listed as Priority Three under Department of Parks and Wildlife Conservation Codes for Western Australian Flora (Western Australian Herbarium 1998–) under the name *A*. sp. A Kimberley Flora (C.R. Dunlop 5303).

Etymology. The epithet is from the Latin *ramosus* (branched) in reference to the openly branched inflorescence.

Notes. The morphology of *A. ramosus* is very distinct and it is easily separated from all other named species in the genus by the openly branched inflorescence, the other species all having spikelets more or less sessile in a head.

Collections from the vicinity of the East Alligator River, Northern Territory (e.g. *C.R. Dunlop* 4403; *R. Fensham* 872; *J. Russell-Smith* 8423 *& J. Brock*) known by the phrase name *Fimbristylis* sp. Deaf Adder Gorge (C.R. Dunlop 4403) at DNA are evidently very closely related to *A. ramosus*. Indeed, the DNA duplicate of *C.R. Dunlop* 5303 (the voucher specimen for *A.* sp. A Kimberley Flora, upon which *A. ramosus* is based), is determined there as *F.* sp. Deaf Adder Gorge, highlighting their close similarity. While specimens from both states are very similar in general appearance, the Northern Territory collections have smaller spikelets and fruits, and thinner, 3(4)-ribbed culms relative to the thicker, (3)4-ribbed culms of the Western Australian collections seen. The culm differences are illustrated in Figure 1H–K. The differences in spikelet, fruit and culm size may represent clinal variation within a single taxon or *F.* sp. Deaf Adder Gorge may be a distinct taxon; further study of *F.* sp. Deaf Adder Gorge is underway by one of us (KLC) and it is retained as separate here pending the outcome of that study.

The vernacular name of Soft Actinoschoenus is suggested.

Fimbristylis Vahl

Fimbristylis helicophylla Rye, R.L.Barrett & M.D.Barrett, *sp. nov.*

Type: east of Theda Station Homestead, Western Australia [precise locality withheld for conservation reasons], 11 March 2014, *R.L. Barrett* RLB 8945 (*holo*: PERTH 08614881; *iso*: BM, BRI, CANB, DNA, GENT, MEL, NE, NSW, NY, PERTH).

Fimbristylis sp. G, B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1093, Figure 317R (1992).

Fimbristylis sp. G Kimberley Flora (A.C. Beauglehole 51810), G. Paczkowska & A.R. Chapman, *West. Austral. Fl.: Descr. Cat.*, p. 49 (2000); Western Australian Herbarium, in *FloraBase*, http://florabase.dpaw.wa.gov.au/ [accessed 1 March 2014].

Illustration. B.L. Rye in J.R. Wheeler (ed.), *Fl. Kimberley Reg.*, p. 1076, Figure 317R (1992) [as *Fimbristylis* sp. G].

Perennial tufted sedge, 0.35–0.60 m high, with a short rhizome. *Culms* 1.0–1.4 mm wide, striate, glabrous. *Lowest leaves* initially distichous, usually 5–17 cm long, the sheath green to pale brown to dark red-brown, almost glabrous with just a few ciliate hairs at the apex, the blade 2.0–3.6 mm wide, twisted along its length, glabrous, or with scattered ciliate hairs on margins, margins pale, thickened. *Culm-sheathing leaves* 1 or 2 per culm, reduced to sheath, almost glabrous with just a few ciliate hairs at the membranous apex, 8.5–12 cm long. *Inflorescence* a cyme or compound cyme, with a central sessile spikelet and 1–4 pedunculate lateral spikelets; primary rays 1–3, erect to spreading, 15–30 mm long. *Bracts* usually 2, reduced to sheath, rather glume-like, with broad, membranous margins reaching apex, ciliate, the basal bract 5.3–6.2 mm long. *Spikelets* pale brown, ovoid or narrowly obloid-ellipsoid to almost globular, 6.2–10.4(–12.1) mm long, 3.1–6.1 mm diam., many-flowered, obtuse; axis not prominently winged. *Glumes* spirally arranged, with a prominent green and red-brown keel and red-brown-spotted, broad, membranous margins, oblong-elliptic to almost circular, 4–5 mm long, ciliate,

emarginate. *Stamens* 3; filament white, 4–6 mm long, anther 2.0–2.3 mm long. *Style* triquetrous, glabrous except on base or slightly scabridulous on angles, undivided for *c.* 3 mm; base prominently enlarged, triangular to broadly triangular in outline, 0.3–0.4 mm wide, ciliate on each angle and with larger, patent to retrorse hairs at base, the largest *c.* 0.4 mm long; stigmatic branches 3, shorter than remainder of style. *Nut* very shortly stipitate, brown to black, trigonous with convex faces, subterete, broadly obovate in outline, 0.8–1.0 mm long, 0.7–0.8 mm wide, tuberculate. (Figure 7)

Diagnostic characters. *Perennial* sedge. *Culms* 1.0–1.4 mm wide, striate. *Leaves* with blade 2.0–3.6 mm wide, twisted along its length, margins pale, thickened. *Inflorescence* a cyme or compound cyme, with a central sessile spikelet and 1–4 pedunculate lateral spikelets. *Spikelets* ovoid to almost globular, 6.2–10.4(–12.1) mm long. *Glumes* spirally arranged, with red-brown-spotted, broad, membranous margins, 4–5 mm long, ciliate. *Nut* trigonous, 0.8–1.0 mm long, 0.7–0.8 mm wide, tuberculate.

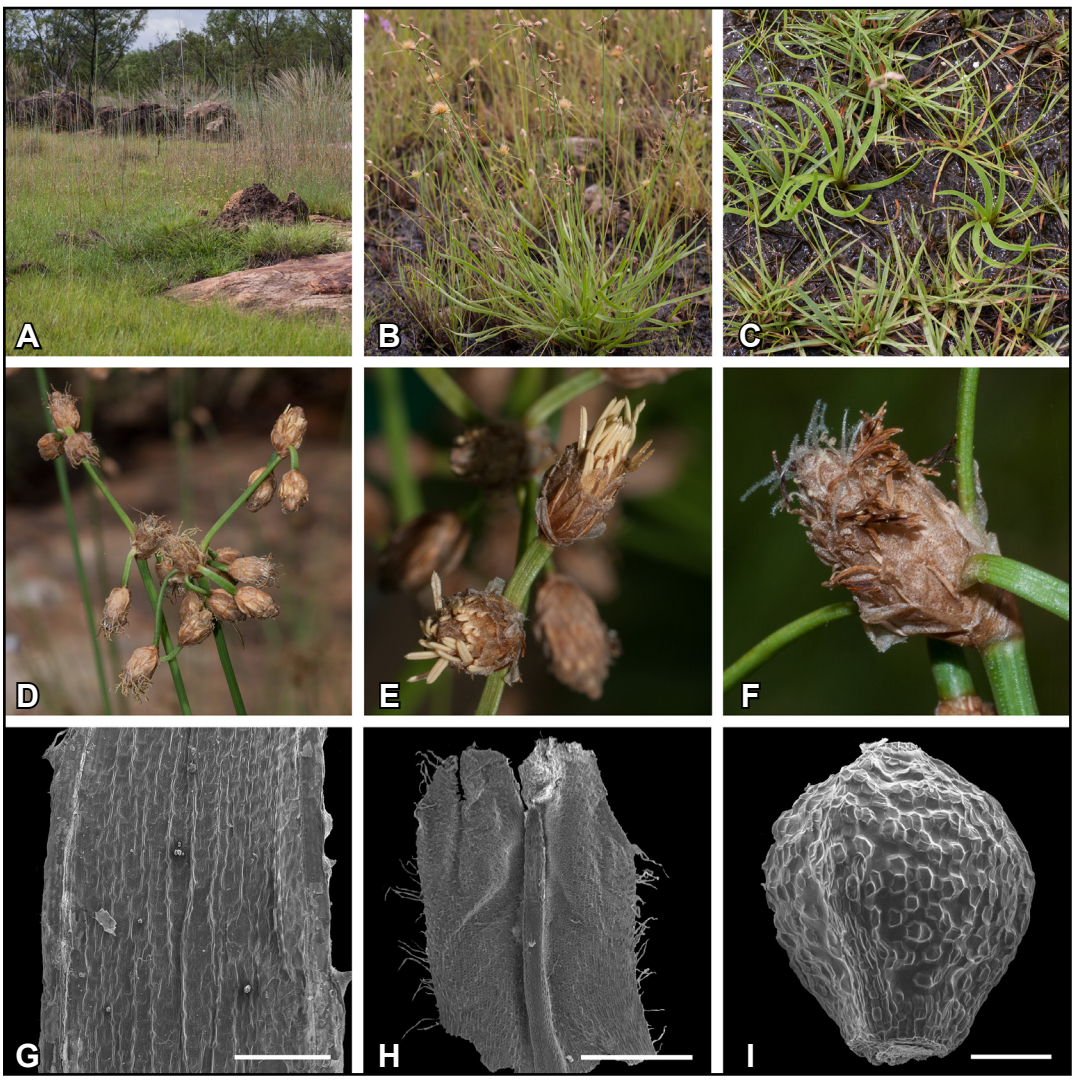

Figure 7. *Fimbristylis helicophylla*. A – habitat; B – habit; C – leafy rosettes with twisted leaves; D – branched inflorescence; E – spikelets showing anthers; F – spikelet showing style branches; G – SEM of leaf; H – SEM of glume; I – SEM of nut. Scale bars = 500 μm (G); 1 mm (H); 200 μm (I). Images from *R.L. Barrett* RLB 8945. Photographs by R.L. Barrett.

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 22 Feb. 2005, *M.D. Barrett* MDB 1643 B (PERTH); 25 Mar. 2010, *M.D. Barrett & R.L. Barrett* MDB 2781 (PERTH); 4 Dec. 1994, *R.L. Barrett & M.D. Barrett* RLB 1009 (PERTH); 16 Feb. 2006, *R.L. Barrett & M.D. Barrett* RLB 3117 (NE, NSW, PERTH); 6 June 2012, *R.L. Barrett* RLB 7687 (DNA, NE, NSW, PERTH); 31 May 1976, *A.C. Beauglehole* 51810 (NT, PERTH).

Phenology. Flowers and fruits recorded for March to June.

Distribution and habitat. Possibly endemic to the Kimberley region, known from Theda and Doongan Stations on the Kalumburu–Gibb River road, and south to Prince Regent National Park and the Harding Range.

Conservation status. *Fimbristylis helicophylla* is listed by Jones (2014) as Priority One under Department of Parks and Wildlife Conservation Codes for Western Australian Flora under the name *F.* sp. G Kimberley Flora (A.C. Beauglehole 51810).

Etymology. The epithet is from the Greek *helicus* (spirally twisted) and *-phyllus* (leaved), in reference to the leaves of this species which are distinctly twisted along their length.

Notes. Superficially similar to *F. lanceolata* C.B.Clarke, with which it grows on Theda Station, in having broad leaves, but readily distinguished when fertile by the relatively short, ovoid to almost globular spikelets (6.2–10.4(–12.1) vs 10–35 mm long) with pale brown glumes (vs mid-brown). *Fimbristylis helicophylla* has broad spikelets on rather curved branches like *F. rara* R.Br. and similar species placed in sect. *Leptocladae* Ohwi by Kern (1974). *Fimbristylis rara* is an annual with mid-brown (vs pale brown) spikelets, which are often shorter (2.5–7(–13) vs 6.2–10.4(–12.1) mm long). The broad, twisted leaves of *F. helicophylla* are unusual in this section.

The vernacular name of Twisted Leaf Fimbristylis is recommended.

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