

## New combinations in *Chordifex* (Restionaceae) from eastern Australia and new species from Western Australia

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### Abstract

Briggs, Barbara G. and Johnson, L.A.S. (Royal Botanic Gardens, Mrs Macquaries Road, Sydney, NSW 2000, Australia) 2004. *New combinations in Chordifex (Restionaceae) from eastern Australia and new species from Western Australia*. *Telopea* (10)3: 683–700. New combinations in *Chordifex* are provided for two species from New South Wales (*C. dimorphus* and *C. fastigiatus*) and two Tasmanian endemics (*C. hookeri* and *C. monocephalus*), extending the distribution of the genus to eastern Australia. Phylogenetic analysis of chloroplast DNA data has shown these species to be embedded in *Chordifex*, so that the latter is paraphyletic if they are excluded. These species were previously included in *Restio* and subsequently divided among the genera *Acion*, *Guringalia* and *Saropsis* which are now synonymised under *Chordifex*. The main concentration of *Chordifex* is in the south of Western Australia where there are sixteen species. Ten of these were formerly transferred from *Restio* and a further five of them are now described and illustrated. *C. microcodon* (occurring from near Eneabba south almost to Perth) and *C. sinuosus* (from near Geraldton to Perth and Yarloop) are widespread species, *C. capillaceus* (around South Stirling and Wellstead) is relatively common in a more restricted area, while *C. reseminans* (near Eneabba to Cataby) is endangered and *C. jacksonii* (near Walpole) vulnerable. The colliculate or ridged seed type of *Chordifex* contrasts with the smooth seeds of *Baloskion*; while the strongly ridged seeds of *C. sinuosus*, *C. reseminans* and *C. chaunocoleus* are compared with the colliculate seeds of other *Chordifex* species. Seed surface features show greater congruence with results from DNA data than does the presence or absence of the conspicuous culm anatomical feature of pillar cells in the chlorenchyma.

### Introduction

Extensive studies from a variety of approaches, but especially morphological and anatomical (Johnson & Briggs 1981; Linder 1984, 1985; Linder et al. 1998, 2000; Briggs & Johnson 1999), and DNA sequencing studies (Briggs et al. 2000, Eldenäs & Linder 2000) have resulted in classifications in which no genera of Restionaceae are common to the Australasian and the African regions. Since *Restio* is typified by an African species, and the Australian species previously referred to *Restio* are a diverse assemblage, the latter were divided among several genera (Briggs & Johnson 1998a, b). The majority of eastern Australian species were transferred to *Baloskion* Raf., while the largest group of Western Australian species were placed in the newly-described genus *Chordifex*, typified by the new species *C. stenandrus* B.G. Briggs & L.A.S. Johnson. Thus *Chordifex* has been regarded as a Western Australian endemic and included *C. abortivus* (Nees) B.G. Briggs & L.A.S. Johnson, *C. amblycoleus* (F. Muell.) B.G. Briggs & L.A.S. Johnson, *C. chaunocoleus* (F. Muell.) B.G. Briggs & L.A.S. Johnson, *C. crispatus* (R. Br.)

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\* BGB is responsible for the new combinations published here; the newly described species were distinguished and studied by both authors.

† Deceased 1 August 1997.

B.G. Briggs & L.A.S. Johnson, *C. gracilior* (F. Muell. ex Benth.) B.G. Briggs & L.A.S. Johnson, *C. isomorphus* (K.W. Dixon & K.A. Meney) B.G. Briggs & L.A.S. Johnson, *C. laxus* (R. Br.) B.G. Briggs & L.A.S. Johnson, *C. leucoblepharus* (Gilg) B.G. Briggs & L.A.S. Johnson, *C. ornatus* (Steud.) B.G. Briggs & L.A.S. Johnson and *C. sphacelatus* (R. Br.) B.G. Briggs & L.A.S. Johnson.

When we described *Chordifex* we also segregated from *Restio* three new, small genera, *Acion*, *Guringalia* and *Saropsis* (Briggs & Johnson 1998a) and transferred two species into *Acion* and one each into the latter two genera. These species differed from *Chordifex*, as it was then circumscribed, in lacking the distinctive and very prominent culm anatomical feature of pillar cells (Cutler 1966, Briggs & Johnson 1998a, 1999) extending across the chlorenchyma. These thick-walled cells divide the chlorenchyma into linear segments and produce a striated culm surface. They were among the major features characterising the anatomical groups distinguished by Cutler (1969) within *Restio* as then broadly circumscribed and defining a major multi-generic lineage in a tentative phylogeny of Restionaceae (Johnson & Briggs 1981). The presence of uninterrupted chlorenchyma led to comparisons of these four species being made principally with *Baloskion*, which also shares an eastern Australian distribution, rather than with *Chordifex*. Inflorescence, floral, and seed coat features (Figs 1, 2) all distinguish these species from *Baloskion*, while features of culm branching, culm sheaths, single or multiflowered spikelets, and numbers of cell layers in the chlorenchyma characterised each of the segregate genera.

Phylogenies based on DNA data for three segments of the chloroplast genome (*rbcL*, *trnL-trnF* and *matK*) strongly support the distinctness of the African and Australian lineages and the separation of *Chordifex* and *Baloskion*., but show *Acion*, *Guringalia* and *Saropsis* embedded within *Chordifex* (Briggs et al. 2000, Marchant pers. com.). Referring to these four eastern Australian species, Briggs et al. (2000) observed that 'It is notable that these associate with the south-western Australian genus *Chordifex*, which they resemble in seed ornamentation, rather than with *Baloskion*' and 'The phylogeny inferred from these [DNA] findings suggests that a prominent and distinctive feature of culm anatomy, the presence of pillar cells, may have been lost in several separate clades'. Thus pillar cells are now considered have evolved early in the diversification of Australian Restionaceae (although after divergence of *Lepyrodia* group) and presence or absence of pillar cells is considered to be unreliable basis for characterising monophyletic groups in Australian Restionaceae. Seed-coat characters, however, are given prominence by their congruence with DNA data in corroborating relationships that were previously considered unlikely on grounds of culm anatomy and biogeography. Other vegetative and reproductive features of the three eastern genera are compatible with those of *Chordifex*, which already includes a relatively diverse array of species. These three genera are therefore placed in synonymy and new combinations in *Chordifex* provided for the relevant species.

Congeneric with the named species of *Chordifex* are five Western Australian species that are described here. These were not collected until recent decades or were not distinguished from related species. The names now published were included (without formal description) in the conspectus of our classification of Australian Restionaceae (Briggs & Johnson 1999). Information on their features and biology, in advance of formal naming, was also given by Meney, Pate & Hickman (1999), who provide excellent illustrations of these and the already-named species. Further information on the biology, ecology and conservation of various species is given in other chapters of Meney and Pate (1999). An account of all species of *Chordifex* will be given in the *Flora of Australia* (Briggs, Johnson, Porter & Krauss, in preparation).

### ***Baloskion* and *Chordifex* seed surface patterns**

Seed surfaces in those Restionaceae with indehiscent or late-dehiscent fruit are mostly smooth or almost so. Where the seed is the disseminule, the seed surfaces show much variation and provide features that are synapomorphies of clades or assist in characterising genera (Linder 1984, Briggs & Johnson 1998a, 1999). In *Baloskion* the pedicel of the flower is fused to the subtending glume and the seeds are mostly dispersed within the late-dehiscent capsule, still attached to the glume, and the seed surface is almost smooth (Fig. 1). In most seed-dispersed species the outer cellular layer is white, fragile and easily removed. In most *Chordifex* species this layer is colliculate, with lines of convex cells with a thick cuticle, and these often also bear a pattern of smaller angular cells, apparently the imprint of the cells of the inner layer of the pericarp. Such features are shown by the four eastern Australian species transferred to *Chordifex* (Fig. 2) and by three of the newly described species: *C. capillaceus*, *C. microcodon* and *C. jacksonii* (Figs 3, 4). A small group of *Chordifex* species, however, have strikingly ridged seeds, as in the two new species *C. sinuosus* and *C. reseminans* (Figs 5, 6). Such seed ornamentation, seen also in *C. chaunocoleus*, but not in the somewhat similar species *C. sphacelatus* and *C. laxus*, appears to be an apomorphic development from the more widespread colliculate character state. The ridge- or colliculate-pattern is still clearly shown on the inner surface of the capsule wall after the seeds have been shed.

### **Synonymy and new combinations in *Chordifex***

*Chordifex* B.G. Briggs & L.A.S. Johnson, *Telopea* 7: 356 (1998).

**Synonyms:** *Acion* B.G. Briggs & L.A.S. Johnson, *Telopea* 7: 353 (1998); *Guringalia* B.G. Briggs & L.A.S. Johnson, *Telopea* 7: 353 (1998); *Saropsis* B.G. Briggs & L.A.S. Johnson, *Telopea* 7: 355 (1998).

#### **New combinations**

***Chordifex dimorphus* (R. Br.) B.G. Briggs, *comb. nov.***

Basionym: *Restio dimorphus* R. Brown, Prodr.: 246 (1810).

Synonym: *Guringalia dimorpha* (R. Br.) B.G. Briggs & L.A.S. Johnson, *Telopea* 7: 353.

***Chordifex fastigiatus* (R. Br.) B.G. Briggs, *comb. nov.***

Basionym: *Restio fastigiatus* R. Brown, Prodr.: 246 (1810).

Synonym: *Saropsis fastigiata* (R. Br.) B.G. Briggs & L.A.S. Johnson, *Telopea* 7: 356.

***Chordifex hookeri* (D.I. Morris) B.G. Briggs, *comb. nov.***

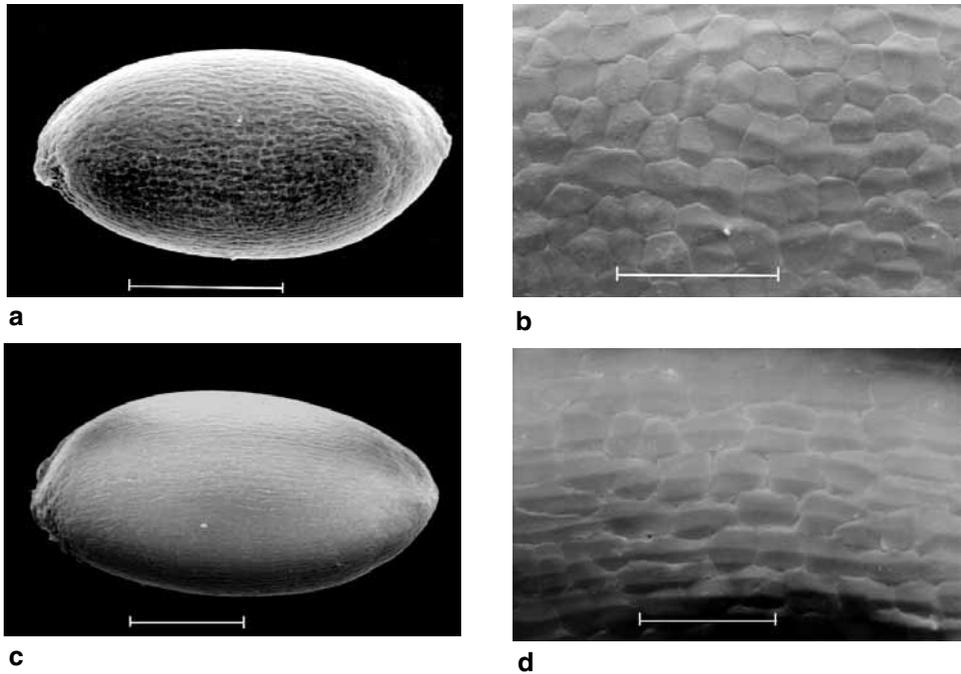
Basionym: *Restio hookeri* D.I. Morris in M.R. Banks et al. (eds), *Aspects Tasmanian Bot., Tribute to Winifred Curtis*: 33 (1991).

Synonym: *Acion hookeri* (R. Br.) B.G. Briggs & L.A.S. Johnson, *Telopea* 8: 22 (1998).

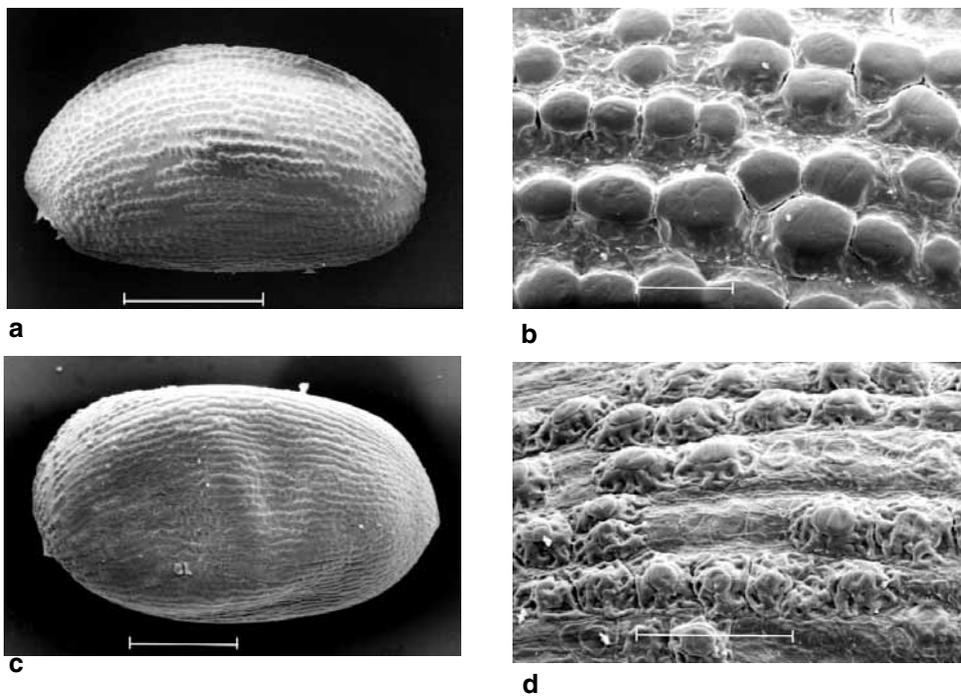
***Chordifex monocephalus* (R. Br.) B.G. Briggs, *comb. nov.***

Basionym: *Restio monocephalus* R. Brown, Prodr.: 245 (1810).

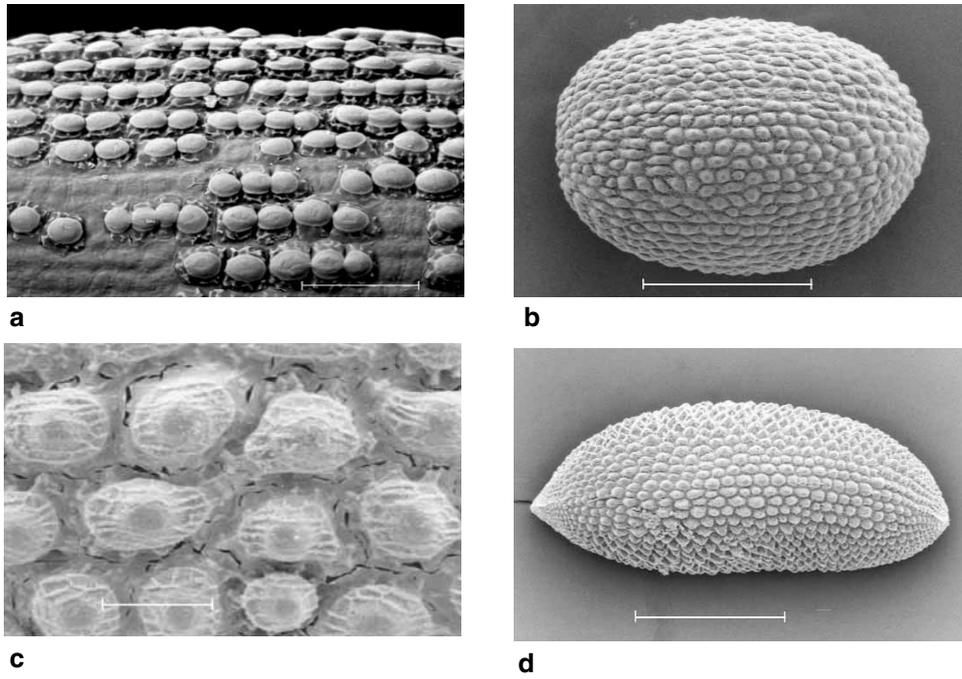
Synonym: *Acion monocephalum* (R. Br.) B.G. Briggs & L.A.S. Johnson, *Telopea* 7: 355 (1998).



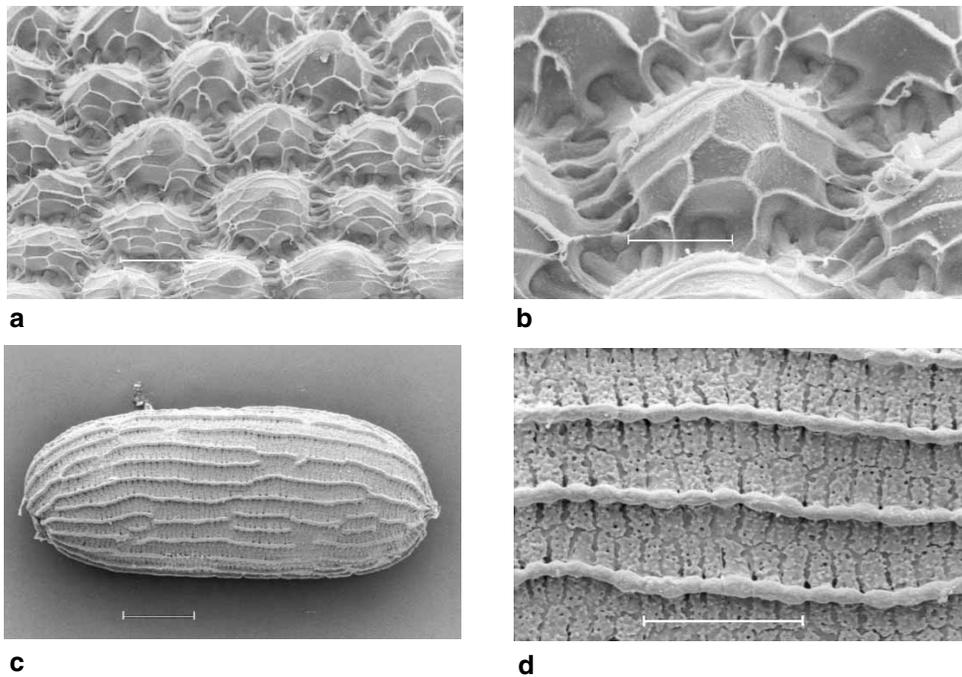
**Fig. 1.** Seed surfaces. **a, b**, *Baloskion pallens* (R. Br.) B.G. Briggs & L.A.S. Johnson (Bowenia State Forest, Qld., 5 May 1981, Johnson 8656 [NSW]); **c, d**, *Baloskion tetraphyllum* (Labill.) B.G. Briggs & L.A.S. Johnson subsp. *meiotachyum* (L.A.S. Johnson & O. Evans) B.G. Briggs & L.A.S. Johnson (Kendall, NSW, Bailey, Sep 1932 [NSW 47937]). Scale bars: a, c = 200  $\mu\text{m}$ ; b, d = 50  $\mu\text{m}$ .



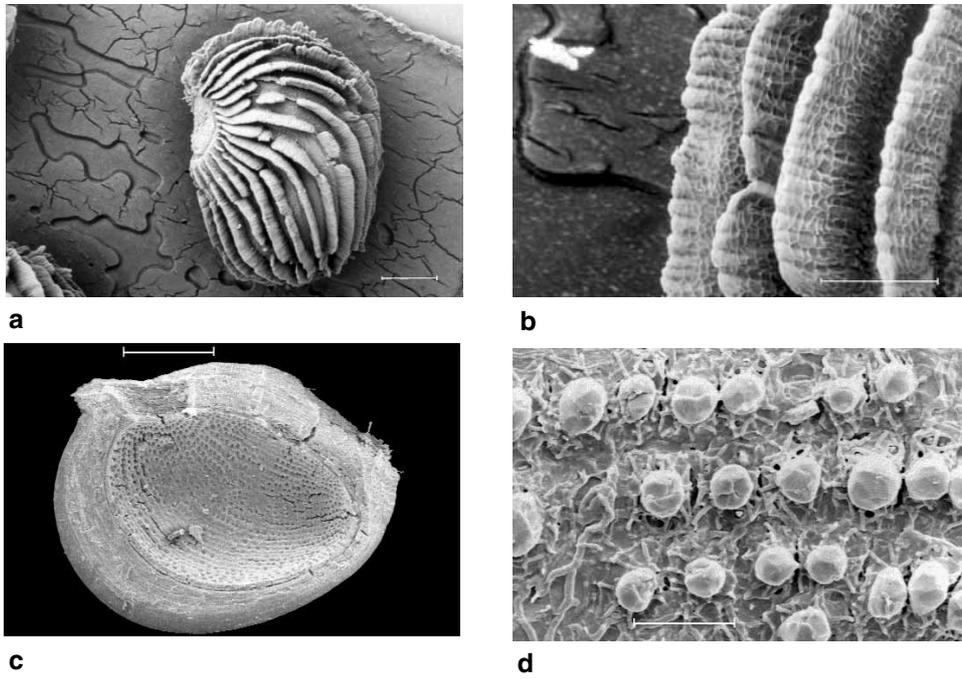
**Fig. 2.** Seed surfaces. **a, b**, *C. dimorphus*. (Ku-ring-gai Chase, Constable 18 Sep 1958 [NSW 48845]); **c, d**, *C. hookeri* (Mt Tim Shea, Tasmania, 18 Jan 1962, J. Vickery [NSW 57045]). Scale bars: a = 500  $\mu\text{m}$ ; b = 50  $\mu\text{m}$ ; c = 300  $\mu\text{m}$ ; d = 100  $\mu\text{m}$ .



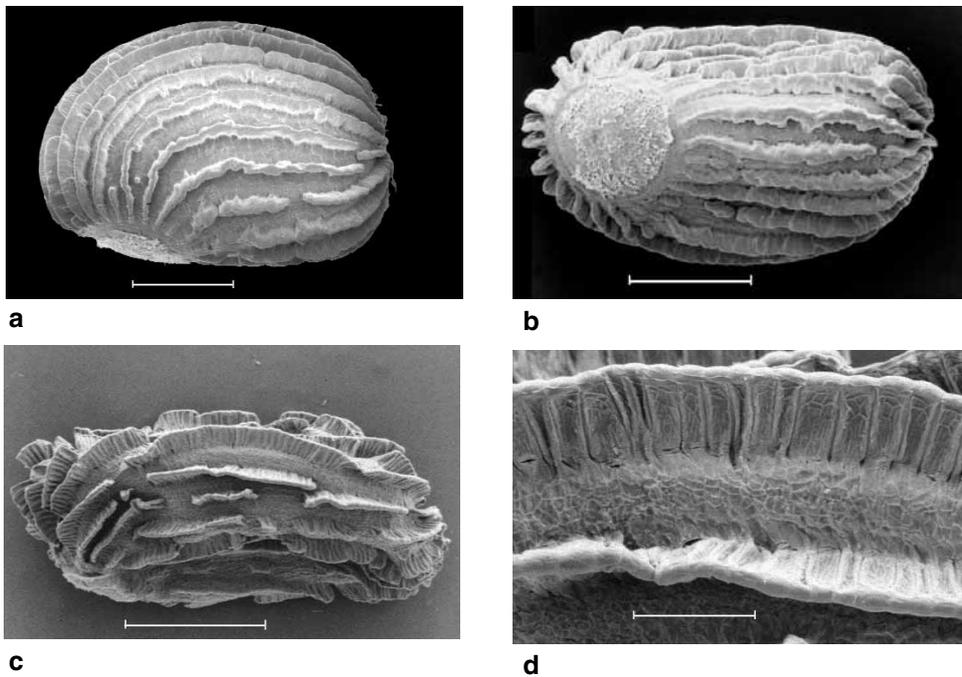
**Fig. 3.** Seed surfaces. **a**, *C. capillaceus* (Briggs 7662); **b**, **c**, *C. microcodon* (Briggs 7491); **d**, *C. jacksonii* (Briggs 9442). Scale bars: **a** = 80  $\mu\text{m}$ ; **b** = 500  $\mu\text{m}$ ; **c** = 50  $\mu\text{m}$ .



**Fig. 4.** Seed surfaces. **a**, **b**, *C. jacksonii* (Briggs 9442); **c**, **d**, *C. amblycoleus* (21 Km ENE of Karridale, 6 Oct 1984, B. Briggs 7575 & L. Johnson [NSW]). Scale bars: **a** = 50  $\mu\text{m}$ ; **b** = 20  $\mu\text{m}$ ; **c** = 200  $\mu\text{m}$ ; **d** = 100  $\mu\text{m}$ .



**Fig. 5.** Seed surfaces. **a, b**, *C. sinuosus* (Briggs 7445); **c, d**, *C. sphacelatus* (12 km WNW of Wellstead, 13 Sep 1990, Briggs *et al.* 8710 [NSW]). Scale bars: a = 400  $\mu\text{m}$ ; b = 170  $\mu\text{m}$ ; c = 500  $\mu\text{m}$ ; d = 50  $\mu\text{m}$ .



**Fig. 6.** Seed surfaces. **a, b**, *C. reseminans* (Briggs 9376); **c, d**, *C. chaunocoleus* (c. 8 km SW of Toodjay, 28 Sep 1990, Briggs *et al.* 8636 [NSW]). Scale bars: a, b, c, = 500  $\mu\text{m}$ ; d = 50  $\mu\text{m}$ .

### Description of new species

#### *Chordifex capillaceus* B.G. Briggs & L.A.S. Johnson, sp. nov.

Inter species *Chordifex* combinatione characterum sequentium distinguitur: rhizomata gracilia (1–1.5 mm diam.); culmi graciles (0.3–0.7 mm diam.); spiculae femineae fructiferae graciles elongataeque.

Type: Western Australia: 1 km W of South Stirling at north end of Pfeiffer Road, W.A., 8 Oct 1984, B.G. Briggs 7662 & L.A.S. Johnson ♀ (holo: NSW; iso AD, CANB, K, MO, MEL, PERTH).

Plants mostly forming a dense small clump. Rhizomes slender, horizontal, much branched and intertwined, to c. 15 cm long, c. 1.0–1.5 mm diam., red-brown and sparsely pubescent, with small brown, scarious, appressed scales. Culms slender, numerous and closely spaced on the rhizomes, 1.3–8 mm apart, erect, terete, 0.5–0.7 mm diam., glabrous above the lowest internode, striate; fertile culms mostly unbranched below the inflorescence, 5–20(–40) cm long, usually simple but occasionally branched, nodes (below the inflorescence) 1–3, the lowest internode mostly more slender (0.3–0.5 mm diam.) and often sparsely pubescent; sterile culms mostly shorter, repeatedly branched, the branches erect or flexuose and terete to compressed. Sheaths appressed; basal sheaths light-brown; cauline sheaths 4–10 mm long, green to brown, ciliate, smooth or slightly ribbed, acute with a caducous lamina c. 1 mm long. Male inflorescence of 1–3 erect or pendulous spikelets, lower spikelets on peduncles to 8(–15) mm long, upper spikelets sessile or shortly pedunculate; subtending bracts similar to culm sheaths. Female inflorescence of 1–2(–4) erect spikelets at the uppermost node(s). Male spikelets ovoid, 4–15 mm long, 2.5–6.0 mm wide; 3–15 glumes, all fertile, lanceolate, light-brown, glabrous or lowest glume apically pubescent, acute, 4.0–4.5 mm long. Female spikelets very narrow oblong, 8–15 mm long, 1.5–3.0 mm wide; glumes 3–5, all fertile, similar to males, 4.0–5.5 mm long; spikelet axis elongating in fruit to 15(–25) mm long, so that the flowers are widely separated. Male flowers: tepals 5, lanceolate, acute, membranous, pale, 2.6–3.0 mm long; outer tepals keeled, occasionally pubescent; inner tepals flat, glabrous; stamens 3, filaments 3.0–3.5 mm long, anthers (1.3–)1.8–2.1 mm long. Female flowers shortly pedicellate; tepals 5, similar to males; staminodes 3; styles 2, free almost to the base, mostly stigmatic. Capsule c. 1–2 mm long, smooth, brown. Seed oblong-cylindrical, c. 1.3 mm long, colliculate with lines of convex cells. (Figs 3a, 7).

The epithet is from the Latin *capillus*, a hair, referring to the very slender culms.

**Distribution:** occurs in the south of Western Australia from South Stirling to Chillinup and Wellstead, c. 100 km NE of Albany. Grows in heathy shrubland on yellow sand, often with laterite gravel; in somewhat poorly drained situations in a low-rainfall region.

**Conservation status:** common (Meney, Pate, Dixon, Briggs & Johnson 1999) and moderately widespread.

**Fire response:** killed by fire.

**Note:** Somewhat resembling *C. ornatus*, but culms shorter and more slender, with less branching of the vegetative culms; with small appressed culm sheaths; male spikelets ovoid, with fewer glumes and glumes acute. Culms of *C. ornatus* are 20–35 cm tall, 0.5–1 mm diam., with lax sheaths 8–17 mm long; the male spikelets are globular with 20–55 glumes and the glumes aristate. *Chordifex ornatus* occurs near Tambellup and the Stirling Range.

**Selected specimens examined:** Western Australia: Eyre: South Stirling, just W of township, 4 Oct 1976, *B. Briggs* 6586 ♂, 6602 ♀ (NSW, CANB, K, PERTH, RSA), 6603 ♂ (NSW, CANB, PERTH); 1 km W of South Stirling at N end of Pfeiffer road, 8 Oct 1984, *B.G. Briggs* 7661 & *L.A.S. Johnson* ♂ (NSW, AD, B, BOL, CANB, K, MEL, MO, PE, PRE, PERTH, RSA); Wellstead, Hassell Hwy, Apr 1992, *K. Meney* & *J. Pate* (NSW 254925); 2 km E of Wellstead, 29 Aug 1998, *B.G. Briggs* 9453 ♂, 9454 ♀ (NSW); 13 km NW of Black Head, 23 Sep 1973, *K. Newbey* 3840 ♀ (PERTH, NSW); 3.7 km along the Boat Harbour road from the turn-off on the Hassell Hwy, 25 Jun 1976, *D.J. McGillivray* 3498 & *A.S. George* ♀ (NSW, K, MO, PERTH), 3499 ♂ (NSW, AD, PERTH).

**2. *Chordifex microcodon* *B.G. Briggs & L.A.S. Johnson, sp. nov.***

Inter species *Chordifex* combinatione characterum sequentium distinguitur: planta caespitosa; culmi crassi (1.5–2.3 mm diam.), teretes, ramosi; spiculae campanulatae; spiculae masculae plerumque pendulae.

Type: Western Australia: 22.8 km E of Brand Hwy on Green Head–Coorow Road, Alexander Morrison Natl Park, 30 Sep 1984, *B.G. Briggs* 7733 & *L.A.S. Johnson* ♀ (holo: NSW; iso: K, PERTH).

Plant caespitose, the base with short brown scales partly covering a dense pale woolly pubescence. Culms numerous, densely clumped on the very short rhizomes, branched, mostly erect, ± terete, 40–70 cm long, main culms 1.5–2.3 mm diam., striate, basally pubescent with white appressed hairs; the branches straight or flexuose or occasionally convoluted and then usually barren; internodes several, 4.5–9.0 cm long. Sheaths lax, open, flaring from the base, 0.6–1.9 cm long, scarious, smooth to striate, dark tan, glabrous, obtuse to truncate, lamina c. 1–1.8 mm long. Inflorescence with long (to 15 cm), spreading lower branches and short upper branches, spikelets numerous; the males mostly pendulous on short, filiform pedicels; females erect; subtending bracts similar to culm sheaths. Male spikelets campanulate, 7–10 mm long, 3–4 mm wide; sterile lower glumes 15–21; fertile upper glumes 10–16, lanceolate, brown, usually glabrous, acuminate, 2.5–7.5 mm long; mucro 0.5–0.9 mm long. Female spikelets campanulate, slightly shorter than males; sterile lower glumes 6–13; fertile upper glumes 1–3(–11), similar to males, broad-lanceolate, 2–5 mm long; mucro c. 1 mm long. Male flowers: tepals 5, linear, membranous; outer tepals keeled, c. 3.5 mm long, sparsely pubescent; inner tepals slightly shorter, flat, glabrous; stamens 3; filaments filiform, 3.0–4.5 mm long; anthers 2.0–2.4 mm long, becoming spirally twisted. Female flowers: tepals 5, narrow lanceolate, rigid, acute; outer tepals keeled, c. 3.5 mm long, sparsely pubescent; inner tepals slightly shorter, flat, glabrous; staminodes 3; styles 2, mostly free, half-stigmatic. Capsule compressed, 2.0–2.5 mm long. Seed globose, c. 1.3 mm long, colliculate with lines of convex cells. (Figs 3b, c; 8).

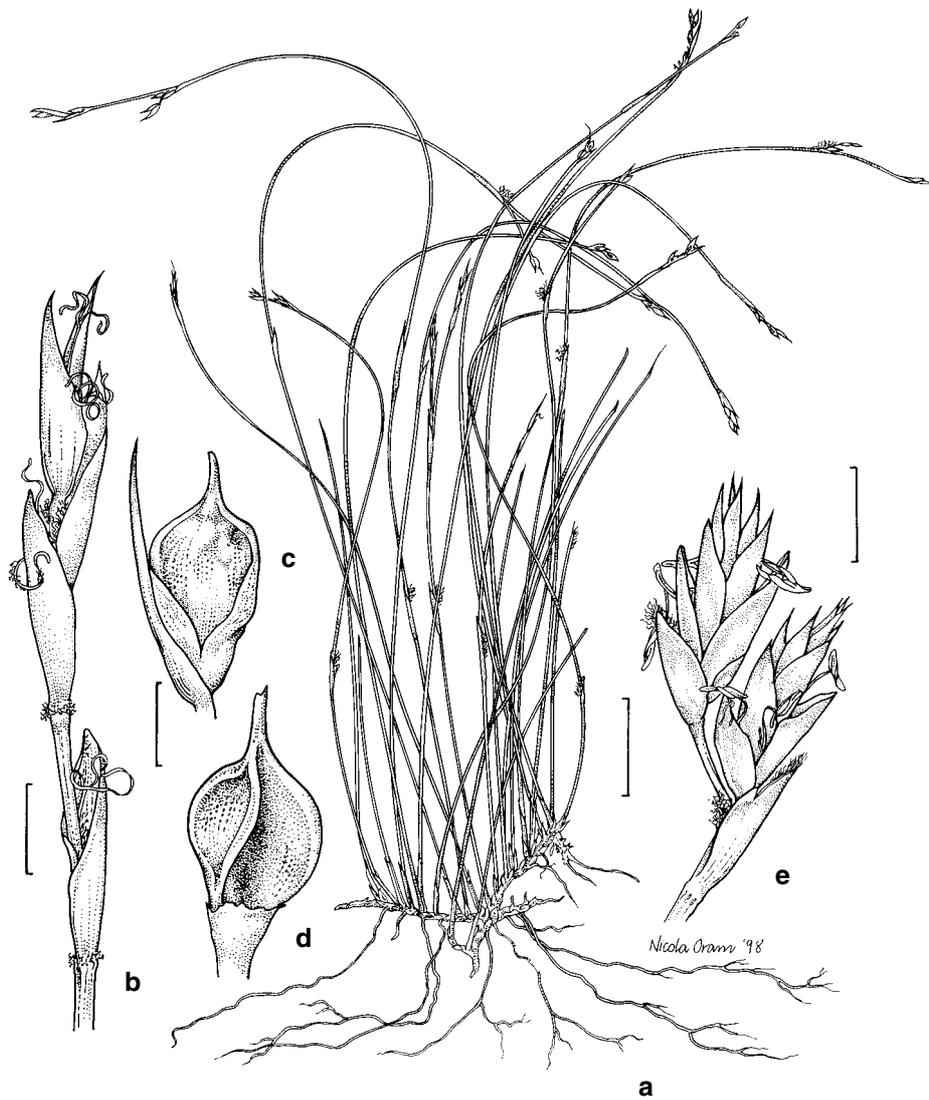
The epithet is from the Greek, *mikros*, small, and *kodon*, a bell, referring to the shape of the spikelets after anthesis.

**Distribution:** occurs in Western Australia from Eneabba to Regans Ford district and south to near Wanneroo. On deep sand, or sand over laterite, in heath and woodland, mostly in well-drained sites.

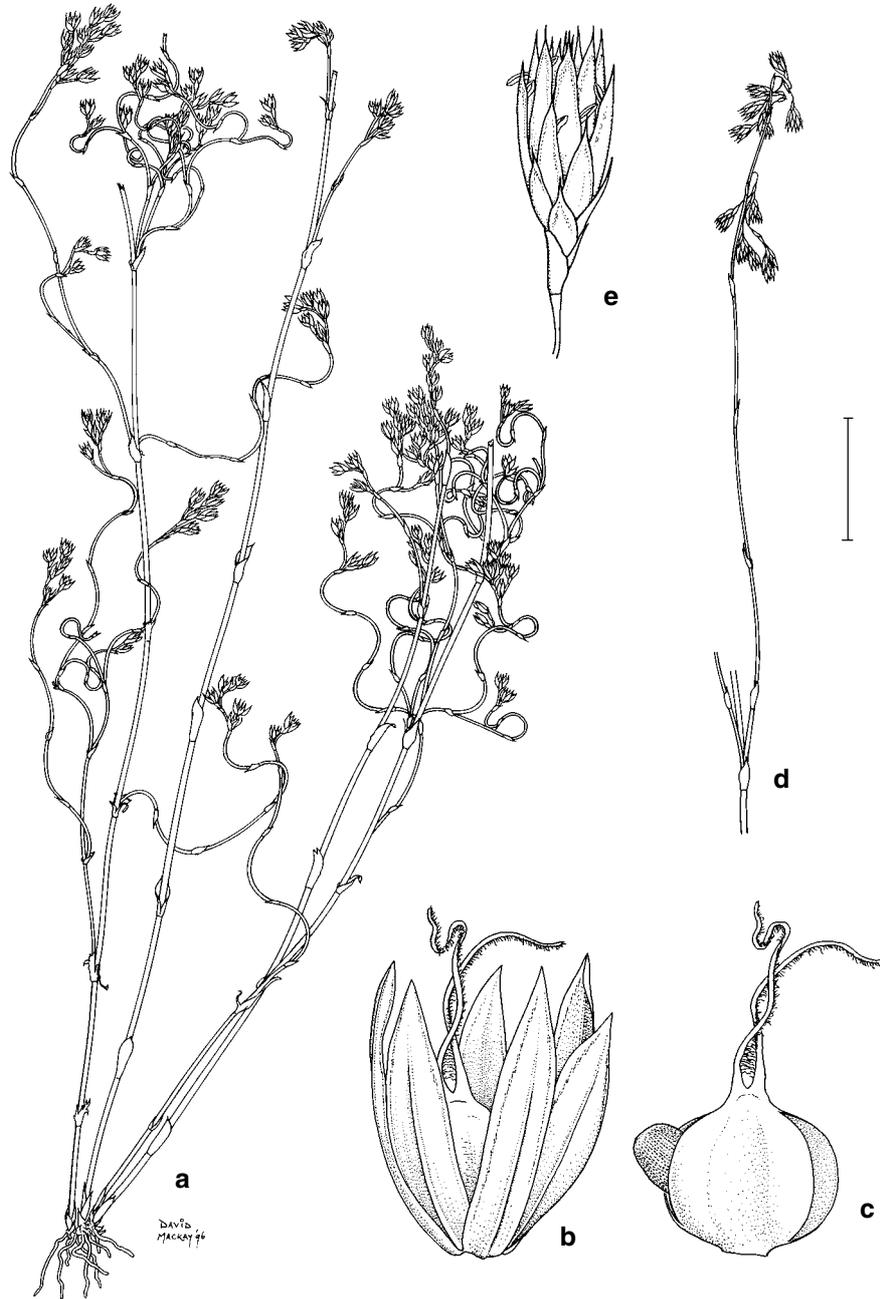
**Conservation status:** common and widespread.

**Fire response:** killed by fire.

**Note:** A distinctive species, differing from other *Chordifex* species by the following combination of characters: habit caespitose; culms stout, terete, branching; spikelets campanulate and often pendulous. *Chordifex microcodon* is a host to a pathogenic smut fungus tentatively identified as a species of *Tolyposporium* (Sieler et al. 1999); smutted male plants may produce infertile inflorescences similar in appearance to those of female plants.



**Fig. 7.** *Chordifex capillaceus*. **a–d**, female (Briggs 7662): **a**, habit; **b**, spikelet; **c**, capsule; **d**, dehiscent capsule.; **e**, male spikelet (Briggs 6586). Scale bars: a = 2 cm; b = 3 mm; c, d = 1 mm; e = 3 mm.



**Fig. 8.** *Chordifex microcodon*. **a–c**, female (Briggs 7733 & Johnson): **a**, habit (part of a plant with many culms); **b**, flower; **c**, dehiscent capsule with emerging seed; **d, e**, male (Briggs 7490 & Johnson): **d**, inflorescence; **e**, spikelet. Scale bar: **a, d** = 8 cm; **b, c** = 4 mm; **e** = 1.5 cm.

**Selected specimens examined:** Western Australia: Irwin: 25 miles [40 km] W of Winchester to Eneabba, 30 Sep 1966, *E.M. Bennett* 1405 ♂ (PERTH, NSW); 29 km S of Eneabba on Brand Highway, 29 Sep 1984, *B. Briggs* 7490 & *L. Johnson* ♂, 7491 ♀ (NSW, CANB, NBG, PERTH); 22.8 km E of Brand Hwy on Green Head–Coorow Road, Alexander Morrison Natl Park, 30 Sep 1984, *B.G. Briggs* 7732 & *L.A.S. Johnson* ♂ (NSW, PERTH); 5 km SE of Badgingarra, 10 Sep 1979, *G.J. Keighery* 2554 ♂ (PERTH, NSW); 6.5 km S of New Badgingarra, Badgingarra Natl Park, 25 Sep 1976, *B. Briggs* 6312 ♂ (NSW, CANB, K). Darling: 19 km WNW of Mogumber, 23 Sep 1966, *B.G. Briggs* 857 ♂ (NSW, K, PERTH), 858 ♀ (NSW); 1.5 miles [2.4 km] S of Regans Ford on Gingin road, 23 Sep 1966, *B. Briggs* 852 ♀ (NSW, K, MEL, PERTH); Bullsbrook, May 1944, *F.M. Bailey* ♀ (PERTH); Neaves Rd, c. 15 km NE of Wanneroo, 18 May 1983, *B. Briggs* 7236 & *L. Johnson* ♂ (NSW, CANB, PERTH, K, MEL, RSA), 7237 ♀ (NSW, CANB, PERTH).

### 3. *Chordifex jacksonii* B.G. Briggs & L.A.S. Johnson, **sp. nov.**

*A.C. amblycoleo* combinatione characterum sequentium distinguitur: culmi graciles (c. 1 mm diam.); vaginae culmorum acutae, lamina filiformis; spiculae parvae globosaeque; semina colliculosa.

Type: Western Australia: near Mt Frankland, 13 Feb 1913, *S.W. Jackson* ♂ (holo: NSW 78864; iso: CANB, K, MEL, AD, MO, PERTH).

Plant tufted; the base with brown, scarios scales covering a pale woolly pubescence. Culms few, erect, straight, terete or slightly compressed, simple, 40–100 cm long, c. 1 mm diam., striate, glabrous. Sheaths imbricate, closely appressed, 1.6–2.2 cm long, striate, light-brown to straw-coloured, tapering into a filiform lamina (2–)4–7 mm long. Inflorescence of up to 5 spikelets on each of several long, filiform, occasionally branched peduncles; subtending bract usually apically ciliate, similar to culm sheaths or shorter. Male spikelets ovoid to globose, c. 5 mm long, 3–5 mm wide; sterile lower glumes 15–38, fertile upper glumes 4–14, oblong-ovate to spatulate, apex sparsely ciliate, 1.5–2.5 mm long; mucro erect or spreading, 1.5–2.2 mm long; uppermost c. 5 glumes smaller and sterile. Female spikelets similar to males. Male flowers: tepals 6, red-brown; 2 outer tepals keeled, sparsely pilose along keel; lanceolate, usually obtuse, 2.2–2.8 mm long; inner tepals and 3rd outer tepal, glabrous, 1.9–2.7 mm long; stamens 3; filaments 2.5 mm long; anthers c. 1.2 mm long. Female flowers: tepals similar to males, glabrous; staminodes 3; styles 2, free, almost wholly stigmatic. Capsule 2.5 mm long. Seed ellipsoid, white, 1.9 mm long, colliculate with lines of convex cells. (Figs 3d; 4a, b; 9).

The epithet commemorates Sydney William Jackson (1873–1946), a noted collector of bird and plant specimens. He first collected this species, as his handwritten specimen label states: ‘on low damp sandy flat near Mt Frankland ... under great difficulties’.

**Distribution:** occurs in the south of Western Australia, near and west of Mt Frankland, NW of Walpole. Grows in wet heaths on damp, sandy flats.

**Conservation status:** vulnerable, known from few localities, CALM conservation status P2 (Meney, Pate, Dixon, Briggs & Johnson 1999; Wheeler et al. 2002).

**Fire response:** killed by fire.

**Note:** *Chordifex jacksonii* resembles the more widespread and robust species *C. amblycoleus* (F. Muell.) B.G. Briggs & L.A.S. Johnson, although these do not appear as sister species among *Chordifex* species sampled in DNA-based phylogenetic analyses (Marchant pers. com.). *Chordifex jacksonii* has more slender culms, acute culm sheaths that taper into a filiform lamina and small ovoid or globular spikelets that do not elongate in fruit. *Chordifex amblycoleus* has culms 1–2 mm diam., truncate sheaths with lamina absent or minute, and ovoid or narrow ovoid spikelets 6–23 mm long, elongating in fruit; it occurs near Jindong (Busselton region) and from Augusta to Walpole. The seed surfaces of the species differ; seeds of *C. jacksonii* are colliculate with lines of large convex cells whereas *C. amblycoleus* seeds have narrow, widely spaced ridges (Figs 4c, d).

**Selected specimens examined:** Western Australia: Darling: Beardmore Rd intersection with South Western Hwy, 34 km W of Walpole, Oct 1990, *S. Pignatti* ♀ (KPBG); 0.3 km E of Beardmore Rd and South Western Highway intersection, 28 Aug 1998, *B. Briggs* 9442 ♀ (NSW); 3.5 km E of South Western Hwy on Beardmore Rd, 14 Oct 1992, *B.G. Briggs* 9078 & *K. Meney* ♂ (NSW, CANB, PERTH), 9079 ♀ (NSW); Pingerup Rd, c. 4 km NE of Marron Rd junction, 5 May 1991, *N. Gibson* & *M. Lyons* 630 ♀ (PERTH); near Mt Frankland, 13 Feb 1913, *S.W. Jackson* ♀ (NSW 91597).

**4. *Chordifex sinuosus* B.G. Briggs & L.A.S. Johnson, sp. nov.**

A *C. sphacelatus* combinatione characterum sequentium distinguitur: vaginae culmorum mucrone 1–2 mm longo instructae; mucro glumae 1–1.7 mm longus; culmi teretes (autem rami compressi); semina valde porcata.

Type: Western Australia: 34 km NNW of Gingin on Brand Hwy, *B.G. Briggs* 7445 & *L.A.S. Johnson* ♀ (holo: NSW; iso PERTH, CANB, K, MO).

Forming diffuse tussocks or large patches of widely spaced culms. Rhizome horizontal to c. 20 cm long or more, stout, 3–5 mm diam., with scarios, pale- to dark-brown, appressed scales partly covering a pale, thick, woolly pubescence. Culms at intervals of c. 0.5–1.0 cm on the rhizome, usually much branched, initially erect but sinuose distally, terete, 20–45 cm long, c. 1 mm diam., striate, grey-green, mostly glabrous or the basal internodes occasionally pubescent; branches short, sinuose or convoluted, terete or compressed, often barren; internodes numerous, 2.5–5.5 cm long. Sheaths loosely appressed, 0.6–1.2 cm long, initially red-brown or blackish, often grey and weathered with age; apex obtuse or truncate, shortly ciliate; margins narrow, caducous, membranous; mucro 1–2 mm long. Inflorescence of 1–4 spikelets, the spikelets terminal on the culm or on short lateral branches, or sessile at the upper nodes; subtending bracts similar to culm sheaths but shorter. Male spikelets ovoid, 5–10 mm long, 3–4 mm wide; sterile lower glumes 5–12; fertile upper glumes c. 15–18, broad-ovate, mostly glabrous, brown, acute, 3.0–4.0 mm long, outer margin with a few hairs; mucro 1–1.7 mm long. Female spikelets elliptic to ovoid, 6–8 mm long, 3.0–4.0 mm wide; 11–21 sterile lower glumes and 2 or 3 fertile upper glumes, similar to males, obtuse to acute, 2.5–4.5 mm long, occasionally with a few short hairs on margin. Male flowers: tepals 5 or 6, pale-brown, membranous, 2.5–3.0 mm long; outer tepals keeled, pubescent; inner tepals flat, narrow-lanceolate, acute; stamens 3; filaments stout and basally dilated and spongy, 3.0–4.0 mm long; anthers c. 1.5–2.0 mm long. Female flowers: tepals 5, brown, lanceolate, 4.0–5.7 mm long; 2 outer tepals keeled and pubescent; inner tepals flat; staminodes 3, 1.2–1.5 mm long; styles 2, bases connate. Capsule 2.2–2.8 mm long, smooth, brown. Seed ovoid, c. 2 mm long, prominently ridged. (Figs 5a, b; 10).

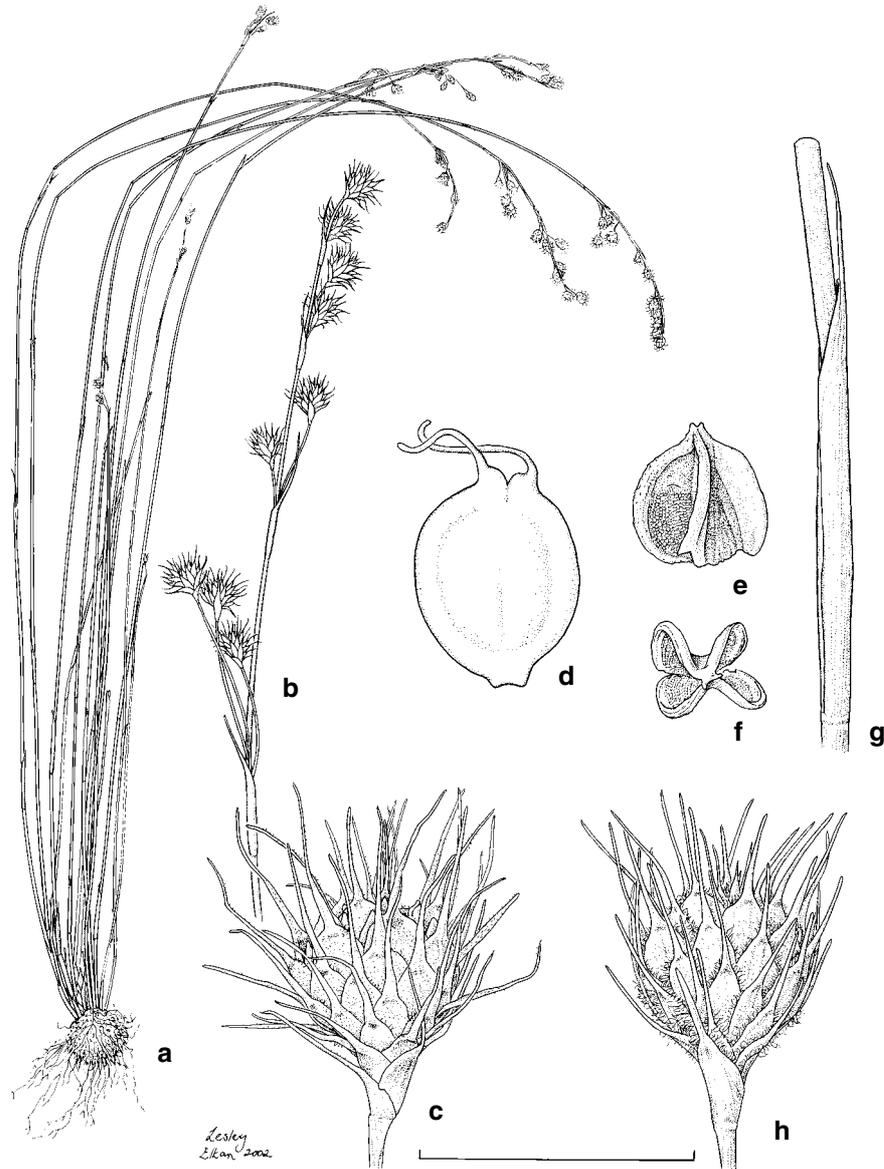
The epithet is from the Latin *sinuosus*, full of bendings, referring to the flexuose culms.

**Distribution:** occurs in Western Australia from Walkaway near Geraldton south to Perth and Yarloop. Grows in heaths and woodland on sand, in dry or seasonally moist sites.

**Conservation status:** common and widespread.

**Fire response:** resprouts after fire.

**Note:** *Chordifex sinuosus* resembles *C. sphacelatus*, which occurs from Kulin and Albany to Israelite Bay, but differs in the longer mucro on culm sheaths and glumes, the culms terete in the upper half (though culm branches  $\pm$  compressed) and the seeds being very strongly ridged. *Chordifex sphacelatus* has the mucro on culm sheaths < 0.5 mm long and on glumes absent or minute; the upper culms (as well as the branches) are compressed and the seeds are colliculate with lines of convex cells (Fig. 5c, d). Both these species are hosts to smut fungi tentatively identified as a species of *Tolyposporium* (Sieler et al. 1999). Some of the spikelets on both male and female plants affected by



**Fig. 9.** *Chordifex jacksonii*. **a–f**, female (Briggs 9079): **a**, habit; **b**, inflorescence; **c**, spikelet; **d**, capsule; **e**, **f**, dehiscent capsule, side and top views; **g–h** male (Jackson NSW 78864): **g**, culm sheath. **h**, spikelet. Scale bar: a = 9 cm; b = 3 cm; c, h = 1 cm; d, e, f = 0.3 cm; g = 0.5 cm.



**Fig. 10.** *Chordifex sinuosus*. **a–d**, female: **a**, habit; **b**, spikelet; **c**, dehiscent capsule with tepals, showing ridges on inner surface of pericarp (holotype); **d**, young female spikelet (*Krauss 142 & Howitt*); **e**, male inflorescence **f**, male spikelet (*Pate & Meney NSW 255721*). Scale bar: **a** = 10 cm, **b** = 1 cm, **c** = 0.6 cm, **d**, **f** = 0.75 cm, **e** = 3 cm.

this inflorescence-smut are enlarged (to 16 mm long and 11 mm wide) and infertile, with the glumes modified in shape and lacking a mucro. Largely because of such smut infection, female plants of *C. sphacelatus* are often infertile and few specimens bear seeds or well-developed capsules. Occasional uninfected plants, such as *Briggs 8710 et al.* bear abundant capsules and seed.

**Selected specimens examined:** Western Australia; Irwin: Burma Rd, 13.3 km SE of Nangetty–Walkaway Rd, 13 Aug 1991, *B. Briggs 8894 & L. Johnson* ♀ (NSW, PERTH); 27 km SE of Dongara, 26 Oct 1981, *K. Newbey 9379* ♂ (PERTH); 31 km NNW of Eneabba on Brand Highway, 22 Apr 1989, *S. Krauss 142 & L. Howitt* ♀ (NSW, CANB, K, MO, PERTH); 11.7 km S of Eneabba Road on Brand Highway, 6 Oct 1995, *B.G. Briggs 9374 & J. Pate* ♂, 9373 ♀ (NSW, PERTH); Brand Highway 12.3 km S of Eneabba, May 1992, *J. Pate & K. Meney* ♂ (NSW 255721), ♀ (NSW 255721). Darling; c. 1.5 km NE of Mt Lesueur, 24 May 1983, *L.A.S. Johnson 8719a* ♂, *8719b* ♀ (NSW); 30 km E of Jurien Bay, 2 Sep 1976, *R.G. Coveny 8005 & B.R. Maslin* ♂, 8020 ♀ (NSW); 6 km S of Regans Ford, N of Gingin, 23 Sep 1966, *B.G. Briggs 845* ♀ (NSW, K, MEL, PERTH); 34 km NNW of Gin Gin on Brand Highway, 28 Sep 1984, *B. Briggs 7445 & L. Johnson* ♀ (NSW); High Wycombe, 31 May 1998, *M. Hislop 1056A* ♀, *1056B* ♂ (PERTH, NSW); Maida Vale Rd, Kewdale, 7 Sep 1976, *R.G. Coveny 8224* ♂ (NSW, AD, MEL); 0.8 km N of Yarloop, *B. Briggs 7528 & L. Johnson* ♀ (NSW, AD, CANB, PERTH).

**5. *Chordifex reseminans* B.G. Briggs & L.A.S. Johnson, sp. nov.**

A *C. sphacelato* combinatione characterum sequentium distinguitur: planta caespitosa; rhizomata brevia; inflorescentiae spiculis numerosis instructae; a *C. chaunocoleo* sic distinguitur: rami inflorescentiae producti; mucro glumae brevis (usque 1.5 mm longus).

Type: Western Australia: 11.7 km S of Eneabba Road on Brand Highway, 6 Oct 1995, *B.G. Briggs 9375 & J. Pate* ♂ (holo NSW; iso CANB, K, MO, NBG, PERTH, RSA).

Plants caespitose, forming dense clumps to 30 cm diam. Rhizomes short, horizontal, much-branched and interlaced, up to 3 cm long on specimens, c. 3 mm diam., with short straw-coloured scales covering a pale pubescence. Culms crowded, initially erect and unbranched, with 3–4 long internodes, but usually branched and sinuose distally, terete, 30–60 cm long, 1.0–1.4 mm diam., striate, mostly glabrous or the basal internodes occasionally pubescent; branches at several upper nodes, sinuous, terete or compressed. Sheaths loosely appressed, (0.8–)1–2 cm long, initially red-brown but becoming grey and weathered with age; apex obtuse or truncate, shortly ciliate, with narrow, caducous, membranous margins; lamina 1.5–3 mm long. Inflorescence: lateral branches to 10 cm long, each with 2–10 (males) or 1–4 (females) sessile or pedicellate spikelets near the apex; subtending bracts similar to culm sheaths but shorter. Male spikelets ovoid, 4.5–6 mm long, 3–4 mm wide; sterile lower glumes c. 12–15; fertile upper glumes c. 11–16, broad-ovate, brown, acute, 3.0–3.7 mm long, mostly glabrous but distal margin with a few hairs; mucro to 1.2 mm long; Female spikelets elliptic to ovoid, 6–8 mm long, 3.0–4.0 mm wide (when fruiting up to 6–7 mm wide); sterile lower glumes 11–25; fertile upper glumes 2 or 3, similar to males, obtuse to acute, 3.5–6.0 mm long, occasionally with a few short hairs on margin; mucro to 1.5 mm long. Male flowers: tepals 5 or 6, pale-brown, membranous, 2.5–3.0 mm long; outer tepals keeled, pubescent; inner tepals flat, narrow-lanceolate, acute; stamens 3; filaments stout, dilated and spongy at the base, 3.0–4.0 mm long; anthers c. 1.5–2.0 mm long. Female flowers: tepals 5, brown, lanceolate, 4.7–6.3 mm long; 2 outer tepals keeled and pubescent; inner tepals flat; staminodes 3, 1.1–1.5 mm long; styles 2, bases connate. Capsule (2.2–)2.4–2.8 mm long, smooth, glossy, brown. Seeds ovoid, 1.4–2 mm long, prominently striated. (Figs 6a, b; 11).

The epithet is from the Latin *re-*, again or very, and *semen*, a seed, (plural *semina*), referring to the reproductive habit of establishing from seed, rather than resprouting, after fire or disturbance.



**Fig. 11.** *Chordifex reseminans*. a–d, male: a, habit; b, flower; c, spikelet; d, inflorescence (holotype). e, f, female: e, young spikelet; f, old spikelet with dehiscent capsule showing ridges on inner surface of pericarp (Pate & Meney NSW 255720). Scale bar: a = 7.5 cm, b = 0.4 cm, c, e, f = 0.75 cm, d = 3 cm.

**Distribution:** occurs in Western Australia from near Eneabba to Cataby. Grows in dry heath, shrubland and woodland on white sand.

**Conservation status:** endangered, rare and restricted in distribution (Meney, Pate, Dixon, Briggs & Johnson 1999; Meney, Pate & Hickman 1999), known from few localities, in a region where there has been much loss of natural habitat. Especially vulnerable because of its fire sensitivity.

**Fire response:** killed by fire.

**Note:** Differs from *C. sinuosus* in the caespitose habit with culms crowded on short, interlaced, branching rhizomes, longer culm sheaths, more branching in the inflorescence; more spikelets per culm and recovery after fire by seed rather than resprouting. The two species sometimes occur together (e.g. *Briggs 8917b* and at the type locality). In habit and fire response it resembles *C. chaunocoleus* but the inflorescence branches are longer and the glume mucro shorter. *Chordifex chaunocoleus* has inflorescence branches to 2.5 cm long, glumes with a mucro 0.8–2.4 mm long, and occurs in isolated localities near Badgingarra and Toodyay. All three species have similar, strongly ridged seeds (Figs 5, 6).

**Specimens examined:** Western Australia: Irwin: 11.7 km S of Eneabba Road on Brand Highway, 6 Oct 1995, B.G. Briggs 9376, 9377 & J. Pate ♀ (NSW, PERTH, NBG); Brand Highway, 12.3 km S of Eneabba, May 1992, J. Pate & K. Meney ♂ (NSW 255717), ♀ (NSW255720); 16 km N of Cooroo Road on Highway 1, 15 Aug 1991, B.G. Briggs 8917b & L.A.S. Johnson ♂ (NSW, PERTH, BOL); 29 km N of Tootbardi Road, Badgingarra, 31 Nov 1990, K. Meney / K. Dixon 911 ♀ (KPBG, NSW); Bibby Road, N boundary of Badgingarra National Park (Reserve 31809), W of Badgingarra, 7 Dec 1992, E.A. Griffin 8321 ♀ (PERTH); Cataby, Apr 1992, K. Meney & J. Pate ♂ (NSW 416522), ♀ (NSW 254918).

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