Calyptochloa sphaerocarpa E.J.Thomps. (Poaceae: *Panicoideae*), a new species from central Queensland

E.J. Thompson

Summary

Thompson, E.J. (2021). *Calyptochloa sphaerocarpa* E.J.Thomps. (Poaceae: *Panicoideae*), a new species from central Queensland. ***Austrobaileya* 11: 135–154**. A new species, *Calyptochloa sphaerocarpa* E.J.Thomps., endemic to central Queensland is described and illustrated, both for general morphology and for anatomy and surface micromorphology of the leaf and inflorescence culm. It is distinguishable from the other three species of *Calyptochloa* by characters including the cleistogamous axillary racemes consisting of three to four spherical spikelets with scabrid upper glume and lower lemma, spherical caryopsis and glabrous culm internodes.

Key Words: Poaceae; *Panicoideae*; *Calyptochloa*; *Calyptochloa sphaerocarpa*; Australia flora; Queensland flora; new species; species taxonomy; identification key; anatomy; micromorphology

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Introduction

Calyptochloa C.E.Hubb. is a genus of three endemic species of Australian grasses, allied to *Cleistochloa* C.E.Hubb. and *Dimorphochloa* S.T.Blake and to be included in a new subtribe as circumscribed in Thompson (accepted). The subtribe is defined by having reproductive dimorphism with amphigamous inflorescences and corresponding dimorphic spikelets (Hubbard 1933; Thompson & Simon 2012; Thompson accepted; Thompson & Fabillo 2021; **Fig. 1**). *Calyptochloa* is characterised by having a stoloniferous growth habit and dimorphic reproductive system with terminal inflorescences. These consist of spike-like panicles comprising chasmogamous (CH: flowers open to release stigmas and anthers with the potential of cross-pollination) spikelets and axillary racemes with obligate cleistogamous (CL: self-pollination within a closed flower that never opens) spikelets completely or partially hidden by the enveloping leaf sheath. *Calyptochloa* differs from *Cleistochloa* by several characters including the rhizomatous, tufted, growth habit and CL spikelets with an elaiosome (Thompson accepted).

The three species of *Calyptochloa* are consistently grouped with *Cleistochloa* sp. (Duaringa K.B.Addison 42) in various topologies generated from analyses using multiple algorithms and data sets (Thompson accepted; Thompson & Fabillo 2021). This close affinity suggests *Cleistochloa* sp. (Duaringa K.B.Addison 42) should be transferred to *Calyptochloa*.

The purpose of this paper is to formally describe the new species, *Calyptochloa sphaerocarpa* E.J.Thomps., with the phrase name entity *Cleistochloa* sp. (Duaringa K.B.Addison 42) referred to its synonymy.

Materials and methods

This paper is based primarily on plant material held at the Queensland Herbarium (BRI), field collections by the author and material observed in cultivation in Brisbane.

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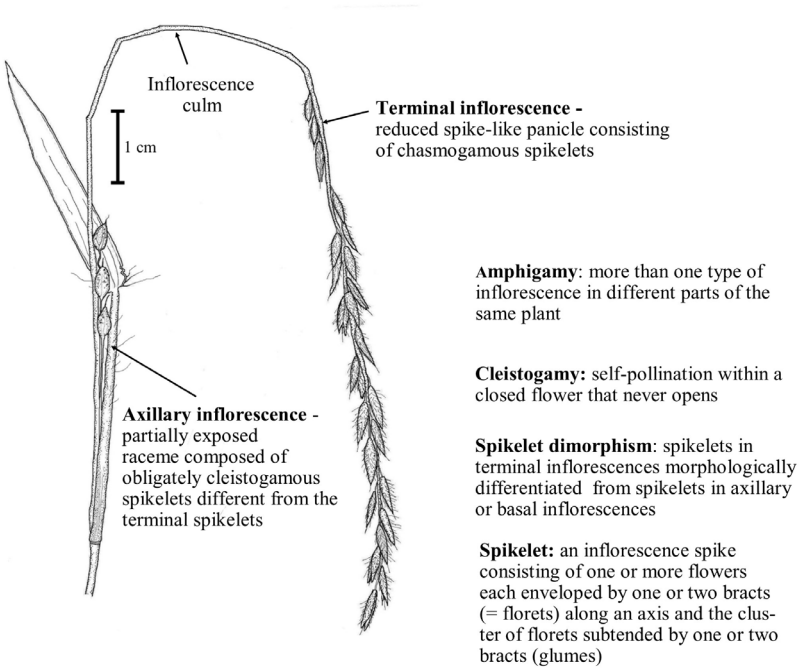

Fig. 1. Glossary of inflorescence components. Del. E.J. Thompson.

Leaf, culm and spikelet materials were obtained from herbarium specimens and fresh material was taken from cultivated plants of the four species of *Calyptochloa*. Nursery stock was initially grown from *ex situ* plants and additional stock was propagated from caryopses and stolons that readily root at the nodes during humid weather in summer. Plants of all species of *Calyptochloa* were cultivated in pots under nursery conditions at latitude 27.5° S, from 2013–2020.

Data used for circumscriptions provided in this paper were obtained from the 161-character list and data matrix provided by Thompson (accepted). Measurements are inclusive, i.e. 1.0–2.7 is given as 1–2.7.

Nomenclature and terminology

Botanical nomenclature follows Thompson (2021a).

General botanical terminology follows Harris & Harris (1994) and Beentje (2010) with additional terminology provided in **Fig. 1**. Terminology relating to inflorescences and spikelets follows Tothill & Hacker (1983), Jacobs *et al.* (2008), Gibson (2009) and Thompson (2021b, accepted). The spikelet equates to a spike in the broader context of inflorescences (Kellogg 2006; Endress 2010). Terminology relating to grass anatomy and micromorphology follows Ellis (1976, 1979), Watson & Dallwitz (1992) and Dengler *et al.* (1994).

Imagery

Photographs were taken using two light microscopes, firstly using a Nikon SMZ25 binocular microscope with Nikon DS-Ri1 camera and images viewed with NIS-Elements BR (ver. BR 5.11.000 64-bit, USA; Laboratory Imaging (http://www.lim.cz, accessed 15 December 2019), and secondly leaves were examined using a Leica DMLB compound binocular microscope with an industrial digital camera and images viewed using ToupView (ver. x64 4.7.14326.20190401, China; Touptek (http://wwwtouptek.com, accessed 20 September 2019).

Scanning electron micrographs (SEMs) were obtained without sputter coating using a Phenom G2 5kev SEM with backscatter detector. Magnifications in **Figs. 6**, **9**–**14** are those at which the images were taken.

Leaf and inflorescence culm anatomy and surface micromorphology

Transverse sections of leaves and inflorescence culms were obtained using the freehand sectioning method described by Thompson (2017) and modified from Frohlich (1984). Several sections of both leaves and culms were made using fresh material from the cultivated plants.

Leaf surface micromorphology of the abaxial surface was examined using replicas from fresh leaves following the method described by Hilu & Randall (1984).

Observations of leaf and culm anatomy and micromorphology including stomata, silica bodies and microhairs were recorded following descriptions and classifications used by other authors including De Wet (1960), Metcalfe (1960), Twiss *et al.* (1969), Ellis (1979), Renvoize (1987), Watson & Dallwitz (1992), Siqueiros-Delgado & Herrera-Arrieta (1996), Piperno & Pearsall (1998), Krishnan *et al.* (2000), Siqueiros-Delgado (2007), Lu *et al.* (2009) and Jattisha & Sabu (2015).

Spikelet morphology

Observations of micromorphology were made from SEM micrographs of lower and upper lemmas and upper paleas to classify silica bodies, stomata, epidermal long cell walls, microhairs and macrohairs as recorded by Thompson accepted following established descriptions and classifications (Hsu 1965; Jirasek & Jozifova 1968; Ellis 1979; Valdes-Reyna & Hatch 1991; Snow 1996; Acedo & Llamas 2001; Liu *et al.* 2010; Mashau *et al.* 2015; Olonova *et al.* 2016; Neumann *et al.* 2017).

Images of fresh lodicules and stigmas were obtained using light microscopy. Lodicules were classified as plicate or non-plicate (Hsu 1965; Jirasek & Jozifova 1968; Guedes & Dupuy 1976). Stigma macromorphology was classified by the position of emergence from the spikelet, overall shape outline and colour, and micromorphology by characteristics of the lobes including shape of apex, relative length and tilt (Thiele *et al.* 1996).

Caryopsis and embryo morphology including characters relating to hilum, scutellum, epiblast, embryo spermaderm and stylopodium were recorded and classified using established categories (Kennedy 1899; Reeder 1957; Brown 1959, 1960; Watson & Dallwitz 1992; Klak 1994; Kosina 1995; Snow 1998; Liu *et al.* 2005; Liu *et al.* 2015).

Results

The major differences in morphology of the species of *Calyptochloa* are listed in **Table 1**.

Dimorphisms in the CH and CL inflorescences and spikelets vary among the four species, with *Calyptochloa johnsoniana* E.J.Thomps. & B.K.Simon and *C. sphaerocarpa* having closer morphological affinities than *C. gracillima* C.E.Hubb. and *C. cylindrosperma*. *Calyptochloa johnsoniana* and *C. sphaerocarpa* share axillary racemes composed of one or two or as many as four spikelets respectively, with at least the apical one exposed at maturity, while the others are enveloped by the leaf sheath. *C. sphaerocarpa* also differs by the presence of a third type of inflorescence, reduced spike-like panicles apical on subordinate branches, and comprises CL spikelets that are similar but smaller than the spikelets in the terminal inflorescences (**Figs. 2**–**4**).

CH and CL spikelets in *C. sphaerocarpa* also have micromorphological differences in the stigmas and surface pattern on the upper florets. The stigmas differ by size and the shape of the apices of the lobes (**Fig. 5**). Surface pattern on the upper lemmas and paleas differs by the texture of the longitudinal ridges being coarser in the CL upper florets (**Fig. 6**).

The lodicules of *C. sphaerocarpa* have asymmetric shape similar to other taxa in Cleistochloinae and are broadly similar to *C. johnsoniana* (**Fig. 7**).

Fig. 2a. Holotype of ***Calyptochloa sphaerocarpa*** (*Thompson EJT817 & Simon*, BRI). Sheet 1, showing terminal chasmogamous and axillary cleistogamous inflorescences. Photo: Queensland Herbarium.

Fig. 2b. Holotype of ***Calyptochloa sphaerocarpa*** (*Thompson EJT817 & Simon*, BRI). Sheet 2, showing terminal cleistogamous inflorescences. Photo: Queensland Herbarium.

Taxonomy

Key to the species of *Calyptochloa*

1 Leaf sheath woody and enveloping a single cleistogamous spikelet; fertile culms disarticulating at nodes **2**
1. Leaf sheath with a chartaceous margin, racemes more than 1-flowered, apical spikelet exposed; fertile culms not disarticulating at nodes. **3**

2 Terminal spikelets 3–4.6 mm long; axillary spikelets 3.5–5.5 mm long . . . . **C. gracillima**
2. Terminal spikelets 5–6 mm long; axillary spikelets 6–7.5 mm long . . . **C. cylindrosperma**

3 Axillary racemes 3 or 4-flowered; spikelets broadly elliptical with short stiff tuberculate-based trichomes . . . . . **C. sphaerocarpa**
3. Axillary racemes 1 or 2-flowered; spikelets lanceolate, glabrous . . . . . **C. johnsoniana**

Calyptochloa sphaerocarpa E.J.Thomps., **sp. nov.**

Similar to *C. johnsoniana* E.J.Thomps. & B.K.Simon but differing by the axillary racemes comprising 3 or 4 scabrid spikelets that are broadly elliptical. **Typus:** Queensland. Leichhardt District: 17.3 km west of Baralaba, 24 April 2012, *E.J. Thompson EJT817 & B.K. Simon* (holo: BRI [AQ1017420 comprising 2 sheets]).

Calyptochloa sp. (Duaringa K.P.Addison 42): Thompson & Simon (2012); Simon & Thompson (2013).

Cleistochloa sp. (Duaringa K.P.Addison 42): Thompson (2016); Thompson (2019); Thompson & Fabillo (2021); Thompson (2021a & b).

***Illustration*:** Thompson (2021b: Fig. 1)

Stoloniferous perennial to *c*. 50 cm tall, rooting at the nodes and with stolons to 6 m long; vegetative culms *c*. 2 mm wide and up to 4 m long, copiously branched, nodes 6-many. Culm internodes smooth to scabrid. Ligule a fringe of hairs 0.3–0.4 mm long; contraligule *c*. 0.1 mm long. Leaf sheaths glabrous to hirsute, one margin pilose the other glabrous, margins chartaceous. Leaf blades at mid-culm 3–11 cm long, 3.5–8 mm wide, ultimately disarticulating; glabrous to occasionally hispid, hairs to *c*. 1.5 mm long; base truncate, apex mucronate; margins undulate on one side, minutely scabrid, thickened, white. Inflorescences of three types with dimorphic spikelets in separate parts of the plant. **Inflorescence type 1** comprising a terminal inflorescence with a reduced panicle, axes 4–9 cm long, 14–30 flowered, on taller culms; branched near base, branches to *c*. 1.5 cm long, 2–3-flowered. Spikelets overlapping, appressed to rachis, elliptic, adaxial, heteromorphic, largest at apex, 4.8–6.5 mm long (without awn), 1.3–1.6 mm wide; lateral pedicels 0.5–1 mm long, apical pedicels 3–6 mm long. Lower glume lunate, 0.1–0.5 mm long, membranous, apex truncate, hairy. Upper glume elliptic, 4.8–6.5 mm long, margin hyaline, chartaceous, 7-veined, hispid with moderately dense tubercle-based trichomes to 0.5 mm long over body and to 1 mm on margins, apex obtuse. Lower floret sterile; lemma lanceolate, 4–4.8 mm long, margins hyaline, chartaceous, 7-veined, pubescent with scattered tubercle-based trichomes to 1 mm long over body and margins, apex acute to attenuate; palea absent. Upper florets mostly bisexual, some female, chasmogamous; lodicules fan-shaped, 0.3–0.5 mm long. Upper lemma body lanceolate, 2.9–4 mm long, margin flat hyaline, cartilaginous, 3-veined, awn 1.2–3 mm long; palea elliptic, 2.9–3.5 mm long, cartilaginous, obscurely 2-veined, apex acute. Anthers 3, equal, chasmogamous 2.5–3.7 mm long. Caryopses 1.6–2.2 mm long × 1–1.2 mm wide. **Inflorescence type 2** comprising apical racemes on subordinate culms separate from the terminal spike-like panicles, axes 1.8–2.5 cm long, 8–12-flowered (occasionally with 2-flowered branch at base). Spikelets mostly partly overlapping, appressed to rachis, lanceolate, adaxial, heteromorphic, largest at

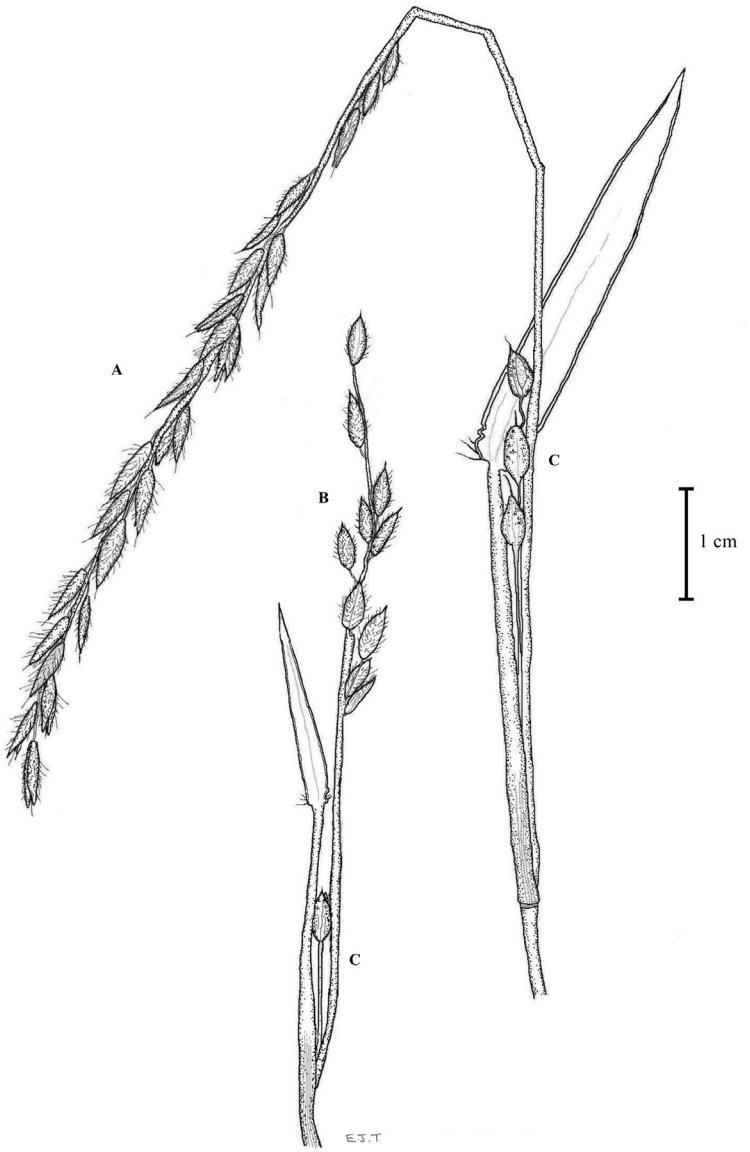

Fig. 3. Types of inflorescences of ***Calyptochloa sphaerocarpa***. A. terminal spike-like panicle comprising chasmogamous spikelets. B. reduced spike-like panicle comprising cleistogamous spikelets terminal on subordinate culms. C. axillary racemes with cleistogamous spikelets. Scales as shown. All from *Thompson EJT301 et al.* (BRI). Del. E.J. Thompson.

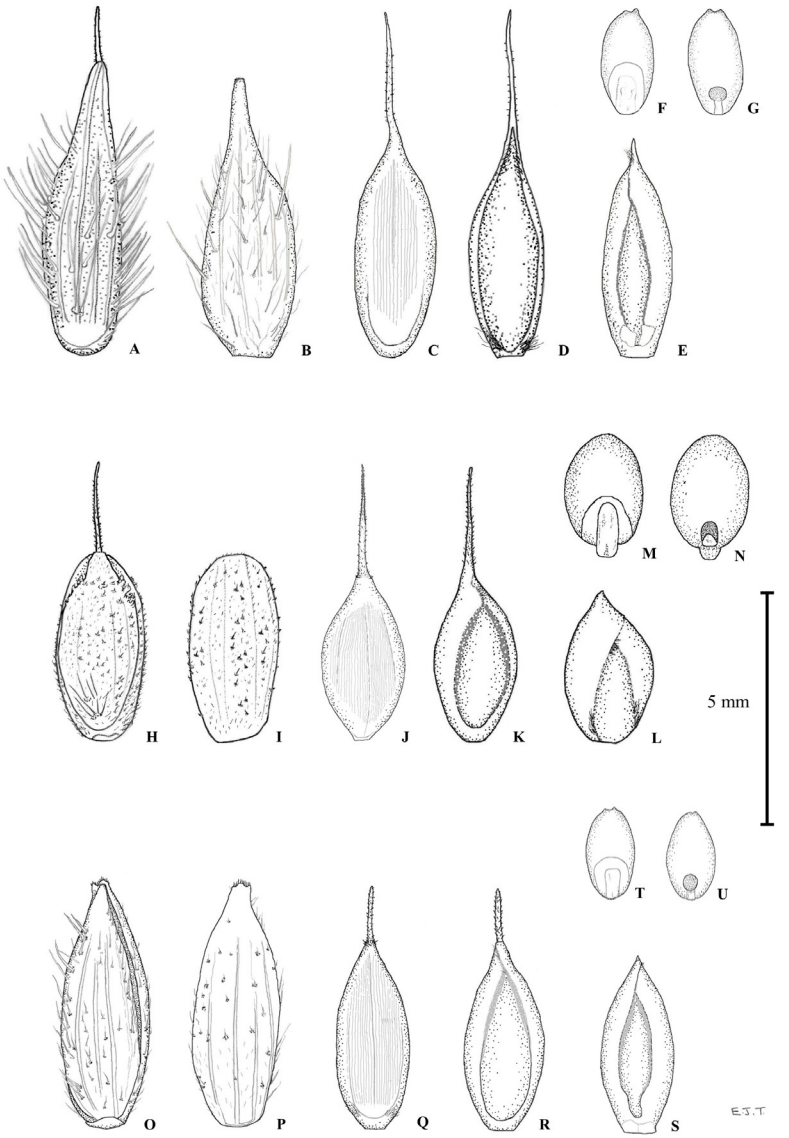

Fig. 4. Three kinds of spikelets of ***Calyptochloa sphaerocarpa***. A–G. chasmogamous spikelet from terminal spike-like panicle. A. adaxial view of spikelet showing small lower glume and lower lemma. B. dorsal view of upper glume. C. dorsal view of upper lemma. D. ventral view of upper lemma. E. ventral view of upper palea. F & G. dorsal and ventral views of caryopsis. H–N. cleistogamous spikelet from axillary raceme. H. adaxial view of spikelet showing small lower glume and lower lemma. I. dorsal view of upper glume. J. dorsal view of upper lemma. K. ventral view of upper lemma. L. ventral view of upper palea. M–N dorsal and ventral views of caryopsis. O–U. cleistogamous spikelet from apical raceme on subordinate culm. O. adaxial view of spikelet showing small lower glume and lower lemma. P. dorsal view of upper glume. Q. dorsal view of upper lemma. R. ventral view of upper lemma. S. ventral view of upper palea. T & U. ventral and dorsal views of caryopsis. Scales as shown. All from *Thompson EJT301 et al.* (BRI). Del. E.J. Thompson.

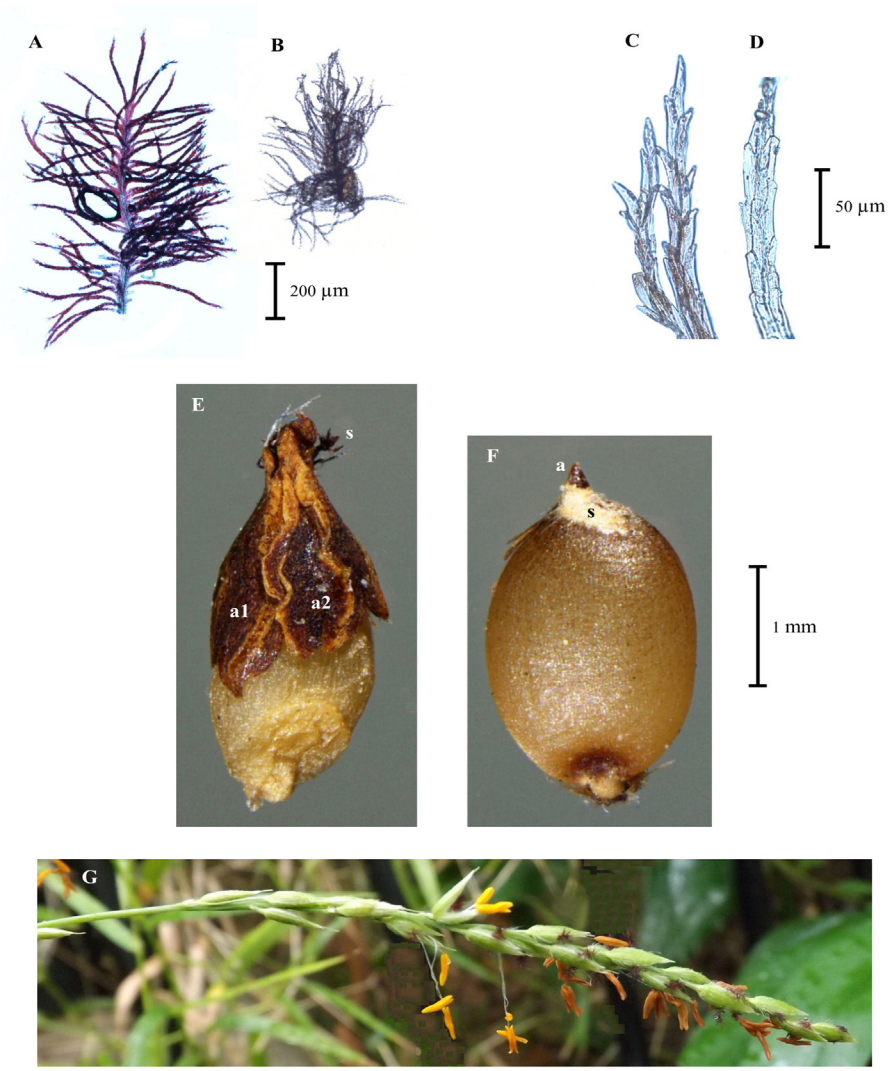

Fig. 5. Chasmogamous and cleistogamous stigmas of ***Calyptochloa sphaerocarpa***. A. stigma from spikelet from terminal spike-like panicle. B. rehydrated entangled stigmas from cleistogamous spikelet from axillary raceme. C. branch of stigma from terminal spikelet. D. branch of stigma from axillary cleistogamous spikelet. E. caryopsis from cleistogamous spikelet from apical raceme on subordinate culm showing anthers of two sizes (a1 & a2) and stigmas (s). F. caryopsis from cleistogamous spikelet from axillary raceme showing much reduced stigmas (s) anthers (a). G. terminal spike-like panicle from cultivated plant. Scales as shown. All from *Thompson EJT301 et al.* (BRI). Photos: E.J. Thompson.

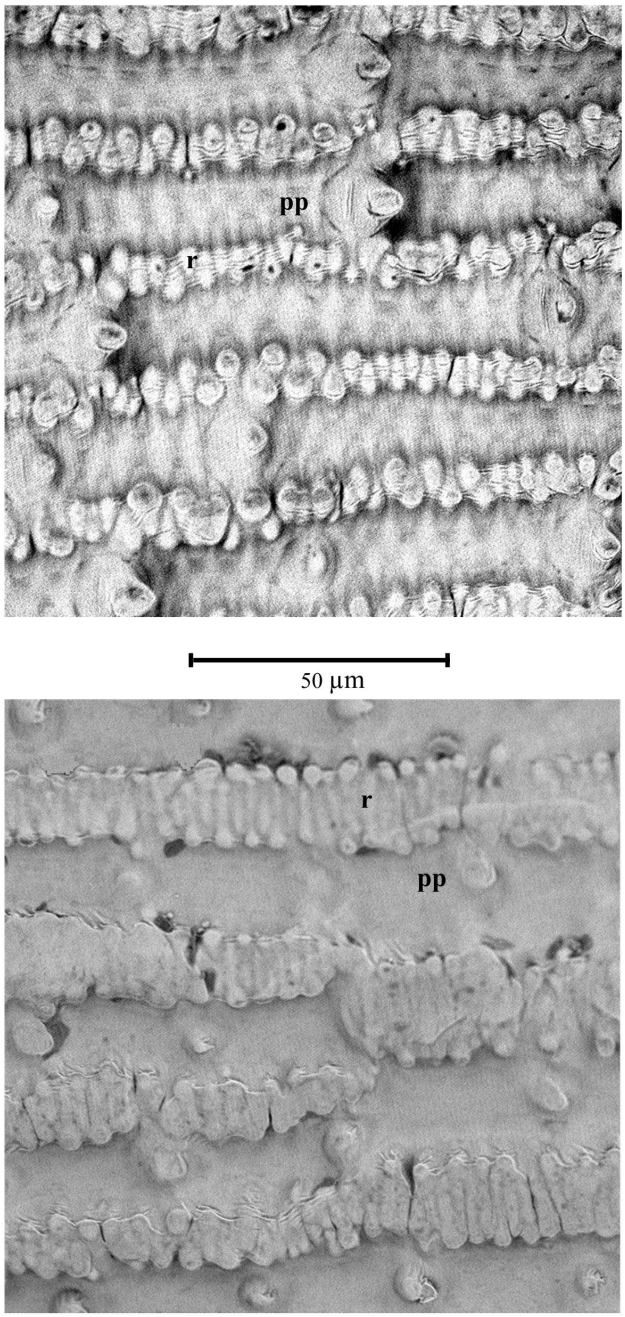

Fig. 6. Scanning electron micrographs of surface of upper lemmas of ***Calyptochloa sphaerocarpa*** (**pp** papillae; **r** ridge), ×2000. A. from chasmogamous spikelet. B. from cleistogamous axillary spikelet. All from *Thompson EJT301 et al.* (BRI). Photos: E.J. Thompson.

apex, 2.9–3.8 mm long (without awn), 1.2–1.5 mm wide; lateral pedicels 0.5–1.5 mm long, terminal pedicels included on branches 2–5 mm long. Lower glume lunate, 0.1–0.4 mm long, membranous, apex truncate, hairy. Upper glume elliptic, 3.2–4.8 mm long, chartaceous, 7-veined, pubescent with tubercle-based trichomes 0.5 mm long, apex truncate. Lower floret sterile; lemma lanceolate, 2.7–3.6 mm long, chartaceous, 7-veined, pubescent with tubercle-based trichomes to 1 mm long, apex obtuse, revolute; palea absent. Upper florets bisexual, cleistogamous or partially autogamous (anthers enclosed and stigmas exserted); lodicules 2, linear, *c*. 0.2 mm long. Upper lemma body elliptic, 2.5–3 mm long, cartilaginous, 3-veined, apex revolute, truncate with awn 0.5–1 mm long; palea elliptic, 2.4–3 mm long, cartilaginous, margin hyaline, obscurely 2-veined, apex revolute, acute. Anthers 3, cleistogamous, unequal, 2 at 0.7–0.9 mm long, 1 shorter 1.1–1.7 mm long; partially autogamous (stigmas exserted), equal, 1.6–2 mm long. Caryopses 1.8–2 mm long, *c*. 1 mm wide. **Inflorescence type 3** comprising axillary racemes, axes 1–3 cm long, 2–4-flowered, 1or 2 exserted from leaf sheath. Basal spikelets sessile, others with pedicels 0.5–4 mm long. Spikelets 4.5–4.8 mm long (without awn), 2–3 mm wide, adaxial. Lower glume lunate, 0.1–0.2 mm long, cartilaginous, apex truncate, minutely pubescent. Upper glume ovate, 3.5–4 mm long, margin hyaline, woody, apex truncate, involute, scabrid with tubercle-based trichomes. Lower floret sterile; lemma lanceolate, 4–4.8 mm long, 1.4–1.6 mm wide, margin hyaline, woody, 7–9-veined, involute, hispid, apex truncate; palea absent. Upper floret fertile; lemma body ovate, 3.5–4 mm long, indurated, papillate, apex convolute, glabrous, margin flat hyaline, 3-veined, awn 0.5–2.6 mm long; palea elliptic, convolute, *c*. 3 mm long, indurated, glabrous, striate, obscurely 2-veined. Anthers 3, equal, *c*. 0.3 mm long. Caryopsis pale, 1.6–2.5 mm long, 1.1–1.5 mm wide, ovoid. **Figs. 2**–**7**.

***Additional specimens examined*: Queensland**. Leichhardt District: Gainaford, Duaringa, Apr 1964, *Addison 42* (BRI); 3 miles [5km] E of Duaringa, Apr 1971, *Munroe 15* (BRI); South Blackwater Mine, Laleham, Jan 1986, *Thompson s.n*. (BRI [AQ0399041]); 3 km NW of River View Station, Dec 1998, *Ryan 1394* (BRI); Duaringa SF – 15 km NW of Duaringa, Mar 2009, *Naske 03/09* (BRI); Blackwater–Rolleston Road, *c*. 44 km S (by road) from Railway Street, Blackwater, Jul 2011, *Menkins ILM 0501* (BRI); Duaringa SF, 8 km W of Duaringa, Dec 2011, *Thompson EJT503* (BRI); 16 km W of Baralaba on edge of road, Dec 2011, *Thompson EJT510* (BRI); *ibid*, Dec 2011, *Thompson EJT511* (BRI); 35.5 km SSW of Duaringa, Dec 2011, *Thompson EJT506* (BRI); Edge of highway, 53 km NW of Clermont, May 2012, *Thompson EJT879 & Simon* (BRI); Duaringa SF, 12 km W of Duaringa, May 2012, *Thompson EJT882 & Simon* (BRI); *ibid*, May 2012, *Thompson EJT886 & Simon* (BRI); 20.2 km W of Blackwater on edge of Capricorn Highway, Mar 2011, *Thompson EJT296, Simon & Edginton* (BRI); Edge of Capricorn Highway, 20 km W of Blackwater, May 2014, *Thompson EJT1028* (BRI); 8 km E of Bluff on edge of Capricorn Highway in Walton SF, Mar 2011, *Thompson EJT301, Simon & Edginton* (BRI); 17.3 km W of Blackwater on edge of Capricorn Highway, Mar 2011, *Thompson EJT307, Simon & Edginton* (BRI); 9.6 km W of Blackwater on edge of Capricorn Highway, Mar 2011, *Thompson EJT308, Simon & Edginton* (BRI); 16 km W of Bauhinia Downs, Apr 2012, *Thompson EJT811 & Simon* (BRI; Edge of Gregory Development Road, 53 km NNW of Clermont, May 2012, *Thompson EJT883 & Simon* (BRI); Duaringa SF, southern side of Capricorn Highway, *c*. 5 km W of Duaringa, May 2013, *Thompson EJT934 & Simon* (BRI); Near Wallaroo Siding, *c*. 12 km W of Duaringa, May 2013, *Thompson EJT925 & Simon* (BRI); 16 km W of Bauhinia Downs, Apr 2012, *Thompson EJT814 & Simon* (BRI). Port Curtis District: Overdeen SF, Jul 2017, *Fensham 6684* (BRI). **CULTIVATED**. Ashgrove, Mar 2017, *Thompson MOR817* (BRI).

***Distribution and habitat*:** *Calyptochloa sphaerocarpa* is endemic to central Queensland and has been recorded mostly near Duaringa and Blackwater (**Map 1**). It is frequently a co-dominant in the ground layer under woodland of lancewood (*Acacia shirleyi* Maiden), and/or bendee (*A. catenulata* C.T.White), and occasionally in woodland of lemon-scented spotted-gum (*Corymbia citriodora* var. *citriodora* (Hook.) K.D.Hill & L.A.S.Johnson) within the Regional Ecosystems 11.7.2 and 11.7.6, respectively (Queensland Government 2020).

Typically, the habitat is shady on lateritic landscapes with undulating to steeply sloping terrain and shallow to skeletal soils (**Fig. 8**). It is commonly sympatric with *Calyptochloa gracillima* var. *gracillima, C. johnsoniana* and *Cleistochloa subjuncea* C.E.Hubb., and other grasses including *Aristida queenslandica* Henrard and *A. caput-medusae* Domin are frequently present.

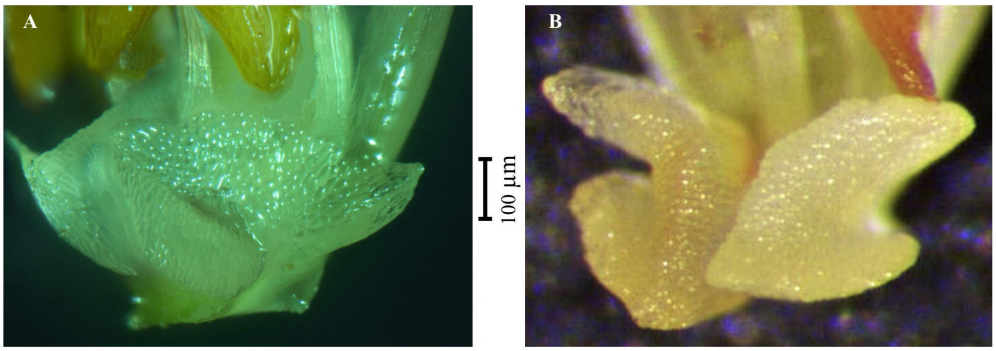

Fig. 7. *Ex situ* fresh lodicules showing comparison of A. ***Calyptochloa sphaerocarpa*** (*Thompson MOR817*, BRI). B. ***C. johnsoniana*** (*Thompson MOR799*, BRI). Photos: E.J. Thompson.

Fig. 8. Growth habit of ***Calyptochloa sphaerocarpa*** and habitat of low woodland of *Acacia shirleyi* (lancewood) on laterite (*Thompson EJT510*, BRI). Photo: E.J. Thompson.

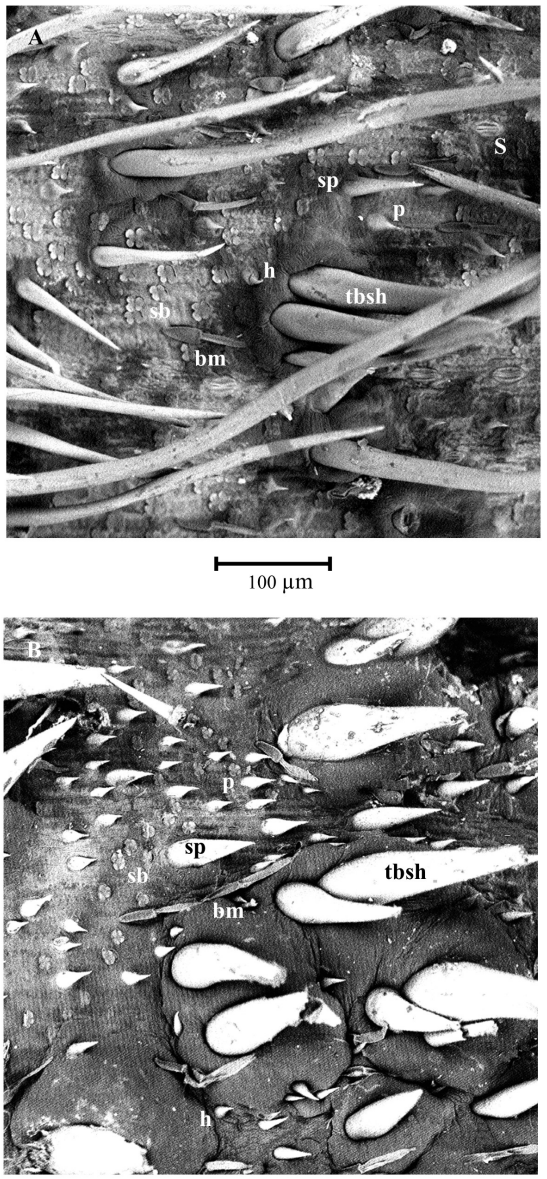

Fig. 9. Scanning electron micrographs of surface of lower lemmas of ***Calyptochloa sphaerocarpa*.** A. from chasmogamous spikelet. B. from cleistogamous axillary spikelet, both ×500 (**bm** bicellular microhair; **h** hook; **tbmh** macrohair; **p** prickle; **sb** silica body; **sp** spicule-like trichome; **tbsh**, tuberculate-based simple hair; **S** stoma). From *Thompson EJT301 et al.* (BRI). Photos: E.J. Thompson.

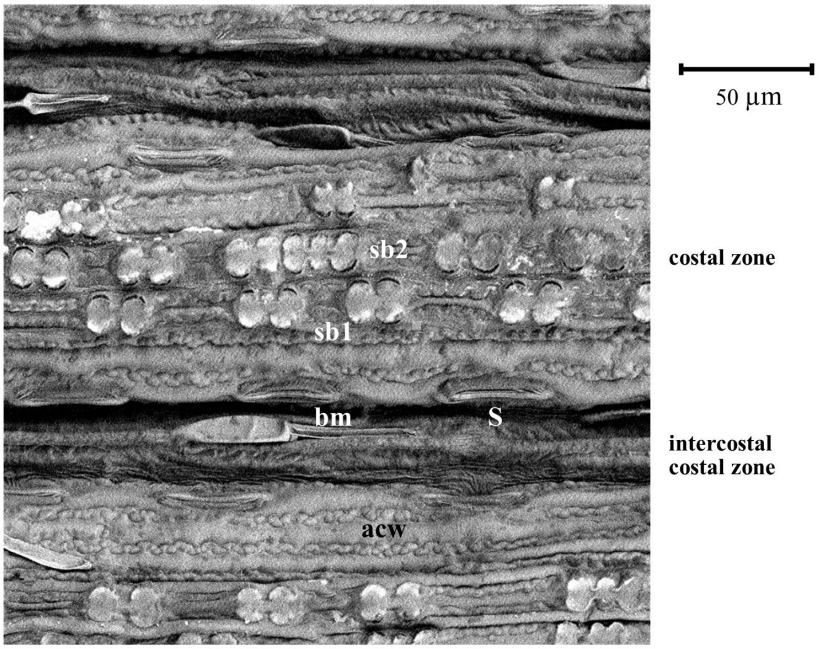

Fig. 10. Scanning electron micrograph of abaxial leaf surface of ***Calyptochloa sphaerocarpa***, ×1000 (**acw** anticlinal walls; **bm** bicellular microhair; **sb1** silica body – bilobate type; **sb2** silica body – polylobate type; **S** stoma). From *Thompson EJT301 et al.* (BRI). Photo: E.J. Thompson.

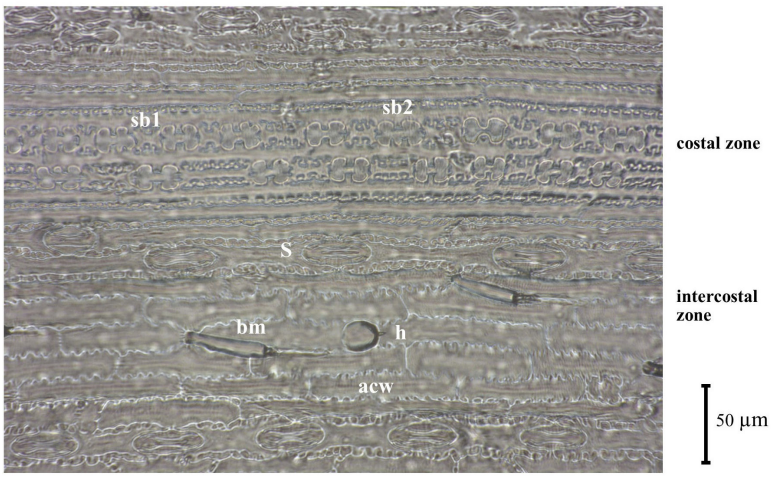

Fig. 11. Abaxial leaf surface replica of ***Calyptochloa sphaerocarpa***, ×20 (**acw** anticlinal walls; **bm** bicellular microhair; **h** hook; **sb1** silica body – bilobate type; **sb2** silica body – polylobate type; **S** stoma). From *Thompson EJT301 et al.* (BRI). Photo: E.J. Thompson.

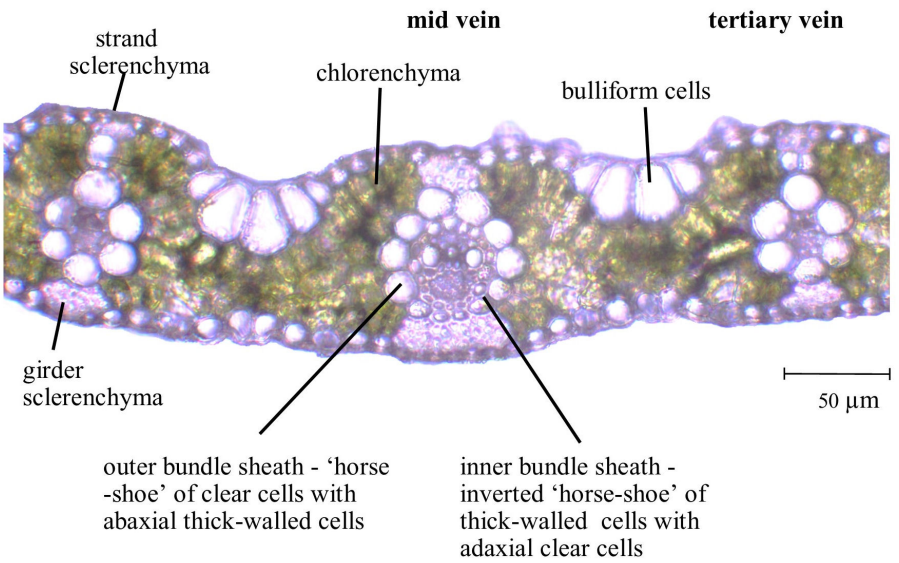

Fig. 12. Transverse section of fresh leaf at mid vein of ***Calyptochloa sphaerocarpa,*** ×20. From *Thompson EJT301 et al.* (BRI). Photo: E.J. Thompson.

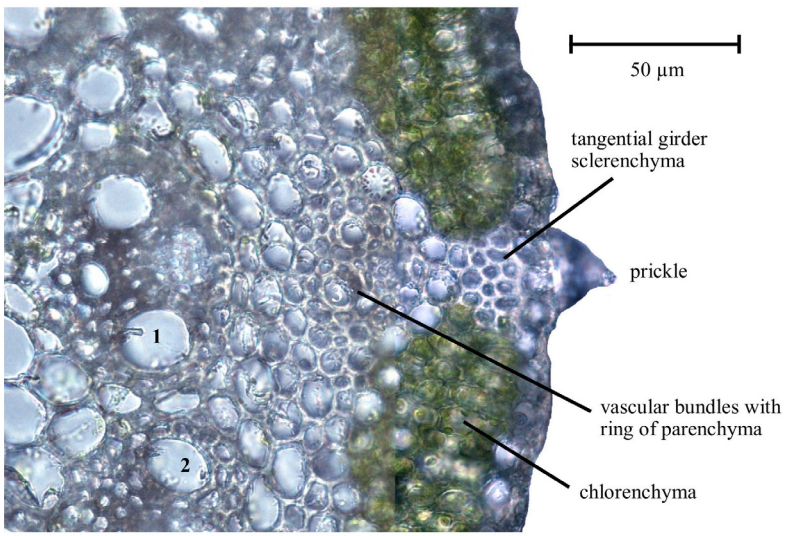

Fig. 13. Transverse section of portion of fertile culm of ***Calyptochloa sphaerocarpa***, ×20 (Vascular bundles: **1** primary; **2** secondary; **3** tertiary). From *Thompson EJT301 et al.* (BRI). Photo: E.J. Thompson.

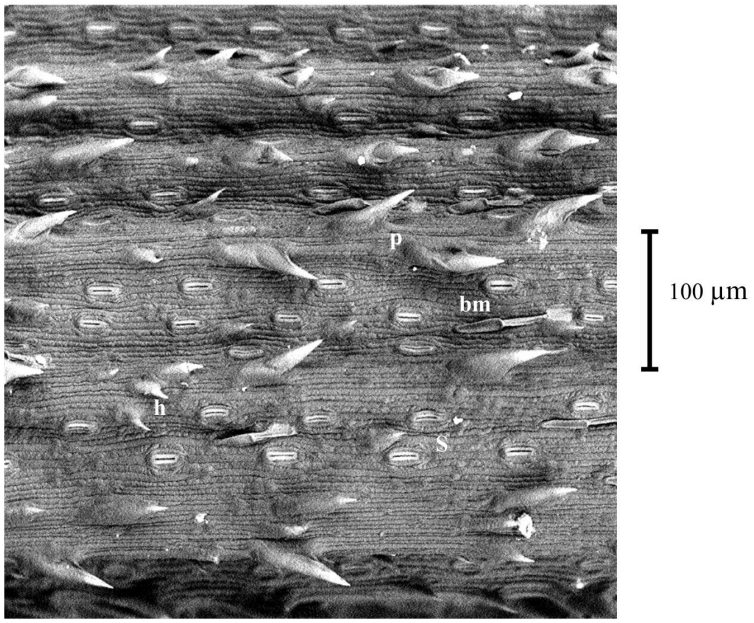

Fig. 14. Scanning electron micrograph of surface of terminal inflorescence culm of ***Calyptochloa sphaerocarpa***, ×500 (**bm** bicellular microhair; **h** hook; **p** prickle; **S** stoma). From *Thompson EJT301 et al.* (BRI). Photo: E.J. Thompson.

***Phenology*:** Flowers December to July.

***Conservation Status*:** *Calyptochloa sphaerocarpa* has been recorded for four State Forests - Duaringa, Dawson Range, Expedition and Overdeen. Plants are usually common at sites. The species is presently adequately conserved but its response to fire requires research.

***Etymology*:** The species epithet is derived from Latin and refers to the spherical shape of the axillary cleistogamous spikelets.

***Breeding system*:** *Calyptochloa* has a dimorphic breeding system with amphigamous inflorescences comprising CH terminal spike-like panicles and CL axillary racemes with distinct spikelet dimorphism. *Calyptochloa sphaerocarpa* differs by also having occasional apical racemes on subordinate culms comprising spikelets with similar morphology to those in the terminal panicles but smaller. The spikelets in these racemes can be either of two types, completely CL or partially autogamous, with heteromorphic anthers. The partially autogamous spikelets consist of an upper floret with anthers of two sizes enclosed by the lemma and palea and exserted stigmas (**Fig. 5**).

***Micromorphology and macromorphology of the lemmas*:** The CH and CL lower lemmas (**Figs. 6 & 9**) differ in several ways including type of macrohairs, viz. tuberculate-based simple hairs vs tuberculate-based spicule-like trichomes; abundance of stomata, viz. occasional vs absent; and abundance of prickles, viz. common vs abundant. Upper lemmas differ the width of the longitudinal ridges, narrow vs wide.

***Abaxial leaf blade epidermis* (Figs. 10 & 11):** Costal/intercostal zonation conspicuous. Papillae absent. Costal long cells rectangular, much narrower than intercostal; anticlinal walls of intercostal long cells Ω-shaped. Stomata 34–45 µm long with low triangular subsidiaries, in single rows separated by 5–7

files of long cells. Bicellular microhairs 85–90 µm long, distal cell longer than proximal. Silica bodies predominantly bilobate or occasionally polylobate, 22–28 µm long. Hooks sparse.

Transverse section of leaf blade **(Fig. 12):** C_3; XyMS+. Mesophyll without radiate chlorenchyma; adaxial palisade inconspicuous. Midrib not prominent; with a double bundle sheath; partial outer ring of clear parenchyma cells with abaxial thick-walled cells and inner ring of partially thick-walled cells with adaxial clear parenchyma cells. Bulliform cells in discrete regular groups, in simple fans. Sclerenchyma accompanying mid-vein as adaxial and abaxial girders; secondary and tertiary vascular bundles as adaxial strands and abaxial girders.

Transverse section of culm **(Fig. 13):** Culm examined *c*. 1 mm in diameter. Outer smallest vascular bundles adjacent to tangential girder sclerenchyma and imbedded in large-celled sclerenchyma. Vascular bundles with a ring of clear parenchyma; three sizes in separate circles, smallest to the periphery. Chlorenchyma in rectangular blocks, 3–4 cells deep by *c*. 12 cells wide; outer layer of cells more elongated than the more or less circular, inner three layers. Inner ground tissue consisting of large thin-walled cells.

Surface of inflorescence culm **(Fig. 14):** Scabrid with hooks and prickles. Stomata abundant, 25–25 µm long, smaller than those on the abaxial leaf surface. Bicellular microhairs, *c*. 75 µm long, occasional. Silica bodies absent as for other species of *Calyptochloa* and taxa in *Cleistochloinae*.

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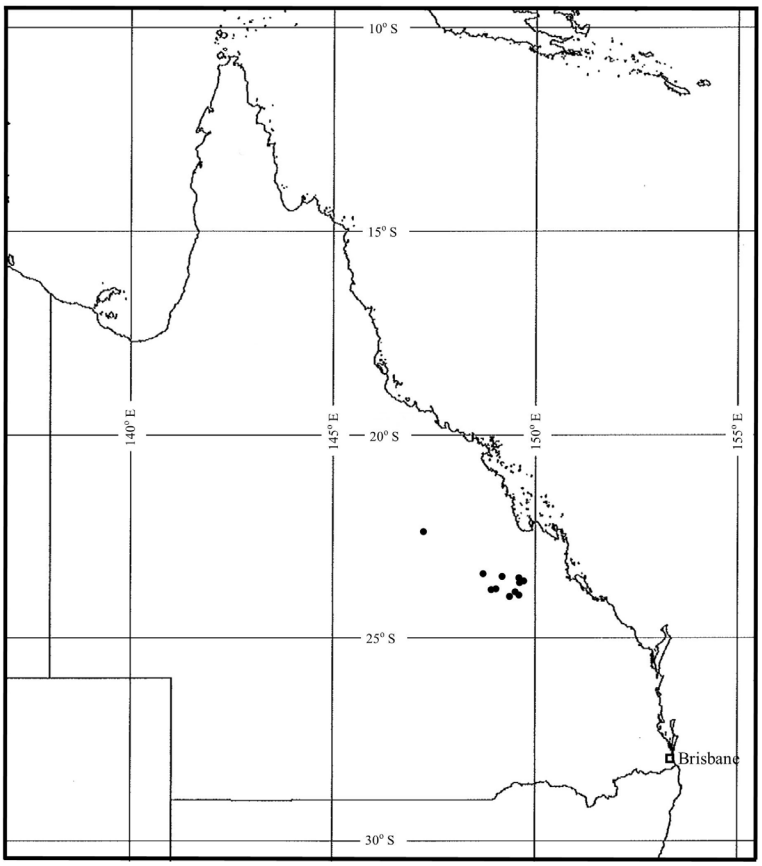
Table 1. Morphological differences between the species of *Calyptochloa*

Character	*Calyptochloa cylindrosperma*	*Calyptochloa gracillima*	*Calyptochloa johnsoniana*	*Calyptochloa sphaerocarpa*
Leaves: length (cm) × width (mm)	1.5–3 ×2–4	1.2–4 ×2.5–6	2–5.5 ×3–5	3–11 ×3.5–8
Culm internodes	pilose	pilose	pilose	glabrous
CL racemes apical on subordinate culms	absent	absent	absent	present
Number of spikelets in axillary racemes	1	1	1 or 2	3 or 4
Fertile culm disarticulating	yes	yes	no	no
Upper glume and lower lemma of axillary spikelets	smooth	smooth	smooth	scabrid
Axillary spikelet length (mm)	6–7.5	3.5–5.5	6–6.1	4.5–4.8
Outline shape of axillary spikelet	lanceolate	lanceolate	broadly lanceolate	broadly elliptical



Map 1. Distribution of ***Calyptochloa sphaerocarpa*** based on Queensland Herbarium collection records.