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# A revision of *Calyptochloa* C.E.Hubb. (Poaceae), with two new species and a new subspecies

E.J. Thompson & B.K. Simon

## Summary

Thompson, E.J. & Simon, B.K. (2012). A revision of *Calyptochloa* C.E.Hubb. (Poaceae), with two new species and a new subspecies. *Austrobaileya* 8(4): 634–652. Two new species of *Calyptochloa* C.E.Hubb. (*Calyptochloa cylindrosperma* E.J.Thomps. & B.K.Simon and *C. johnsoniana* E.J.Thomps. & B.K.Simon) endemic to central Queensland, and a new subspecies of *Calyptochloa gracillima* C.E.Hubb. (*C. gracillima* subsp. *ipsviciensis* E.J.Thomps. & B.K.Simon) endemic to southeast Queensland are described and illustrated.

Key Words: Poaceae, Paniceae, panicoid, cleistogamous, *Calyptochloa*, *Calyptochloa cylindrosperma*, *Calyptochloa gracillima* subsp. *gracillima*, *Calyptochloa gracillima* subsp. *ipsviciensis*, *Calyptochloa johnsoniana*, *Cleistochloa*, Queensland flora, taxonomy, new species, new subspecies, identification key

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## Introduction

*Calyptochloa* C.E.Hubb., an endemic Australian genus, is placed in the subfamily *Panicoideae* Link, tribe *Paniceae* R.Br. This tribe is characterised by the spikelets having a pair of dimorphic florets with the lower often incomplete, male or sterile, and falling entire, the upper fertile, and by the relative induration of the glumes and lemmas (Clayton & Renvoize 1986; Kellogg & Campbell 1987). *Calyptochloa* is amphigamous by having two types of inflorescences, *viz.* in terminal and axillary positions. The terminal inflorescence (Connor 1979), is a spike-like raceme with chasmogamous (CH) pedicellate spikelets that open at maturity and thereby potentially cross-fertilise. Conversely, the axillary inflorescence usually consists of a single sessile cleistogamous (enclosed self-fertilising flowers) (CL) spikelet which is hidden within semi-woody to woody leaf sheaths at each of several nodes along the culm. In the summer wet season, the axillary spikelets are produced at nodes with the terminal inflorescence above. At other times of the year, these chains

of axillary spikelets may be produced in the absence of terminal inflorescences. Webster (1987) stated that the CL spikelets occur singly or in pairs but we have not observed paired spikelets in any specimens at BRI, including those cited by Webster (1987), until we examined the type specimen for one of the new species described herein (*Calyptochloa johnsoniana* E.J.Thomps. & B.K.Simon). In *Calyptochloa*, the CL spikelets are obligately self-fertilised and never open. Plants of *Calyptochloa* retain the CL spikelets for a few months enclosed in the leaf sheaths before disarticulation at the culm nodes or at the leaf sheath bases which then fall at maturity with subsequent dispersal of the caryopses.

*Calyptochloa* has remained a monotypic genus since description with only *C. gracillima* C.E.Hubb. recognised until now (Hubbard 1933b; Tothill & Hacker 1983). The genus is characterised by the perennial mat-forming growth habit and the fertile leaf sheaths which enclose the CL spikelets. Clifford & Ludlow (1972) differentiated *Calyptochloa* from other Queensland grass genera in their key using “stems disarticulating at the nodes at maturity” and “prostrate to creeping” habit.

The genus is both clonal (stoloniferous) and cleistogamous, a rare combination in grasses (Campbell *et al.* 1983).

*Cleistochloa* C.E.Hubb. (Hubbard 1933a), another perennial panicoid genus from Australia and New Guinea, was listed by Connor (1981) with *Calyptochloa* amongst 13 genera world wide that possess clandestine axillary CL spikelets and belong in four different subfamilies of the Poaceae. Seven of these genera have amphigamous inflorescences and dimorphic spikelets of which *Calyptochloa* and *Cleistochloa* are the only panicoid genera. *Dimorphochloa* S.T.Blake (Blake 1941; Simon *et al.* 2010), which is also an Australian CL panicoid genus, was correctly omitted from Connor's (1981) list taking into account that this genus had not been synonymised with *Cleistochloa* (Clayton & Renvoize 1986; Webster 1987) at the time. Although *Dimorphochloa* has amphigamous inflorescences it differs from these other genera in terms of the CL spikelets as follows: similar to the CH spikelets, located apically on branchlets below the terminal inflorescences, and not hidden in the leaf sheaths at anthesis. *Amphicarpum* Kunth, another CL panicoid genus from eastern North America, was also omitted from Connor's (1981) list. *Amphicarpum* has amphigamous inflorescences and dimorphic spikelets but differs by the subterranean CL spikelets (rhizanthogenes) which are borne at the tips of rhizomes.

Connor (1981) reported that the clandestine spikelets are a secondary source of seed with most of the seed produced in the terminal inflorescences. For the Australian genera the reverse is true with most or all of the caryopses produced in the CL spikelets. Of about 30 specimens of *Calyptochloa gracillima* possessing terminal inflorescences inspected at BRI, only one had CH caryopses. No specimens of *Cleistochloa* at BRI were observed to have CH caryopses, thereby confirming this same observation made by Hubbard (1933a). The Australian genera with clandestine spikelets share features, indicative of obligate or habitual cleistogamy (Connor 1979), which when compared to the

CH spikelets (Campbell *et al.* 1983) include the following:

- a) reduced CL inflorescence size, usually one spikelet compared to a raceme or reduced panicle
- b) CL lodicules absent
- c) reduced size of CL anthers usually enravelled in reduced styles
- d) upper floret with lemma and palea convolute towards the apex tightly enclosing the anthers and styles at anthesis compared to gaping, and
- e) the CL caryopses a little larger than the CH caryopses when present.

Campbell *et al.* (1983) provided a detailed classification of CL species comprising four types based on factors that relate to prevention of the spikelets from opening including leaf sheath, spikelet parts or the soil conditions. Campbell *et al.* (1983) classified *Calyptochloa* and *Cleistochloa* as type II where fertilisation occurs in spikelets hidden in the lowermost sheaths and this type is usually associated with major inflorescence and spikelet differentiation. Chase (1908) referred to these clandestine CL spikelets at or near the ground as cleistogenes. However, *Calyptochloa* and *Cleistochloa* have CL spikelets enclosed in the sheaths in upper axils at fertilisation and the upper floret has modifications including revolute lemma and palea, and lodicules are absent, which prevent the floret from opening. These characteristics match type 1 of Campbell *et al.* (1983), where fertilisation takes place within the leaf sheaths of the middle to upper part of the stem but the spikelet may be exerted at maturity.

Hubbard (1933a) stated that as for the American CL grasses, the Australian species are found in arid regions or dry places within humid regions. *Calyptochloa* is distributed from tropical central Queensland with hot humid summers and monsoonal wet season to warm temperate south-eastern Queensland with warm humid summers (**Map 1**). *Calyptochloa* spp. are found in mostly well shaded habitats in a variety of vegetation communities frequently dominated by *Acacia* spp. on gently undulating to steeply sloping

terrain with shallow to skeletal soils derived from a variety of geology but often on landscapes with lateritic profiles.

In the current paper we provide a taxonomic account of *Calyptochloa*, trebling the number of species. Some of these additional species have been recognised for some time; however, their description is now possible following collection of material critical for character delimitation. Other taxa currently listed under *Calyptochloa* include *C. sp.* (Charters Towers E.J.Thompson+ CHA554) (Simon *et al.* 2010) and *C. sp.* (Duaranga K.D.Addison 42) (in BRI HERBRECS database accessed July 2012); both have same similar features to the species described in this paper, but may ultimately be described in other genera. These taxa are new members of the group of Australian panicoid grasses with axillary CL spikelets and are the subject of further study. They have overlapping distribution and habitat to other members of the group and often occur with *Thyridolepis xerophila* (Domin) S.T.Blake which is also a CL panicoid grass but the CL spikelets are in the terminal inflorescences and this species lacks axillary spikelets. On a number of occasions up to three to four of these CL species have been observed growing together.

### Materials and methods

Morphological data were obtained from dried herbarium material at BRI, and from cultivated plants transplanted from the field. Numerous terminal spikelets and leaf sheaths were dissected to examine the contents and describe the characteristics of the spikelets. Caryopsis germination trials were conducted during one summer over a two month period using sealable containers in outdoor conditions with periods of direct sunlight and no artificial lighting, shade or heating.

Habitat descriptions provided include Regional Ecosystems (REs) which are defined by DERM (2011). Botanical terminology follows Beentje (2010). Common abbreviations used in specimen citations include N.P. (National Park), S.F. (State Forest).

### Taxonomy

*Calyptochloa* C.E.Hubb., *Hook. Icon. Pl.* 33: t. 3210 (1933). **Type species:** *C. gracillima* C.E.Hubb.

Decumbent mat forming perennials; rhizomes absent. Stolons wiry, *c.* 1 mm thick; mid-culm internodes hollow. Culms differentiated, sterile and fertile, ascending from stolons. Fertile culms preceded by a portion of sterile culm; disarticulating at nodes or retained. Leaves ultimately disarticulating; margin undulate on one side, thickened, scabrid, white, with scattered tubercle-based hairs to 4 mm long at least at base; adaxial surface usually with scattered to moderately dense, erect simple hairs; abaxial surface with moderately dense, erect simple hairs. Mature fertile leaf sheaths disarticulating or retained, semi-woody to woody, enclosing from *c.* half to most of the length of the internode with scattered appressed to ascending tubercle-based bristles between ribs, with or without simple hairs; outer margin with dense, simple appressed to ascending simple hairs. Fertile culm internodes retained within leaf sheaths or bowing and protruding, scabrid along ribs with occasional simple hairs to 0.5 mm long between ribs. Sterile leaf sheaths retained; usually two types of hairs, with scattered appressed to ascending stiff tubercle-based hairs and sometimes ascending simple hairs. Sterile culm internodes with moderately dense to dense appressed to ascending, normal to flagelliform simple hairs to 2 mm long between ribs. Ligule a fringe of hairs, *c.* 0.3 mm long. Inflorescences of two kinds, chasmogamous terminal and cleistogamous axillary. Terminal inflorescences spike-like. Spikelets appressed to rachis, pedicellate, adaxial, elliptic, dorsiventrally compressed. Lower glume flat, chartaceous, glabrous except at base, apex acute; frequently absent, if present then restricted to apical spikelets. Upper glume as long as spikelet, ovate, flat, chartaceous, 5-nerved, dense simple hairs at base and usually moderately dense simple hairs to 2 mm over lower 30 to 60% and most of margin, upper portion glabrous; apex acute to truncate. Rachilla inconspicuous between florets. Lower floret sterile; lemma ovate, flat, chartaceous, densely hairy with simple

hairs at base and moderately hairy over lower 60 to 80%, upper portion glabrous, margin moderately hairy with hairs to 2 mm long; apex acute to obtuse. Palea absent. Upper floret fertile, shorter than the lower and slightly indurated; lemma ovate in dorsiventral view, convolute, chartaceous, glabrous, 3-nerved, apex acute with minutely scabrid awn; palea ovate, convolute, chartaceous, glabrous, 2-nerved; apex acute. Lodicules, 2. Anthers, 3. Caryopsis rarely present. Axillary inflorescences usually a single cleistogamous spikelet at 5–10 contiguous culm internodes often from immediately below terminal inflorescence; spikelets enclosed within leaf sheaths which are scarcely enlarged to conspicuously swollen towards the base where the walls are thicker, semi-woody to woody. Spikelets sessile, adaxial, narrow elliptic in dorsiventral view, slightly indurated. Lower glume absent. Upper glume lanceolate, flat, shorter than spikelet, chartaceous, glabrous except for base with scattered short simple hairs, 3-nerved; apex acute to truncate. Rachilla inconspicuous between florets. Lower floret sterile; lemma elliptic, boat-shaped, two-keeled, chartaceous, glabrous except for base, 5-nerved; apex obtuse. Palea absent. Upper floret fertile, more than c. 80% of length of first; lemma lanceolate, convolute, chartaceous, glabrous, apex acute with minutely scabrid awn; palea lanceolate, convolute, chartaceous, glabrous, obscurely 5-nerved; apex acute to shortly awned. Lodicules absent. Stamens 3. Caryopsis tan

to light brown, shallowly grooved at least on lower half, on adaxial face; hylum broadly elliptic, c. 40% of caryopsis length.

**Notes:** *Calyptochloa* differs from the other Australian cleistogamous panicoid genera by having terminal spikelets dorsi-ventrally compressed compared to spikelets elliptic in cross-section; the upper floret of the terminal spikelets about 60 to 70% of the spikelet length compared to equal to the spikelet length; the axillary spikelets retained within semi-woody to woody leaf sheaths compared to the spikelets exposed, partially hidden or hidden within cartilaginous leaf sheaths; axillary spikelets lacking spongy tissue at the base of the lower lemma; axillary caryopsis grooved on the adaxial face compared to face convex; and differential indumentum type on the sterile and fertile culm internodes compared to little or no difference in the indumentum types.

Preliminary results from caryopsis germination and seedling trials for most of the *Calyptochloa* spp. recognised here, indicate some variation in dormancy, cotyledon characters and seedling survival. Germination for the trial was sporadic but frequently temporally clustered giving an impression that dormancy may be broken by a period of several hot days. Seedling survival was poor for most taxa suggesting that survival may be affected by nutrient status and/or acidity of the potting medium and is potentially dependent on mycorrhiza. Investigations are continuing into these aspects.

### Key to *Calyptochloa* species

- 1 Fertile culm internode bowed and protruding from leaf sheath with chartaceous margins; axillary spikelet with upper glume >4.8 mm long; upper glume of terminal spikelets scabrid in mid third portion . . . . . **3. *C. johnsoniana***
- 1. Fertile culm internode retained within leaf sheath with margins semi-woody to woody; axillary spikelet with upper glume <4.5 mm long; upper glume of terminal spikelets sparsely hairy to pilose with simple hairs to 1 mm long in mid third portion . . . . . **2**
- 2 Lower portion of fertile leaf sheath conspicuously swollen to 2.7 mm wide, wall 0.3–0.5 mm thick; axillary spikelets 3.5–5.5 mm long (excluding awn); terminal spikelets 3–4.6 mm long (excluding awn) . . . . . **1. *C. gracillima***
- 2. Lower portion of fertile leaf sheath slightly swollen to 1.4 mm wide, wall 0.2–0.3 mm thick; axillary spikelets 6–7.5 mm long (excluding awn); terminal spikelets 5–6 mm long (excluding awn) . . . . . **2. *C. cylindrosperma***



**1. Calyptochloa gracillima** C.E.Hubb., *Hook. Icon. Pl.* 33: t. 3210, 1–6 (1933). **Type:** Queensland. BURNETT DISTRICT: Munduberra, April 1931, *H.S. Bloxsome 9* (holo: BRI; iso: BRI, K [photo BRI]).

Decumbent stoloniferous perennial. Ascending branches to 40 cm tall, copiously branched with 7–30 nodes. Stolons to *c.* 2 m long. Mid-culm leaf blades 12–40 mm long, 2.5–6 mm wide; adaxial surface with sparse hairs 0.5–2 mm long; abaxial surface with moderately dense simple hairs 0.5–1 mm long. Mature fertile leaf sheaths retained, convolute, woody. Fertile culm internodes 14–40 mm long. Sterile leaf sheaths with or without tubercle-based bristles 0.3–0.8 mm long and occasionally simple hairs 1.5–3 mm long; outer margin hairs dense, 0.4–1 mm long. Terminal inflorescences on axes 1.5–3 cm long, 5–8-flowered. Spikelets 2.3–5 mm long (without awn), 1–1.8 mm wide; lateral

pedicels 0.3–1.6 mm long; ultimate pedicel 2.5–5.5 mm long. Lower glume triangular to lanceolate, 0.2–1.8 mm long; apex acute. Upper glume 3–5 mm long. Lower lemma 2.3–5 mm long; apex acute. Upper lemma 2.2–3.5 mm long, awn 0.5–3 mm long; lodicules *c.* 0.2 mm long; palea 2–3 mm long, rarely awned. Anther 1.5–2 mm long. Caryopsis (**1.6–1.8**) 2.2–2.5 mm, rarely present. Axillary inflorescences present at 3–10 internodes. Spikelets 3.5–5.5 mm long (without awn), 0.8–1.1 mm wide. Upper glume 0.5–3.5 mm long, apex acute. Lower lemma 3–5.5 mm long. Upper floret subequal to lower. Upper lemma body 3.5–5.5 mm long, awn 0.5–2.6 mm long; palea 3–3.8 mm long. Anthers 0.3–0.7 mm long. Caryopsis approximately plano-convex, 2–3.5 mm long, 0.7–0.8 mm wide. Measurements in **bold** type are from Hubbard (1933b) and were not repeatable from the specimens examined.

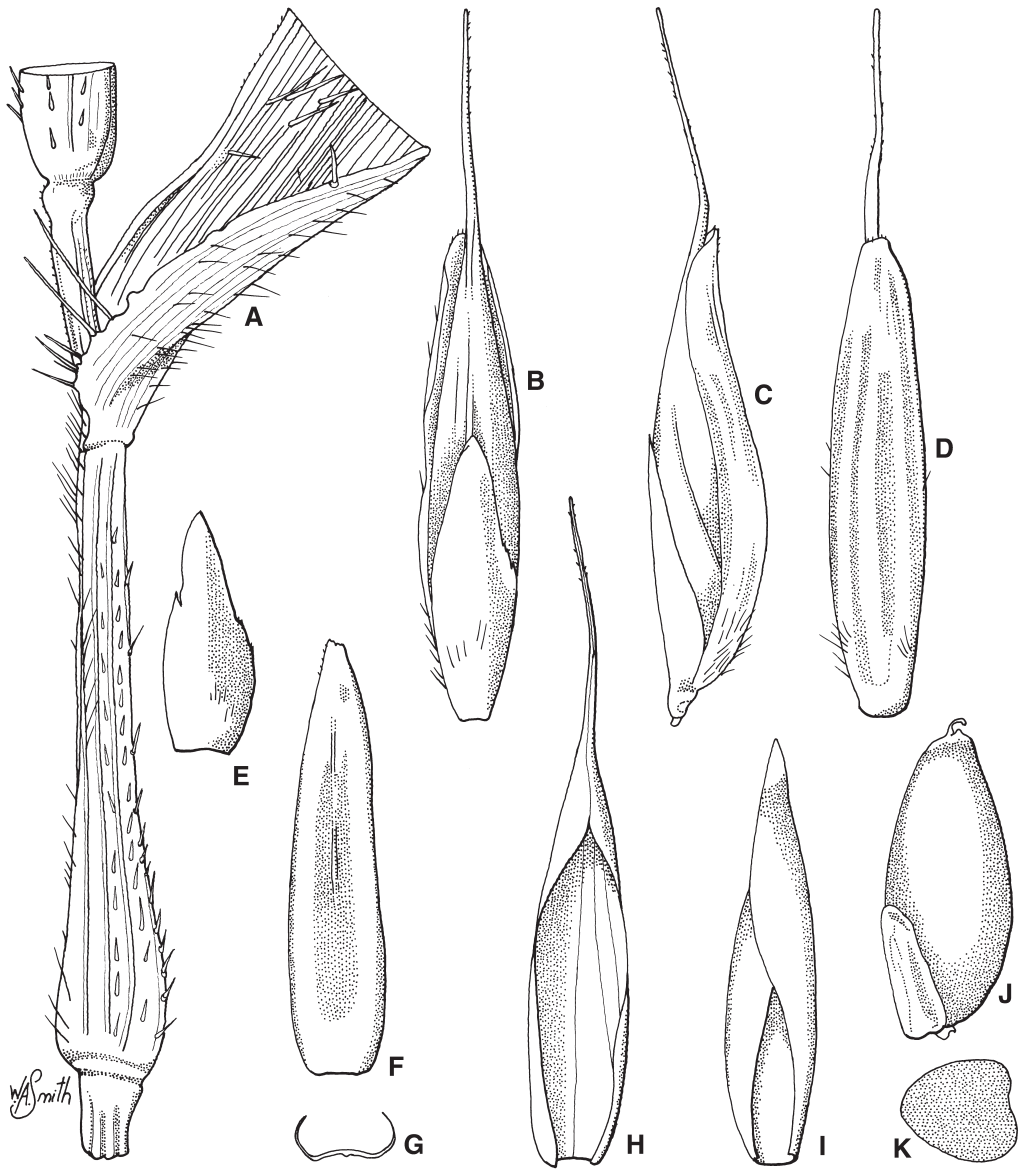
#### Key to subspecies of *Calyptochloa gracillima*

- 1a** Axillary spikelets 4–5.5 mm long (excluding awn) × 1–1.1 mm wide, anthers 0.3–0.4 mm long; terminal spikelets with lower glume when present *c.* 0.2 mm long and upper glume apex obtuse to truncate . . . . . **C. gracillima** subsp. **gracillima**
- 1b** Axillary spikelets 3.5–4.2 mm long (excluding awn) × 0.8–0.9 mm wide, anthers 0.4–0.7 mm long; terminal spikelets with lower glume when present 0.8–1.8 mm long and upper glume apex acute . . . **C. gracillima** subsp. **ipsviciensis**

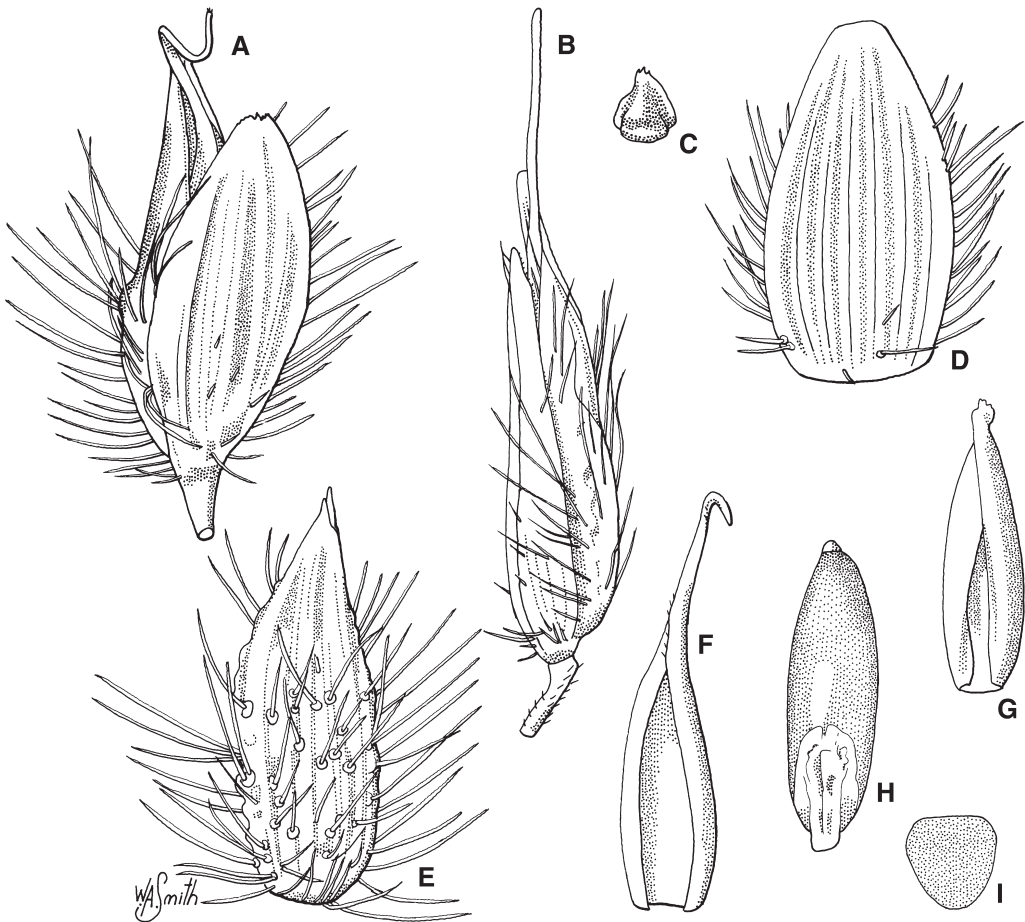
#### **1a. C. gracillima** subsp. **gracillima**

Decumbent stoloniferous perennial. Ascending branches to 25 cm tall, copiously branched with 10–30 nodes. Stolons to *c.* 1.5 m long. Mid-culm leaf blades 25–40 mm long, 2.5–5 mm wide; adaxial surface with sparse to moderately dense simple hairs 0.3–1.6 mm long and usually some tubercle based hairs to 3 mm long on margin at base; abaxial surface with moderately dense simple hairs 0.2–0.8 mm long. Mature fertile leaf sheaths 10–17 mm long, 1.5–3 mm wide near base with wall 0.3–0.4 mm thick. Sterile leaf sheaths with tubercle-based bristles *c.* 0.3 mm long and simple hairs *c.* 1.3 mm long. Terminal inflorescences on axes 1–3 cm long, 5–8-flowered. Spikelets 3–5 mm long

(without awn), 1.3–1.8 mm wide; lateral pedicels 0.4–2 mm long, apical pedicel 2–4.5 mm long. Lower glume triangular to lanceolate, 0.2–1.3 mm long. Upper glume 3–5 mm long; apex truncate. Lower lemma 3–5 mm long. Upper lemma 3–3.5 mm long, awn 2–3 mm long; lodicules 0.2–0.4 mm long; palea 2.5–3 mm long, rarely awned, awn to 2 mm long. Anthers (**0.5–1**) 1.6–2 mm long. Caryopsis (**1.6–1.8**) *c.* 2.3, rarely seen. Axillary inflorescences usually present at 5 (3–10) internodes. Spikelets 4–5.5 mm long (without awn), 1–1.1 mm wide. Upper glume 0.5–1.5 mm long. Lower lemma 4–5.5 mm long. Upper lemma body 4–5.5 mm long, awn 2–2.6 mm long; palea 3–3.8 mm long. Anthers 0.3–0.4 mm long. Caryopsis 2–3.5 mm long, 0.7–0.8 mm wide. **Fig. 1 & 2.**



**Fig. 1.** Axillary spikelet of *Calyptochloa gracillima* subsp. *gracillima*. A. leaf sheath enclosing axillary spikelet  $\times 8$ . B. upper glume facing  $\times 12$ . C. side view  $\times 12$ . D. lower lemma facing  $\times 12$ . E. upper glume  $\times 12$ . F. lower lemma  $\times 12$ . G. cross-sectional view of lower lemma  $\times 12$ . H. upper lemma  $\times 12$ . I. upper palea  $\times 12$ . J. caryopsis  $\times 16$ . K. cross-sectional view of caryopsis  $\times 16$ . A–K from Blake 19976 (BRI). Del. W.Smith.



**Fig. 2.** Terminal spikelet of *Calyptochloa gracillima* subsp. *gracillima*. A. upper glume facing  $\times 16$ . B. side view  $\times 16$ . C. lower glume  $\times 24$ . D. upper glume  $\times 16$ . E. lower lemma facing  $\times 16$ . F. upper lemma  $\times 16$ . G. upper palea  $\times 16$ . H. caryopsis  $\times 16$ . I. cross-sectional view of caryopsis  $\times 16$ . A–F from *Blake 19976* (BRI); H–I from *Bean 20216* (BRI). Del. W. Smith.

Measurements in **bold type** are from Hubbard (1933b) which were not repeatable from the specimens examined.

**Additional selected specimens examined: Queensland.**  
**NORTH KENNEDY DISTRICT:** On edge of road 70 km SSE of Charters Towers, May 2012, *Thompson & Simon CHA795* (BRI). **SOUTH KENNEDY DISTRICT:** Edge of highway, 53 km NW of Clermont, May 2012, *Thompson & Simon EJT875* (BRI); 4 km (direct) NW of haul road overpass, near Newlands coal mine, WNW of Glendon, Jun 2009, *Bean 29028*, (BRI). **LEICHHARDT DISTRICT:** Edge of road, 34 km SW of Springsure, Apr 2012, *Thompson & Simon EJT830* (BRI); site of Brigalow Research Station, 20 miles [32 km] NW of Theodore, Apr 1963, *Johnson 2642* (BRI); 17 km W of Baralaba, on road to Woorabinda, Mar 2005, *Bean 23519* (BRI); Near Bun Bun Kundoo

Spring, Ka Ka Mundi N.P., via Springsure, May 1999, *Bean 14846* (BRI); 16.6 km along Roche Creek Road, E of Wandoan, Mar 2010, *Bean 29485* (BRI). **PORT CURTIS DISTRICT:** Gogango, May 1956, *Blake 19976*, (BRI); Marmor, Mar 1943, *Blake 14819* (BRI); Hibbs Road, N of Jambin, Apr 2003, *Bean 20216* (BRI). **MARANO DISTRICT:** 20 miles [32 km] W of Mitchell, Mar 1936, *Blake 10951* (BRI). **DARLING DOWNS DISTRICT:** Edge of track, Barakula S.F., 32 km NW of Chinchilla, Apr 2012, *Thompson & Simon EJT786* (BRI).

**Distribution and habitat:** *Calyptochloa gracillima* subsp. *gracillima* is endemic to central Queensland (**Map 1**). At its most southern limits, it occurs on a range of soil types e.g. clay under brigalow (*Acacia*



*harpophylla* F.Muell. ex Benth.) (RE 11.3.1), sandy duplex soils to skeletal soils on laterite and shallow sandy soils on sandstone in ironbark woodland (commonly *Eucalyptus fibrosa* subsp. *nubila* (Maiden & Blakely) L.A.S.Johnson) (RE 10.7.7). Other REs represented include 11.5.3 and 11.5.4. Further north it occurs on mostly lateritic landscapes overlapping with the distribution area of *C. cylindrosperma* but the two species are rarely seen together. REs represented include 11.7.2 and 11.7.6. *C. gracillima* subsp. *gracillima* has a much broader habitat range than *C. cylindrosperma*, *C. johnsoniana* and *C. gracillima* subsp. *ipsviciensis*, which is also reflected in its broader overall distribution.

**Phenology:** *Calyptochloa gracillima* subsp. *gracillima* flowers from December to March during the wet season. The cleistogamous spikelets are produced over a broader seasonal period.

**Notes:** Caryopsis germination trials indicate differences between the subspecies of *Calyptochloa gracillima*. Initial trials have revealed more rapid germination of *C. gracillima* subsp. *ipsviciensis* and better seedling survival than for the nominative subspecies.

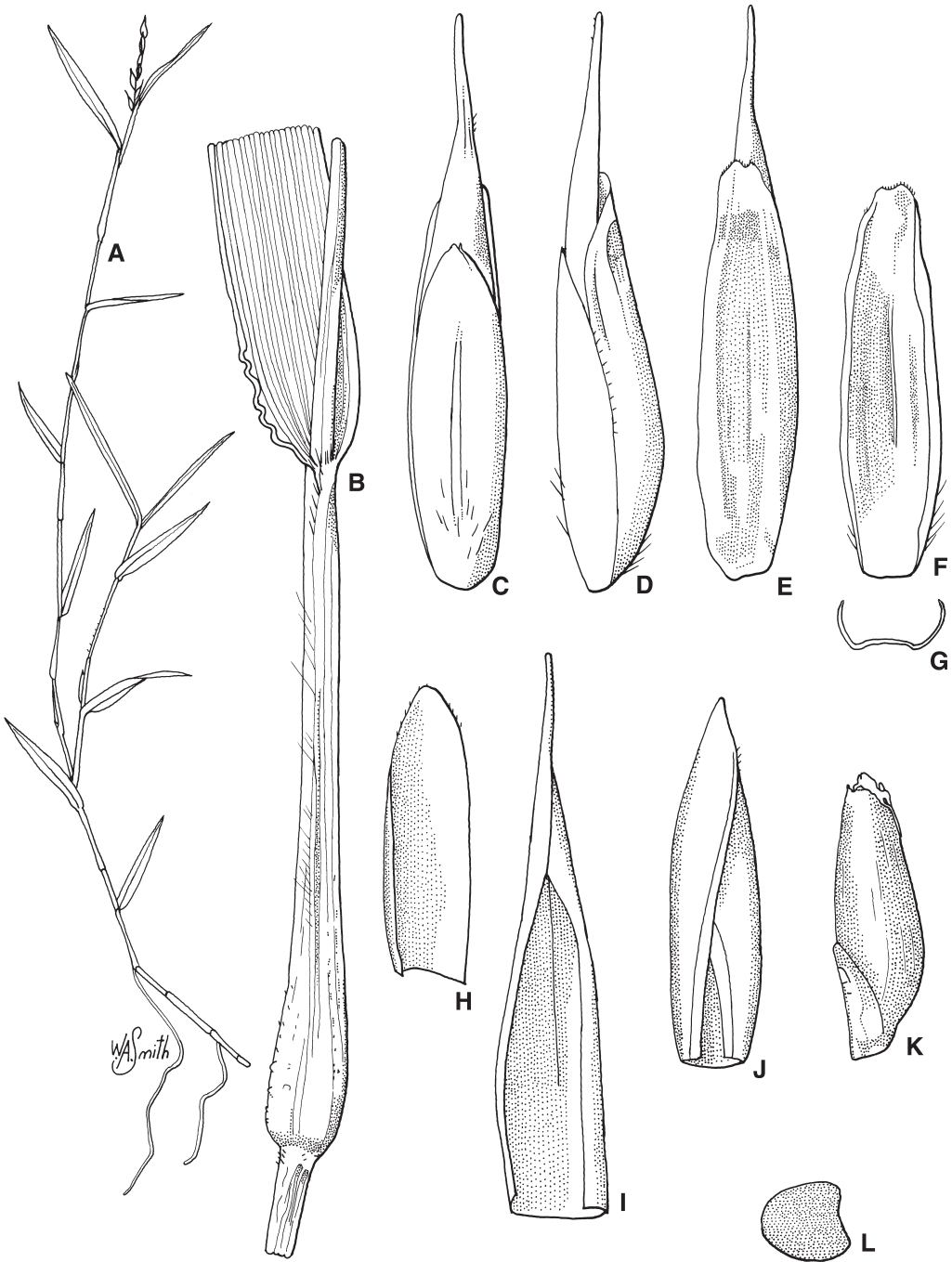
**Conservation status:** This subspecies is widely distributed over a large area and is usually common in the habitats where it occurs suggesting this subspecies is **Least Concern** (IUCN 2001).

**1b. *Calyptochloa gracillima* subsp. *ipsviciensis*** E.J.Thomps. & B.K.Simon, **subspecies nova** similar to *C. gracillima* C.E.Hubb. subsp. *gracillima* differing by the axillary spikelets mostly shorter (3.5–4.2 mm versus 4–5.5 mm) and narrower (0.8–0.9 mm versus 1–1.1 mm); longer anthers (0.4–0.7 versus 0.3–0.4); and by the terminal spikelets with an acute apex of upper glume (versus obtuse to truncate), and longer lower glumes when present (0.8–1.8 mm versus <0.2 mm). **Typus:** Queensland, MORETON DISTRICT: Council reserve, cnr Reservoir Lane and Kholo Road, Ipswich, 4 April 2012, *E.J.Thompson MOR711* (holo: BRI; iso: CANB, K, L, MO, NSW, SI, US).

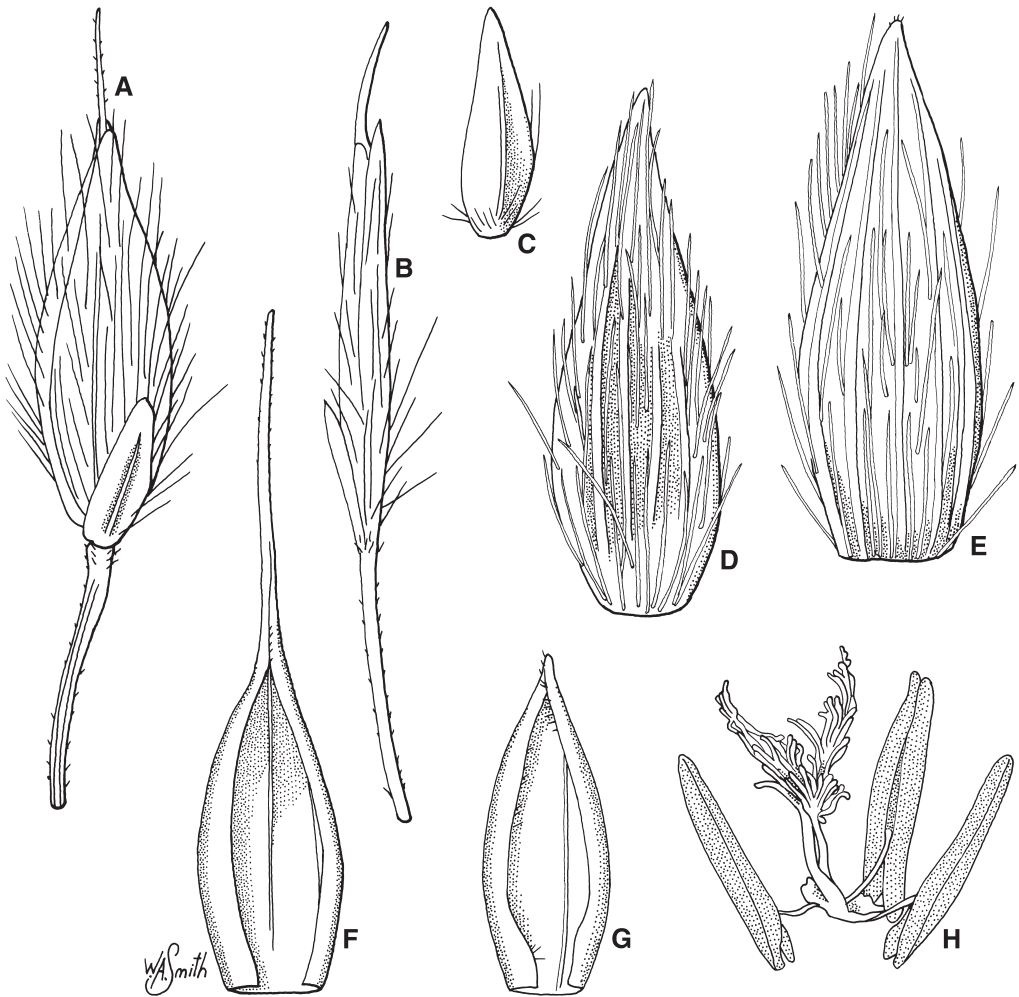
Decumbent stoloniferous perennial. Ascending branches to 40 cm tall, copiously branched with 10–30 nodes. Stolons to c. 3 m long. Mid-culm leaf blades 20–36 mm long, 2.5–5 mm wide; adaxial surface with sparse hairs 0.5–2 mm long; abaxial surface with moderately dense simple hairs 0.5–1 mm long. Mature fertile leaf sheaths 10–15 mm long, 1.2–2.5 mm wide near base with wall 0.3–0.4 mm thick. Sterile leaf sheaths with tubercle-based bristles 0.3–0.7 mm long and simple hairs 1.5–3 mm long. Terminal inflorescences on axes 1.5–3 cm long, 5–8-flowered. Spikelets 3–4.6 mm long (without awn), 1–1.6 mm wide; lateral pedicels 1–1.6 mm long, apical pedicel 2.5–4 mm long. Lower glume lanceolate, 0.7–1.8 mm long. Upper glume 2.3–4.6 mm long; apex acute. Lower lemma 2.3–4.6 mm long. Upper floret lemma 2.2–3.2 mm long, awn 0.5–2.4 mm long; lodicules 0.2 mm long; palea 2–2.7 mm long, apex acute. Anther, 1.5–2 mm long. Caryopsis not seen. Axillary inflorescences usually present at 4 (3–5) internodes. Spikelets 3.5–4.2 mm long (without awn), 0.8–1 mm wide. Upper glume 0.7–3.5 mm long. Lower lemma 3.5–4.2 mm long. Upper lemma body 3–4.2 mm long, awn 0.5–2.5 mm long; palea 2.7–3.5 mm long. Anthers 0.4–0.5 mm long. Caryopsis 2.3–3.7 mm long, 0.5–0.8 mm wide. **Fig. 3 & 4.**

**Additional specimens examined:** Queensland, MORETON DISTRICT: Edge of powerline easement off South Deebing Creek Road, Deebing Heights, Feb 2012, *Thompson MOR689 & Simon* (BRI, CANB, K, SI); Edge of Kerners Road, Yamanto near Ipswich, Aug 2011, *Thompson EJT497* (BRI, CANB, MO); Edge of Kerners Road, Yamanto near Ipswich, Feb 2012, *Thompson MOR688 & Simon* (BRI); Council reserve, corner Reservoir Lane and Kholo Road, Ipswich, May 2002, *Thompson MOR739 & Simon* (BRI); Ipswich Council reserve, end of Powers Road, off Kholo Road, c. 1 km S of Brisbane River crossing, c. 6 km N of Ipswich; Mar 2012, *Thompson MOR709* (BRI); Edge of Kholo Road, c. 1 km SE of Brisbane River crossing near corner of Blackwall Road, c. 6 km N of Ipswich, Mar 2012, *Thompson MOR693* (BRI, CANB, NSW, RSA).

**Distribution and habitat:** *Calyptochloa gracillima* subsp. *ipsviciensis* is endemic to southeast Queensland in the vicinity of Ipswich (**Map 1**) where it is known from a few small areas. It is an uncommon to dominant species in woodlands dominated by *Eucalyptus* spp. including *E. crebra* F.Muell.



**Fig. 3.** Axillary spikelet of *Calyptochloa gracillima* subsp. *ipsviciensis*. A. habit  $\times 0.6$ . B. leaf sheath enclosing axillary spikelet  $\times 8$ . C. upper glume facing  $\times 16$ . D. side view  $\times 16$ . E. lower lemma facing  $\times 16$ . F. lower lemma  $\times 16$ . G. cross-sectional view of lower lemma  $\times 16$ . H. upper glume  $\times 16$ . I. upper lemma  $\times 16$ . J. upper palea  $\times 16$ . K. caryopsis  $\times 16$ . L. cross-sectional view of caryopsis  $\times 16$ . A–L from Thompson MOR689 & Simon (BRI). Del. W.Smith



**Fig. 4.** Terminal spikelet of *Calyptochloa gracillima* subsp. *ipsviciensis*. A. upper glume facing  $\times 12$ . B. side view  $\times 12$ . C. lower glume  $\times 16$ . D. upper glume  $\times 16$ . E. lower lemma  $\times 16$ . F. upper lemma  $\times 16$ . G. upper palea  $\times 16$ . H. stamens and stigmas  $\times 16$ . A–H from Thompson MOR689 & Simon (BRI). Del. W.Smith.

and *E. moluccana* Roxb. and/or *Corymbia citriodora* subsp. *variegata* (F.Muell.) A.R.Bean & M.W.McDonald on loam to clay loam duplex soils derived from shale on gently undulating to hilly terrain. REs represented include 12.9–10.2, 12.9–10.3 and 12.9–10.19. Associated ground layer species include *Aristida caput-medusae* Domin, *Cleistochloa subjuncea* C.E.Hubb. and *Themeda triandra* Forssk. The habitat is typically moderately shaded.

**Phenology:** *Calyptochloa gracillima* subsp. *ipsviciensis* flowers from December to March during the wet season. The cleistogamous spikelets are produced over a broader seasonal period.

**Notes:** Until 2011 there were no specimen records of *Calyptochloa gracillima* at BRI from the Moreton Pastoral District near Ipswich. These new records represent a disjunction of over 200 km from the previous known southern limit of the species.

*Calyptochloa gracillima* subsp. *ipsviciensis*

is similar to *C. gracillima* subsp. *gracillima* in growth habit but on average it is taller, the mats cover a greater area and the leaves are more yellowish green. *C. gracillima* subsp. *ipsviciensis* also differs by the mostly thinner walled fertile leaf sheaths, and often the proportionally shorter fertile leaf sheath in relation to the internode length. Generally the fertile leaf sheaths cover about half the length of the culm internodes whereas for *C. gracillima* subsp. *gracillima* the leaf sheath usually covers most of the length of the culm internode. Only spikelets towards the apex of racemes of terminal inflorescences have a lower glume present, but it is often absent.

The distribution of this subspecies overlaps with *Ottochloa gracillima* C.E.Hubb. and *Entolasia marginata* (R.Br.) Hughes, both of which it could easily be confused with in the field in terms of growth habit and leaf colour and size although to date these species have not been seen growing with *C. gracillima*. *Ottochloa gracillima* and *Entolasia marginata* are distinguishable in the field by the branched inflorescences, the smaller glabrous spikelets and the abaxial leaf surface which is glabrous to sparsely hairy.

**Etymology:** The subspecies epithet is derived in reference to the name of the nearby city of Ipswich where it has been found.

**Conservation status:** *Calyptochloa gracillima* subsp. *ipsviciensis* is only known from a few locations near the urban centre of Ipswich, two of which are Ipswich City Council reserves. At two locations only one or two plants or mats have been observed. The very restricted range and the few small populations suggest this subspecies should be considered **Critically Endangered** (criterion B1a,b [IUCN 2001]). Current threats include invasion from weeds such as *Megathyrsus maxima* var. *pubiglumis* (K.Schum.) B.K.Simon & S.W.L.Jacobs and *Lantana montevidensis* (Spreng.) Briq., inappropriate burning regimes, urbanisation and road construction.

**2. *Calyptochloa cylindrosperma*** E.J.Thomps. & B.K.Simon, **species nova** similar to *C. gracillima* C.E.Hubb. differing by the degree of swelling of the mature fertile leaf sheaths

(slightly versus conspicuous) with thinner walls (0.2–0.3 mm versus 0.3–0.5 mm); the longer axillary spikelets (6–7.5 mm versus 3.5–5.5 mm) with longer caryopses (3.8–4 mm versus 2–3.7 mm) and shape (cylindrical versus plano-convex); the longer terminal spikelets (5–6 mm versus 3–5 mm) with longer anthers (2.5–2.6 mm versus 1.6–2 mm) and longer upper glume (5–6 mm versus 2.3–5 mm). **Typus:** Queensland. NORTH KENNEDY DISTRICT: 16 km SW of Charters Towers on edge of road, 7.5 km W of Black Jack, 30 March 2011, *E.J.Thompson CHA769*, *B.K.Simon & M.Edginton* (holo: BRI; iso: CANB, K, L, MO, NSW, SI, US).

*Calyptochloa* sp. (Blackjack E.J.Thompson+CHA769) (in BRI HERBRECS database accessed July 2012).

Decumbent stoloniferous perennial. Ascending branches to 40 cm tall, copiously branched with 10–30 nodes. Stolons to c. 0.5 m long. Mid-culm leaf blades 15–30 mm long, 2–4 mm wide; adaxial surface with scattered to moderately dense simple hairs to 0.5–1.6 mm long; abaxial surface with moderately dense simple hairs 1–2 mm long. Mature fertile leaf sheaths retained, semi-woody, 15–20 mm long, 1.2–1.7 mm wide near base with wall 0.2–0.3 mm thick; tubercle-based hairs 0.7–1.4 mm long between nerves, simple hairs absent; outer margin hairs to 1 mm long. Fertile culm internodes 20–45 mm long. Sterile leaf sheaths with scattered tubercle-based hairs 0.4–1 mm long and some simple hairs 0.5–2 mm long. Terminal inflorescences on axes 2–5 cm long, 5–10-flowered. Spikelets 5–6 mm long (without awn), 1.5–2 mm wide; lateral pedicels 0.5–1.5 mm long; ultimate pedicels 3–8 mm long; ultimate spikelets frequently longer than basal spikelets. Lower glume triangular, 0.1–0.5 mm long. Upper glume 5–6 mm long; apex acute. Lower lemma 5–6 mm long; apex acute. Upper lemma body 3–4 mm long, awn to 2.5–4 mm long. Lodicules c. 0.3 mm long. Upper palea 3–4 mm long. Anthers 2.5–2.6 mm long. Caryopsis not seen. Axillary inflorescences enclosed in leaf sheaths within scarcely enlarged basal portion usually present at 3–5 internodes. Spikelets 6–7.5 mm long (without



awn), 0.7–0.9 mm wide. Upper glume 0.7–4.5 mm long, apex acute. Lower lemma 6–7.5 mm long. Upper floret subequal to lower. Upper lemma body 6–7.5 mm long, awn 1.5–2.5 mm long. Palea 5.5–6 mm long; acute to shortly awned. Anthers *c.* 0.6 mm long. Caryopsis cylindrical, 3.8–4 mm long, 0.5–0.6 mm wide. **Fig. 5 & 6.**

**Additional specimens examined (c. 55 collections examined): Queensland.** NORTH KENNEDY DISTRICT: near Charters Towers, Apr 1943, *Blake 14904* (BRI); 50 km NW of Charters Towers, Dec 2011, *Thompson CHA779* (BRI); 16 km SW of Charters Towers on edge of road, Mar 2011, *Thompson CHA767 et al.* (BRI); 16 km W of Charters Towers on edge of Capricorn Highway, Mar 2011, *Thompson CHA773 et al.* (BRI); 16 km SW of Charters Towers on road to Jesmond, Mar 2002, *Thompson CHA556 & Turpin* (BRI, CANB, RSA); 20 km SW of Charters Towers, May 2012, *Thompson CHA786 & Simon* (BRI, CANB, K); 15 km NE of Mt Cooper Homestead, Jun 1992, *Thompson CHA332 & Sharpe* (BRI); 88 km SE of Charters Towers, May 2012, *Thompson CHA801 & Simon* (BRI, CANB, K). SOUTH KENNEDY DISTRICT: (site plot 53) 8.5 km SW of Mt Hope Homestead, Apr 1992, *Thompson BUC508 & Simon* (BRI); Blackwood N.P., 160 km S of Charters Towers, Mar 1998, *Cumming 16888* (BRI); *ditto loc.*, Dec 2011, *Thompson CHA776* (BRI).

**Distribution and habitat:** *Calyptochloa cylindrosperma* is known from central Queensland near Charters Towers (**Map 1**). It usually grows as the dominant ground cover, commonly in woodland of *Acacia shirleyi* Maiden, with or without *A. catenulata* C.T.White, on lateritic landscapes on mostly Tertiary plateaux with gently undulating red soil, occasionally jump-ups with shallow soils, or sometimes on shallow soils in sheltered gullies on quartzose sandstone. Associated ground layer species include *Cleistochloa subjuncea*, *Thyridolepis xerophila* and *Aristida caput-medusae*. Regional Ecosystems represented include 10.7.3a and b, and 11.7.2. The habitat is typically well shaded.

**Phenology:** *Calyptochloa cylindrosperma* flowers from December to March during the wet season. Axillary spikelets are produced over a broader seasonal period.

**Notes:** *Calyptochloa cylindrosperma* is similar to *C. gracillima* in growth habit (**Table 1**) and they have been found growing together at the transition of habitat from skeletal soil to

deep red soil with the latter habitat occupied by *C. cylindrosperma*.

Only spikelets towards the apex of racemes of terminal inflorescences have a lower glume present; however, it is often absent.

*Calyptochloa cylindrosperma* also has an overlapping distribution and shares habitat with *Calyptochloa* sp. (Charters Towers E.J.Thompson+ CHA554). This latter species differs by the terminal spikelets having the upper glume and lower lemma convex in cross-section and the upper floret as long as the spikelet, and the axillary inflorescences consisting of two types, one with paired spikelets, sessile and pedicillate, the other a single sessile spikelet.

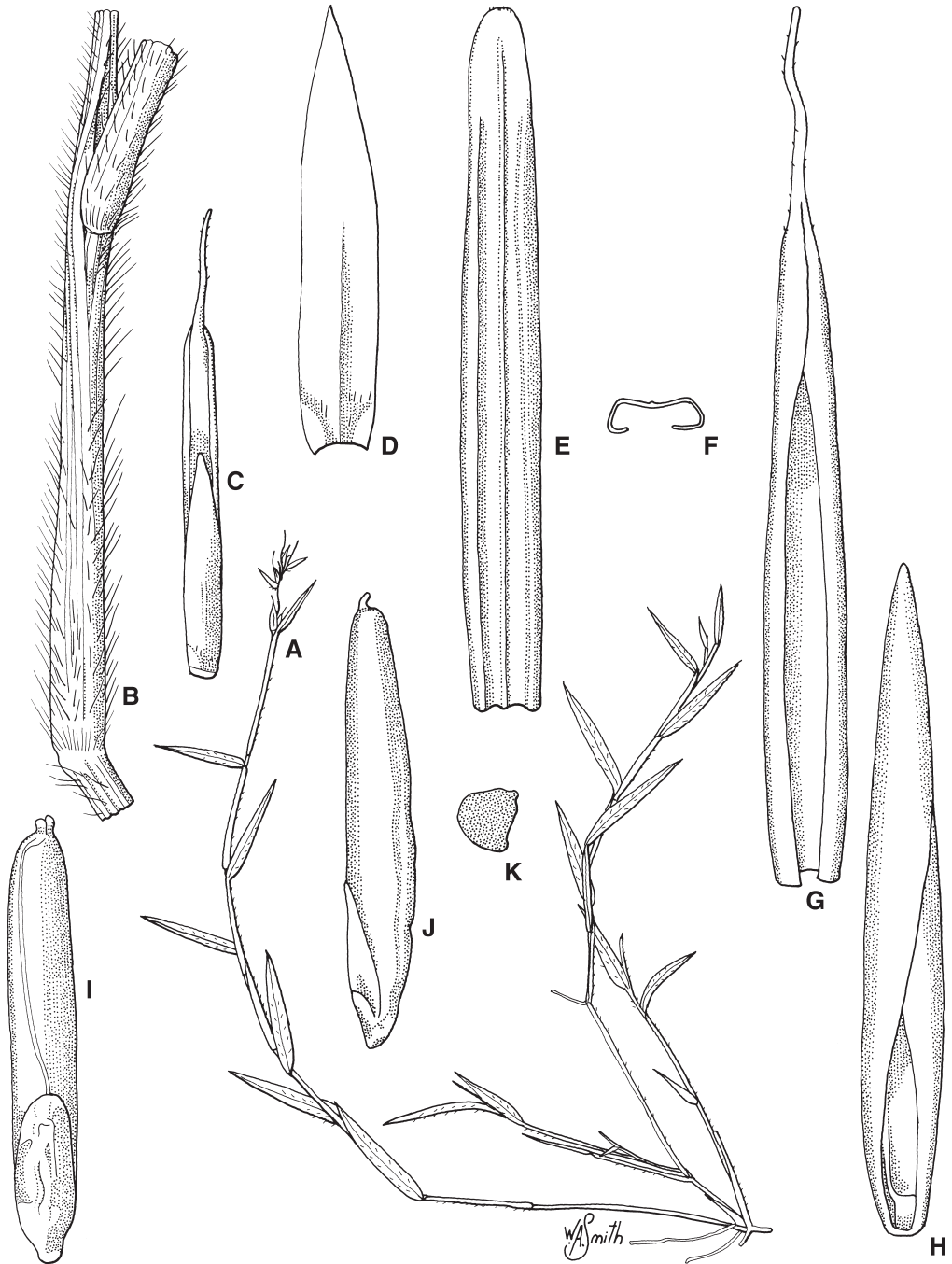
**Etymology:** The specific epithet is from the Greek *cylindro-* (cylindrical) and *-sperma* (seed) in reference to the shape of the cleistogamous caryopses.

**Conservation status:** *Calyptochloa cylindrosperma* is common at several locations in northern central Queensland but has a very restricted range with narrow habitat diversity. The small populations suggest this species should be considered as **Critically Endangered** (criterion B1a,b) (IUCN 2001).

**3. *Calyptochloa johnsoniana*** E.J.Thomps. & B.K.Simon, **species nova** similar to *C. gracillima* differing by the longer axillary spikelets (6–6.1 mm versus 3.5–5.5 mm) with a longer upper glume (>4.8 mm versus <4.5 mm); the fertile leaf sheaths (woody abaxially and chartaceous adaxially versus semi-woody to woody for the whole circumference); the fertile culm internodes (bowed adjacent to the spikelets and exerted from the leaf sheath versus culm retained within the leaf sheath); upper glume of the terminal spikelet (scabrid versus pilose). **Typus:** Queensland. LEICHHARDT DISTRICT: Duaringa, December 1976, *R.W.Strickland s.n.* (holo: BRI [AQ670557]).

Decumbent stoloniferous perennial. Ascending branches to 90 cm tall, copiously branched with 10–20 nodes. Stolons to *c.* 0.5 m long. Mid-culm leaf blades 20–40 mm long, 3–4 mm wide; adaxial surface with scattered





**Fig. 5.** Axillary spikelet of *Calyptochloa cylindrosperma*. A. habit  $\times 0.7$ . B. leaf sheath enclosing axillary spikelet  $\times 6$ . C. spikelet with upper glume facing  $\times 8$ . D. upper glume  $\times 16$ . E. lower lemma  $\times 16$ . F. x-sectional view of lower lemma  $\times 16$ . G. upper lemma  $\times 16$ . H. upper palea  $\times 16$ . I. grain face view  $\times 16$ . J. grain side view  $\times 16$ . K. grain cross-sectional view  $\times 16$ . A–K from Thompson *CHA767 et al.* (BRI). Del. W.Smith.



**Fig. 6.** Terminal spikelet of *Calyptochloa cylindrosperma*. A. side view  $\times 8$ . B. lower glume facing  $\times 8$ . C. upper glume facing  $\times 8$ . D. lower glume  $\times 16$ . E. upper glume  $\times 12$ . F. lower lemma  $\times 12$ . G. upper lemma  $\times 12$ . H. upper palea  $\times 12$ . I. gynoecium and stamens  $\times 16$ . A–I from Thompson *CHA767 et al.* (BR1). Del. W.Smith.

**Table 1. Comparison of morphological characters for *Calyptochloa* taxa\***

Character state		<i>C. cylindrosperma</i>	<i>C. gracillima</i> subsp. <i>gracillima</i>	<i>C. gracillima</i> subsp. <i>ipsviciensis</i>	<i>C. johnsoniana</i>
Terminal spikelets	Spikelet length × width (mm)	5-6 × 1.5-2	3-5 × 1.3-1.8	3-4.6 × 1.1-1.6	4.5-5.1 × 1.5-1.7
	Lower glume length (mm), apex shape	0.1-0.5, acute	<0.2, obtuse-truncate	0.8-1.8, acute	not observed
	Upper glume length (mm), apex shape	5-6, acute	3-5, obtuse to truncate	2.3-4.6, acute	4.5-5.1, truncate
	Lower lemma length (mm)	5-6	3-4.8	2.3-4.6	4.5-5.1
	Upper lemma length (mm)	3-4	3-3.5	2.2-3.2	3.1-3.5
	Upper lemma awn length (mm)	2.5-4	2-3	0.5-2.4	1-2
	Upper palea length (mm)	3-4	2.5-3	2-2.7	3-3.3
	Caryopsis length (mm)	not observed	2.3 (1.6-1.8*)	not observed	not observed
	Anther length (mm)	2.5-2.6	1.6-2 (0.5-1*)	c. 1.5	c. 1.6
Axillary spikelets	Spikelet length × width (mm)	6-7.5 × 0.7-0.9	4-5.5 × 1-1.1	3.5-4.2 × 0.8-0.9	6-6.1
	Upper glume length (mm)	0.7-4.5	0.5-1.5	0.7-3.5	4.8-5.1
	Upper lemma & lower lemma length (mm)	6-7.5	4-5.5	3.5-4.2	4-5
	Upper lemma awn length (mm)	1.5-3	2-2.6	0.5-2.5	c. 4.5
	Upper palea length (mm)	5.5-6	3-3.8	2.7-3.5	4-4.5
	Caryopsis length × width (mm) shape	3.8-4 × 0.5-0.6, cylindrical	2-3.5 × 0.7-0.8, c. plano-convex	2.3-3.7 × 0.5-0.8, c. plano-convex	c. 4 × 1, cylindrical
	Anther length (mm)	c. 0.6	0.3-0.4	0.4-0.7	c. 0.3
	Width of mature fertile leaf sheath (mm)	1.2-1.4	1.5-2.7, mostly c. 2	1.2-2.5, mostly c. 1.5	c. 1.5
	Thickness of mature fertile leaf sheath at abaxial wall (mm)	0.2-0.3	0.3-0.5	0.3-0.4	c. 0.3

\* data from Hubbard (1933b)

simple and tubercle-based hairs 0.5–2 mm long; abaxial surface with scattered simple and tubercle-based hairs 0.5–2 mm long. Mature fertile leaf sheaths disarticulating, 10–20 mm long, *c.* 1.5 mm wide near base with wall to 0.3 mm thick on abaxial side, tapering to chartaceous margins; tubercle-based trichomes *c.* 0.5 mm long between nerves, simple hairs absent; outer margin hairs to 1 mm long. Fertile culm internodes, 13–20 mm long, protruding from leaf sheath and bowing around caryopsis. Sterile leaf sheaths with scattered tubercle-based hairs *c.* 0.3 mm long. Sterile culm internodes with medium density simple hairs to 2 mm long. Terminal inflorescences on axes 2–5 cm long, 5–6-flowered. Spikelets 4.5–5.5 mm long (without awn), 1.5–1.7 mm wide; lateral pedicels 0.3–1 mm long; ultimate pedicels 4–5 mm long. Lower glume not observed. Upper glume 4.5–5.1 mm long, body with simple hairs to 1.5 mm long at base and scabrid for 60% of length; margins with simple hairs to 2 mm long for 75% of length; apex truncate. Lower lemma 4.5–5.1 mm long, dense tubercle-based hairs to 2.5 mm long for 75% of length; apex obtuse. Upper lemma body 3.1–3.5 mm long, awn to 1–2 mm long. Lodicules *c.* 0.2 mm long. Upper palea 3–3.3 mm long. Anthers *c.* 1.6 mm long. Caryopsis not seen. Axillary inflorescences, spikelets single or rarely paired, one sessile and the other pedicellate, pedicel *c.* 6.5 mm long, enclosed within leaf sheaths with scarcely enlarged basal portion, usually present at 3–5 internodes. Spikelets 6–6.1 mm long (without awn), 1.4–1.5 mm wide. Upper glume 4.8–5.1 mm long, apex obtuse to truncate. Lower lemma 6–6.1 mm long. Upper floret *c.* 80% of length of lower. Upper lemma body 4–5 mm long, apex with two lateral lobes 0.3–0.5 mm long and awn 3–4.5 mm long. Palea 4–4.5 mm long. Anthers *c.* 0.3 mm long. Caryopsis cylindrical, *c.* 4 mm long and 1 mm wide. **Fig. 7 & 8.**

**Distribution and habitat:** The species is known only from the type specimen collected from a red soil plateau near Duinga (**Map 1**). The notes on the specimen label do not provide details about the habitat; however, from our existing knowledge it is very likely

to be woodland dominated by *Acacia shirleyi* (RE 11.7.2).

**Phenology:** Flowers in December and probably through to March during the wet season.

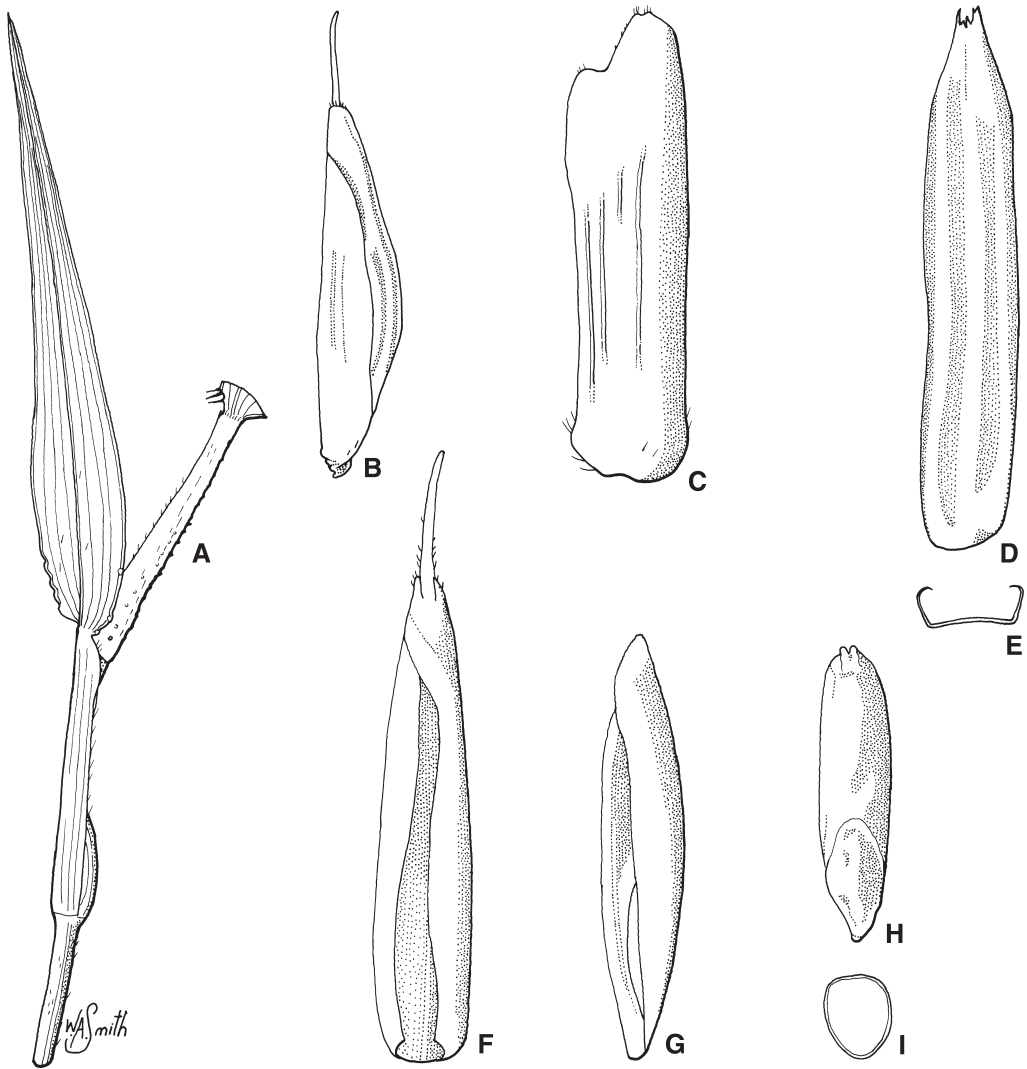
**Notes:** *Calyptochloa johnsoniana* has an overlapping distribution and habitat with *C. gracillima* subsp. *gracillima* (**Table 1**) and *C. sp.* (Duinga K.D. Addison 42). Because of the similar growth habit and leaves, *C. johnsoniana* could easily be confused in the field with *C. sp.* (Duinga K.D. Addison 42) which differs by characters including the following: the scabrid ellipsoid cleistogamous spikelets, with woody upper glume and lower lemma, in axillary racemes; the terminal inflorescences being a reduced panicle; the terminal spikelets with upper glume and lower lemma having elliptical cross-section and upper floret equal to the spikelet length.

**Conservation status:** This species is only known from a single specimen from the type locality near Duinga. Pending the discovery of additional populations that may extend the geographical range, we recommend that this species should be considered **Critically Endangered** (criterion B1a-b [IUCN 2001]).

**Etymology:** The specific epithet is in honour of Dr Robert W. Johnson (1930–2012), former Director at the Queensland Herbarium from 1976–1990.

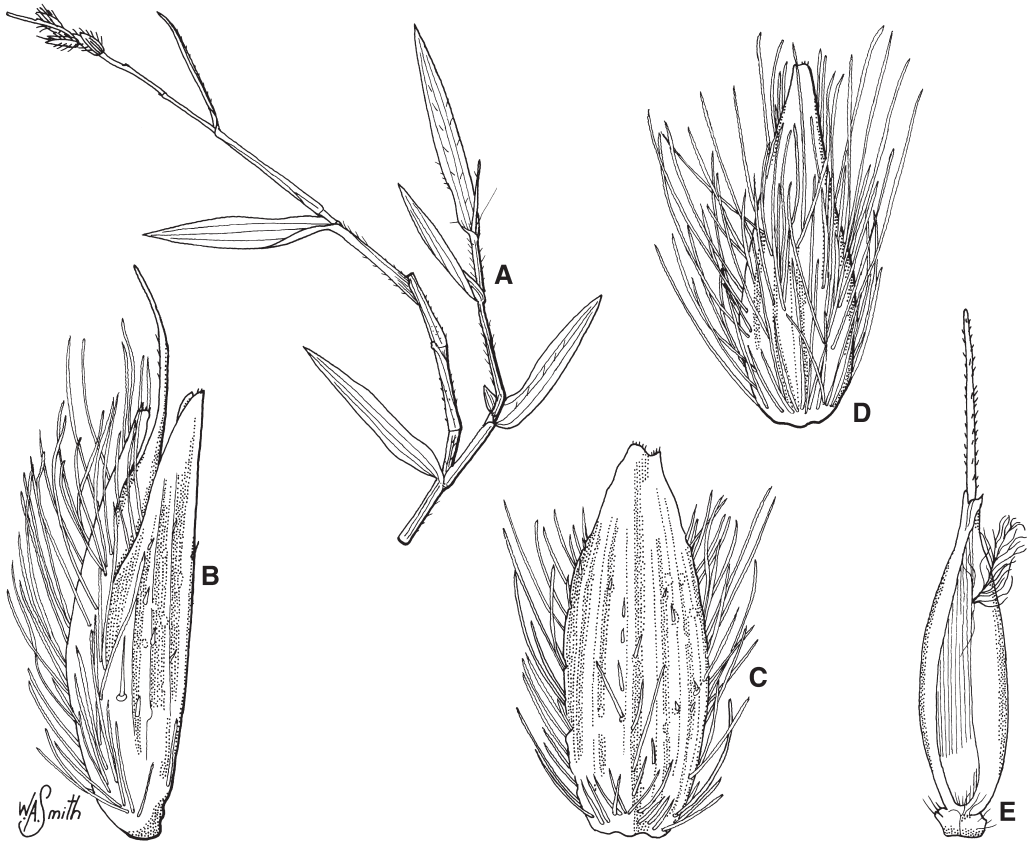
#### Acknowledgements

We are very grateful to Dr. G.P. Guymer and A. Holland for their critical review of a draft of the manuscript, and Will Smith for the botanical illustrations and map. Many thanks to Steven Priday who first brought attention to the location of plants of the new subspecies at Ipswich, and David Moore for additional locations.



**Fig. 7.** Axillary spikelet of *Calyptochloa johnsoniana*. A. leaf sheath enclosing spikelet  $\times 3$ . B. side view  $\times 8$ . C. upper glume  $\times 12$ . D. lower lemma  $\times 12$ . E. lower lemma  $\times 12$ . F. upper lemma  $\times 12$ . G. upper palea  $\times 12$ . H. immature caryopsis  $\times 12$ . I. cross-sectional view of immature caryopsis  $\times 12$ . A–I from *Strickland s.n.* (BRI [AQ670557]). Del. W.Smith.



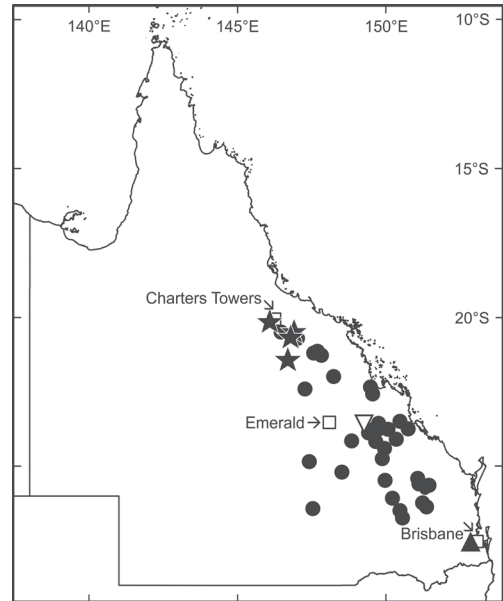


**Fig. 8.** Terminal spikelet of *Calyptochloa johnsoniana*. A. portion of culm with terminal inflorescence  $\times 1$ ; B. side view  $\times 12$ ; C. upper glume  $\times 12$ ; D. lower lemma  $\times 12$ ; E. upper floret  $\times$ . A–E from Strickland s.n. (BRI [AQ670557]). Del. W.Smith.

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**Map 1.** Distribution of *Calyptochloa cylindrosperma* (★), *C. gracillima* subsp. *gracillima* (●), *C. gracillima* subsp. *ipsviciensis* (▲) and *C. johnsoniana* (▽)