

CYPERUS RICHARDII (CYPERACEAE) NEW TO FLORIDA, U.S.A.,
AND THE WESTERN HEMISPHERE

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ABSTRACT

Cyperus richardii Steud. is reported new to Florida, U.S.A., and the Western Hemisphere. A revised dichotomous key to the kyllingoid *Cyperus* in the continental United States, a technical description, distributional and habitat data, and illustrations, photographs, and scanning electron micrographs are provided to aid in identification. Observations about identification of *C. richardii* in the field, its vegetative reproduction, inflorescence morphology, possible pollination by insects, and potential as a weed are discussed.

RESUMEN

Se cita *Cyperus richardii* Steud. Como nuevo para Florida, U.S.A., y el Hemisferio occidental. Se aportan una clave dicotómica revisada para los *Cyperus kyllingoides* en los Estados Unidos continentales continental, una descripción técnica, datos de distribución y hábitat, e ilustraciones, fotografías, y micrografía de microscopio electrónico de barrido para ayudar en la identificación. Se discuten observaciones acerca de la identificación de *C. richardii* en el campo, su reproducción vegetativa, morfología de la inflorescencia, posible polinización por insectos, y su potencial como mala hierba.

INTRODUCTION

We report *Cyperus richardii* Steud., a white-headed sedge superficially resembling *C. sesquiflorus* (Torr.) Mattf. & Kük., new to the Western Hemisphere and Florida, U.S.A. Indigenous to tropical Africa and southern Asia and introduced in Australia and Malaysia, *C. richardii* is widely distributed in the Old World (Govaerts et al. 2016; Fig. 1). Ours is the latest in a series of reports of non-indigenous weedy sedges new for Florida and North America (cf. Carter 1990; Carter et al. 1996; Carter & Bryson 2000; Carter & Mears 2000; Jacono 2001).

As traditionally defined, the kyllingoid sedges have bifid styles, lenticular to flattened achenes, 1-fruited spikelets, and capitate inflorescences of 1-several dense spikes (e.g., Tucker 2002). Certain authors treat these plants in *Kyllinga* (e.g., Adams 1994; Bryson et al. 1997; Lunkai et al. 2010; Gordon-Gray 1995; Hooper & Napper 1972; Kukkonen 2001; Tucker 1984, 2002; Hoenselaar et al 2010), whereas others include them within a more broadly defined *Cyperus* (e.g., DeFilipps 1980; Delahoussaye & Thieret 1967; Godfrey & Wooten 1979; Haines & Lye 1983; Kern 1974; Kükenthal 1935-1936; Lye 1995; Wilson 1993). Because *C. richardii* has spikelets with 2–3 flowers and fruits, a feature in common with *Cyperus*, its classification in *Kyllinga* Rottb. [as *K. bulbosa* P. Beauv.] is problematic. Moreover, recent phylogenies (Larridon et al. 2013; Reid et al. 2014), based on molecular characters, show *Kyllinga* embedded within a paraphyletic *Cyperus*. In light of the morphological ambiguity and this recent genetic work, we adopt the recommendations and synonymy of Govaerts et al. (2016) in treating this taxon as *Cyperus richardii*. Following are names of the other North American kyllingoid *Cyperus* with their *Kyllinga* synonyms: *C. brevifolius* (Rottb.) Endl. ex Hassk. [*K. brevifolia* Rottb.], *C. brevifoli-*

oides Thieret & Delah. [*K. gracillima* Miq.], *C. densicaesпитosus* Mattf. & Kük. [*K. pumila* Michx.], *C. metzii* (Hochst. ex Steud.) Mattf. & Kük. [*K. squamulata* Vahl], and *C. sesquiflorus* [*K. odorata* Vahl].

A revised dichotomous key to the kyllingoid *Cyperus* in the continental United States and a description, distributional and habitat data, and illustrations, photographs and scanning electron micrographs of *C. richardii* are provided to aid in identification. We also discuss the identification of *C. richardii* in the field, its vegetative reproduction, inflorescence morphology, possible pollination by insects, and potential as a weed.

TAXONOMY

KEY TO THE KYLLINGOID *CYPERUS* IN THE CONTINENTAL UNITED STATES

1. Spikes white at anthesis; primary inflorescence bracts divaricate to strongly reflexed.
 2. Plant with slender, delicate stolons; central spike hemispherical to pyramidal; mature achene brown _____ **C. richardii** [*K. bulbosa*]
 2. Plant cespitose; central spike cylindrical; mature achene black _____ **C. sesquiflorus** [*K. odorata*]
1. Spikes green at anthesis; primary inflorescence bracts spreading to divaricate.
 3. Plant with rhizomes.
 4. Floral scale keel toothed; spikes 3–7 mm wide, oval to oblong, 1–3 per inflorescence; stamen 1 _____ **C. brevifolius** [*K. brevifolia*]
 4. Floral scale keel smooth; spikes 8–10 mm wide, spherical, 1 per inflorescence; stamens 2–3 _____ **C. brevifolioides** [*K. gracillima*]
 3. Plant without rhizomes, cespitose.
 5. Keel of floral scale denticulate; spikes 1–3, ovoid. 3–6 mm wide _____ **C. densicaesпитosus** [*K. pumila*]
 5. Keel of floral scale lacerate; spikes 1 (rarely 2–3), subglobose, 6–10 mm wide _____ **C. metzii** [*K. squamulata*]

Cyperus richardii Steud., Syn. Pl. Glumac. 2:8. 1854. (Figs. 1–6).

Kyllinga bulbosa P. Beauv., Fl. Oware 1:11. 1805.

Kyllinga macrocephala A. Rich., Tent. Fl. Abyss. 2:491. 1850.

Perennial herb, (1.3–)4.5–31 cm tall, from globose to ellipsoidal tuberous bases 3–5 mm wide, proliferating from slender stolons. **Stolons** elongated, (0.3–0.5–1.0 mm wide, white, scaly, becoming dark brown to purplish black, threadlike and essentially scaleless with age, easily broken and sometimes hardly evident, bearing persistent tubers derived from persistent plant bases. **Tubers** globose to ellipsoidal, hard, blackish brown, 3–4 mm wide, clothed with fibrous remains of leaves. **Culms** glabrous, slender, 0.4–1.3 mm wide at mid-culm, trigonous, faces multicostate. **Leaves** basal, medium to ±yellowish green, mostly two-thirds or more as long as culm, (1.0–1.5–3.7 mm wide, gradually tapering distally to slender apex, margin and abaxial midrib proximally smooth, both distally scabrid with prickle hairs 0.1–0.2 mm long. **Primary inflorescence bracts** 2–5(–23), medium to ±yellowish green, proximally whitish green, gradate, longest to 15 cm, shortest hardly evident, not exceeding spike, those longer than spike mostly divaricate to reflexed, margin and abaxial midrib scabrid with prickle hairs as in leaves. **Inflorescence** capitate, apparently unispicate, basal lateral spikes, when present, reduced and hardly evident; spikes hemispherical to pyramidal, 5–17 × 5–15 mm, white at anthesis, becoming brownish white with aging of persistent stigmas. **Spikelets** 2.5–2.8 mm long; prophyll (bracteole?) 1.5 mm long. **Floral scales** polystichous, white, 2–4, lowest (1–2–3 fertile; fertile floral scales broadly ovate, 2.0–2.3 mm long, acute, apically straight to slightly recurved, with 3–4 lateral nerves on either side of midrib, medially green in proximal one-half to two-thirds; keel smooth. **Florets** protogynous. **Stamens** 3; anthers 0.6–1.2 mm long, oblong-linear, yellow, conspicuously exerted, with exposed portion of filament mostly 2–3 times the length of anther. **Styles** two, conspicuously exerted, persistent, contorted but not coiled, turning dark brown after anthesis. **Achenes** 1.0–1.2 × 0.5–0.6 mm, oblong to obovate, obtuse, biconvex, brown. Figs. 2, 3, 4 and 5.

Distribution.—Indigenous to Tropical Africa [West Tropical Africa – Benin, Burkina, Gambia, Ghana, Guinea, Ivory Coast, Mali, Nigeria, Senegal, Sierra Leone, Togo; West-Central Tropical Africa – Burundi, Central African Republic, Cameroon, Congo, Equatorial Guinea, Gabon, Gulf of Guinea Is., Rwanda, Zaïre; North-east Tropical Africa—Chad, Eritrea, Ethiopia, Somalia, Sudan; East Tropical Africa—Kenya, Tanzania, Uganda; South Tropical Africa—Angola, Malawi, Mozambique]; Temperate Asia [China—Hainan, Southeast China]; Tropical Asia [Indian Subcontinent—Assam, Bangladesh, East Himalaya, India, Nepal, Pakistan, Sri Lanka; Indo-China—Andaman Is., Myanmar, Thailand, Vietnam]. Introduced in Malesia [Malaya], Australasia [New South Wales, Queensland] (Govaerts et al. 2016; Brummitt 2001), and North America [southern peninsular Florida]. Figures 1 and 6.



Fig. 1. The worldwide distribution of *Cyperus richardii* based upon Govaerts et al. (2015) (circles) and records reported herein (triangle) from Florida, U.S.A.

Habitat.—Open disturbed sites, especially roadsides and lawns.

Phenology.—Flowering and fruiting sporadically throughout the year, but apparently bimodal, peaking in summer and again in winter (R.L. Mears, personal observations).

Voucher specimens of *C. richardii* examined: **U.S.A. FLORIDA. Charlotte Co.**: Exit 161 off I-75 (Jones Loop Road), near NE corner of intersection of Jones Loop Road and C.R. 768 S of Punta Gorda Airport, 23 Nov 2015, R. Mears 7001 (VSC, others tbd); 26.95189°N, 81.99636°W, Cleveland, jct. Hwy US 17 and Ridge Rd, W of Hwy US 17, mowed roadside and shallow ditch, vicinity of culvert, 16 Dec 2015, R. Carter 22607 with R.L. Mears (VSC, others tbd). **Collier Co.**: lawn of Cracker Barrel just SE jct I-75 and SR 951, Exit 101, 6 May 2012, R. Mears 5849 (VSC-2 sheets); 26.12619°N 81.76481°W, Naples, near jct. CR 31 and Hwy US 41, N side Hwy US 41, E of CR 31, grounds of county municipal complex, mowed lawn, turf, with *Stenotaphrum secundatum*, locally common, heads white, 17 Dec 2015, R. Carter 22608 with R.L. Mears (VSC, others tbd). **Dade Co.**: 25.807192°N, 80.297260°W, Miami, vic. Miami International Airport, jct. Perimeter Rd (Hwy. 948) and NW 62nd St, locally common in turf along mowed roadside, 14 Aug 2001, R.L. Mears s.n. (VSC), 15 Dec 2008, R. Carter 18739 with R.L. Mears (VSC, others tbd). **Desoto Co.**: 27.22526°N, 81.85917°W, Arcadia, W of Hwy US 17, jct. N Arcadia Ave and Virginia St, vacant lot, occasionally mowed, 16 Dec 2015, R. Carter 22605 with R.L. Mears (VSC, others tbd). **Hardee Co.**: 27.37198°N, 81.7971°W, 8.4 mi S Zolfo Springs jct. Hwy FL 66 and Hwy US 17, along E side Hwy US 17, road shoulder, 16 Dec 2015, R. Carter 22602 with R.L. Mears (VSC, others tbd); 27.5948°N, 81.86475°W, NW of Wauchula, 2.61 mi W jct. Hwy US 17 and Hwy FL 62, along N side Hwy FL 62, mowed roadside, dark fine sandy loam, with *Cynodon dactylon*, 18 Dec 2015, R. Carter 22615 with R.L. Mears (VSC, others tbd). **Hendry Co.**: 26.7585°N, 81.4375°W, LaBelle, E of Hwy FL 29, jct. Bridge St and Broward Ave, vacant lot, occasionally mowed turf, 17 Dec 2015, R. Carter 22611 with R.L. Mears (VSC, others tbd). **Hillsborough Co.**: 27.86974°N, 82.13712°W, Alderman Ford Park, along E side of Hwy FL 39, mowed weedy border between athletic fields, disturbed sandy loam, 16 Dec 2015, R. Carter 22596 with R.L. Mears (VSC, others tbd); 27.82706°N, 82.14579°W, 1.6 mi S Pinecrest jct. Lithia Pinecrest Rd and Hwy FL 39, 150 m S jct. Moccasin Hollow Rd, along Hwy FL 39, road shoulder and ditch, 16 Dec 2015, R. Carter 22599 with R.L. Mears (ctb, VSC, others tbd). **Lee Co.**: Lee County Parks and Recreation Wild Turkey Strand Natural Area, ca. 2.5 air mi SW jct. Hwy. 82 and Green Meadows Rd, SE Fort Myers, 26°32'17.3"N, 81°42'12.9"W, along embankment of dirt road through cutover wet pine flatwoods and adjacent cypress strand, 12 Nov 2004, R. Carter 15850, D.J. Rosen and A. Smith (SWSL, VSC, others to be distributed). **Okeechobee Co.**: 27.26014°N, 80.83055°W, Okeechobee, jct. Hwy US 441 and NW 16th St, W of Hwy US 441 and N of NW 16th St, grounds of Okeechobee Cattleman's Association Rodeo Arena, infrequently mowed turf, with *Cynodon dactylon*, locally common, heads white, 18 Dec 2015, R. Carter 22613 with R.L. Mears (VSC, others tbd). **Polk Co.**: N of Ft. Meade, E side of Hwy US 17, vic. Jenkins Ford automobile dealership, mowed right-of-way, 27.78884°N, 81.81293°W, 09 Dec 2015, R. Mears 7012 (VSC, others tbd). **Sarasota Co.**: Exit 182 off I-75 (Sumter Blvd.), ca. 0.3 mi S of I-75 on W side of road next to paved jogging trail in grassy swale, 27°54'44"N, 82°12'17"W, 23 Nov 2015, R. Mears 7000 (VSC, others tbd).

Additional specimens cited herein: *Cyperus brevifolioides*—**U.S.A. Alabama. Limestone Co.**: alluvial bank of Tennessee River across from Decatur, by US 31 causeway, 08 Oct 1973, R. Kral 52283 (VSC). *Cyperus brevifolius*—**U.S.A. Alabama. Mobile Co.**: 0.95 mi W jct. hwy US 90 and AL 163 S, jct. Commercial Blvd and Government St, 12 Sep 1995, R. Carter 12717 (VSC). *Cyperus densicaespitosus*—**U.S.A. Georgia. Lowndes Co.**: 5.2 mi S Valdosta, ca. 1 mi S Dasher town center, E side Hwy US 41, 01 Oct 1991, R. Carter 9391 (VSC). *Cyperus metzii*—**U.S.A.**

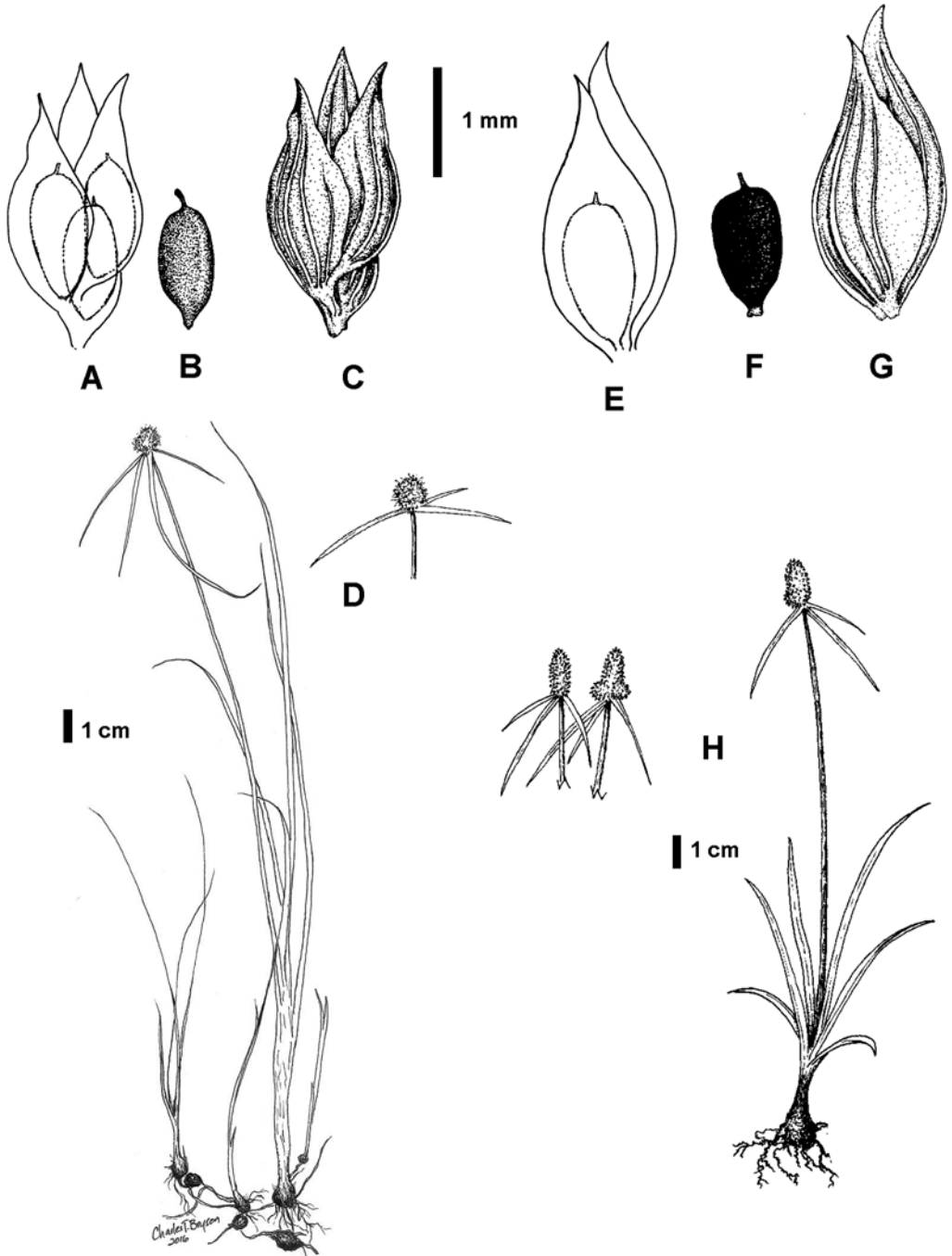


FIG. 2. Comparison of *Cyperus richardii* and *C. sesquiflorus*.—*Cyperus richardii* drawn from Carter & Mears 22599 (ctb). A. Disposition of achenes within spikelet. B. Achene. C. Spikelet. D. Habit showing slender stolons, bulbs, and inflorescence.—*Cyperus sesquiflorus* drawn from Bryson 8707 (ctb). E. Disposition of achene within spikelet. F. Achene. G. Spikelet. H. Habit and variation in inflorescence form.

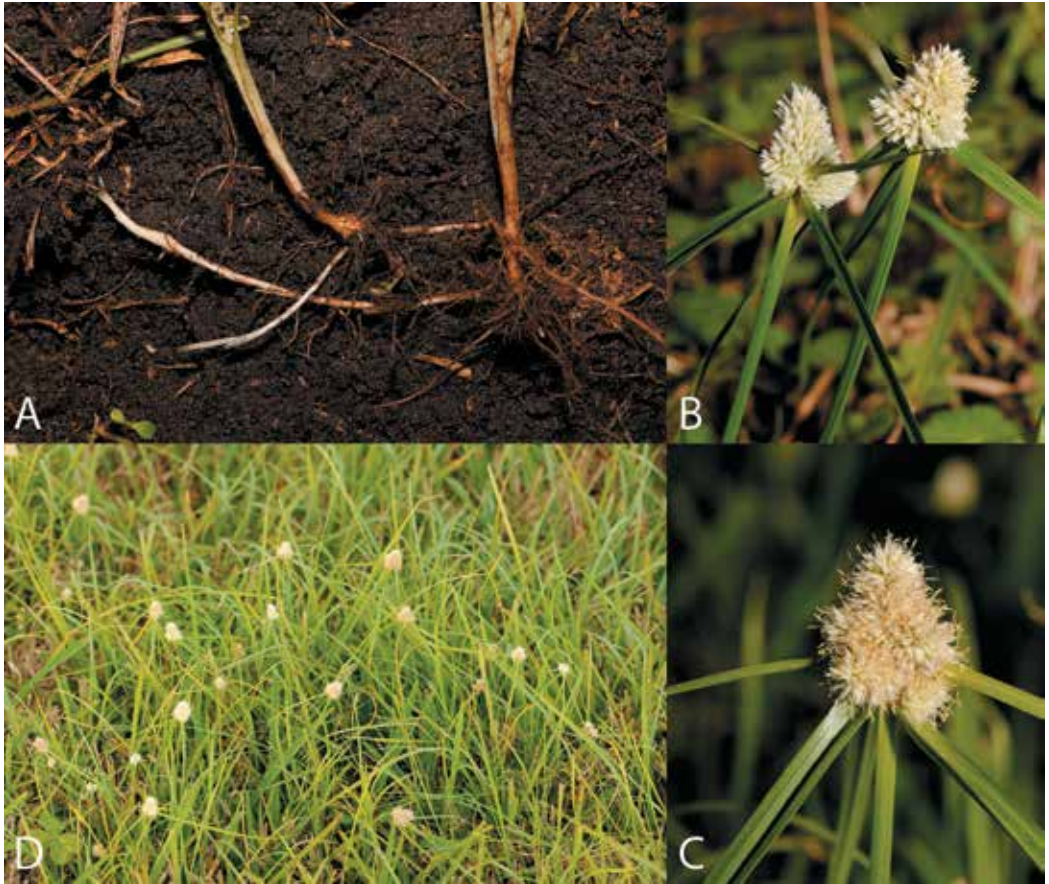


FIG. 3. *Cyperus richardii* from population in Hardee County, Florida [Carter & Mears 22615]. **A.** Stolons attached to bases of aerial shoots; note white actively growing stolons at left and older brown stolons at right. **B.** Immature inflorescences. **C.** Inflorescence at anthesis. **D.** Habit showing multiple flowering heads of colony and yellowish green leaves.

Georgia. Lowndes Co.: NE Valdosta, jct. Inner Perimeter Rd and Forrest St, Valdosta High School grounds, 01 Nov 1998, R. Carter 14207 (VSC). *Cyperus sesquiflorus*—**U.S.A. Florida. Escambia Co.:** steep sandy bluff overlooking bay, just s of I-10, 26 Jul 1989, C.T. Bryson 8707 (ctb, VSC). **Georgia. Glynn Co.:** Brunswick, Lanier Blvd between Hwy US 341 and Ocean Ave, 21 Sep 1991, R. Carter 9249 (VSC).

DISCUSSION

Cyperus richardii is readily distinguished from its congeners in the southeastern United States by the combination of white capitate inflorescences of 1–several dense spikes, slender white stolons that become threadlike and purplish black to brown with age and bear persistent ellipsoidal to globose tubers. The combination of white heads, yellowish green foliage, and the timing of flowering and fruiting (particularly during winter) make it possible to distinguish clones of *C. richardii* along roadsides and in lawns, even at a distance. Table 1 compares *C. richardii* with *C. sesquiflorus* and *C. brevifolius*, and spikelets and achenes of all kyllingoid *Cyperus* known from the southeastern United States are compared in Figs. 4 and 5.

Vegetative reproduction.—Herein, we adopt the terminology of Lawrence (1951) and Haines and Lye (1983) in identifying the modified subterranean stems of *C. richardii* as stolons and tubers. In its vegetative reproduction, *C. richardii* is unlike any other kyllingoid sedge in the southeastern United States. Slender stolons

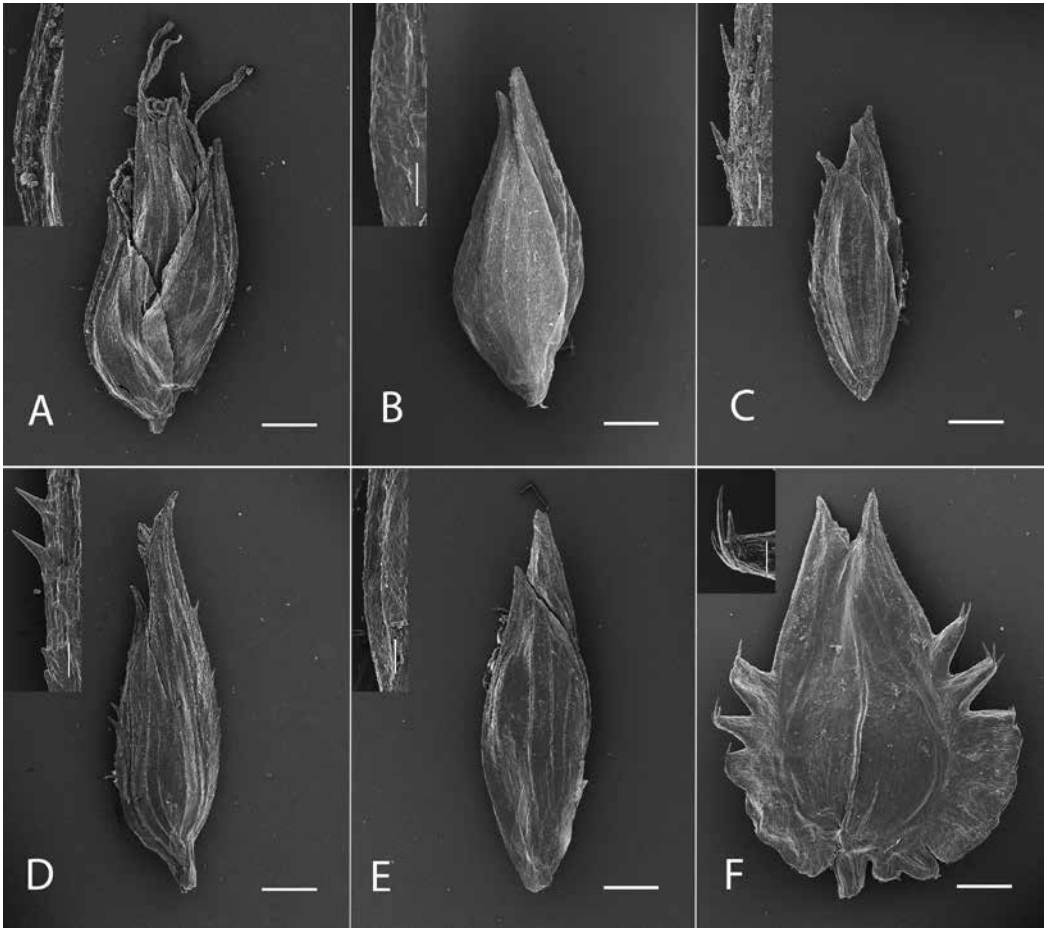


FIG. 4. Scanning electron micrographs comparing spikelets of (A) *Cyperus richardii* [Mears 7012, VSC], (B) *C. sesquiflorus* [Carter 9249, VSC], (C) *C. brevifolius* [Carter 12717, VSC], (D) *C. densicaespitosus* [Carter 9391, VSC], (E) *C. brevifolioides* [Kral 52283, VSC], and (F) *C. metzii* [Carter 14207, VSC]. All photographs are displayed at the same magnification; bar = 500 μm . Inset on each figure is of a higher magnification of the keel for each figure; inset bar = 100 μm .

grow horizontally from the tuberous bases of established ramets. Actively growing stolons are initially white, bearing widely spaced white scales. Periodically, buds grow upward at the tips of stolons, developing into tuberous bases of new aerial shoots (ramets). Thus, colonies are formed. As the stolons age and die, they turn purplish black, then threadlike and dark brown, and their scales wither and decay. Old plant bases connected to threadlike stolons persist as small blackish brown tubers covered by fibrous remains of leaves. When plants are carefully extricated from the soil, chains of tubers connected by slender brown stolons are observed (cf. Carter & Mears 22613). Although the tubers are smaller and the stolons more slender in *C. richardii*, they and the subterranean growth pattern are apparently similar to reports for *Cyperus rotundus* L. (Wills & Briscoe 1970; Wills 1987, 1998). Direct evidence is lacking, but we suspect these tubers may be effective in vegetative propagation and dispersal of *C. richardii*, especially through activities involving movement of soil or turf, as with *C. rotundus* (Holm et al. 1977).

Inflorescence morphology.—The floral scales of *Cyperus* and *Kyllinga*, as the taxa are traditionally defined, are distichous. In our specimens of *C. richardii*, the floral scales show a tendency to be polystichous (cf.

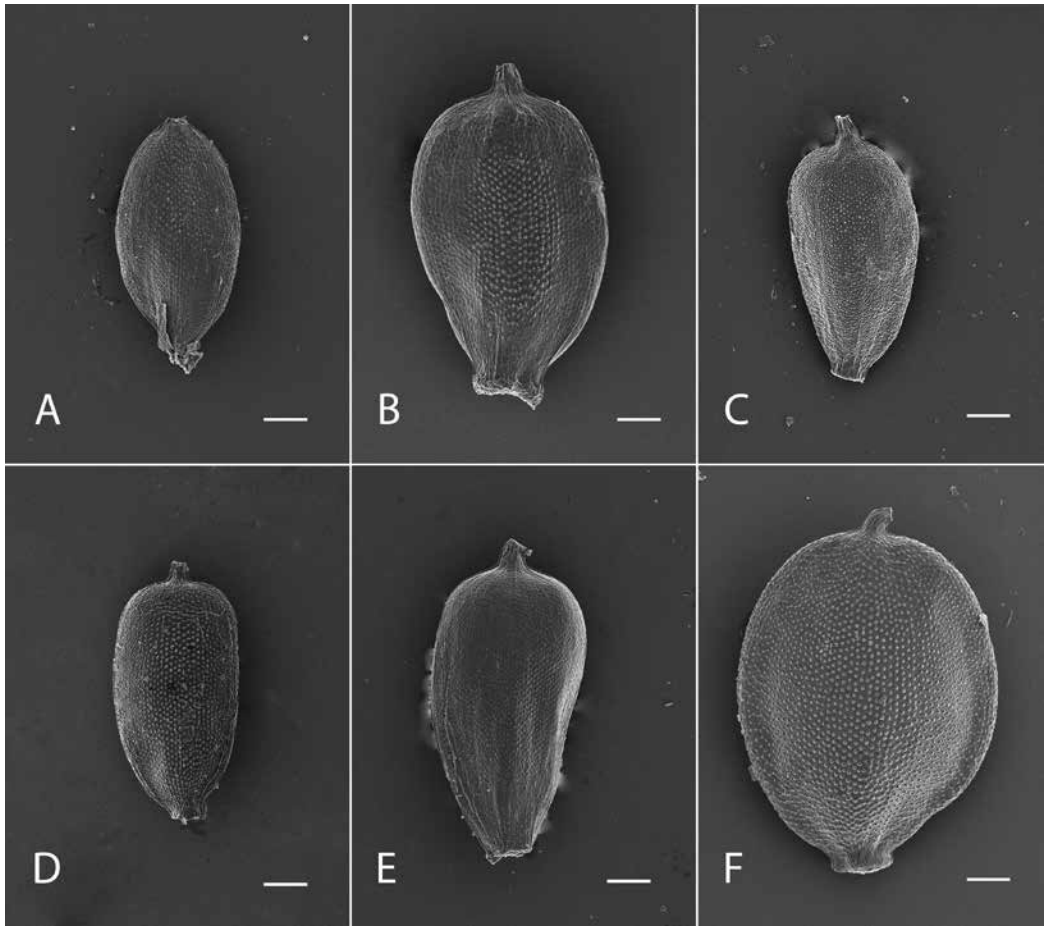


Fig. 5. Scanning electron micrographs comparing achenes of (A) *Cyperus richardii* [Mears 7012, VSC], (B) *C. sesquiflorus* [Carter 9249, VSC], (C) *C. brevifolius* [Carter 12717, VSC], (D) *C. densicaespitosus* [Carter 9391, VSC], (E) *C. brevifolioides* [Kral 52283, VSC], and (F) *C. metzii* [Carter 14207, VSC]. All photographs are displayed at the same magnification; bar = 200 μ m. A healing brush tool was used to soften protruding adhesive from the underside of the achenes in Figs. 2c and 2e. Additionally, scratches were removed from the background in Figs. 2b and 2d. In no case was any digital alteration applied to the achenes in the photographs.

Fig. 2C). Moreover, the primary inflorescence bracts of our *C. richardii* specimens range greatly in size, generally with 2–5 exceeding the head-like inflorescence and additional ones, some very short, coming from the midst of densely clustered spikelets well above the base of the spike (cf. Fig. 2B). This is especially apparent in a duplicate of Carter & Mears 22596 with at least 23 primary inflorescence bracts. Curiously, Haines and Lye (1983: 227, Fig. 457) describe and illustrate a similar specimen of *C. richardii* from Africa. Although we do not know the extent other African sedges might show such interesting combinations of characteristics, the position of *C. richardii* in molecular phylogenies vis-à-vis *Kyllinga* and the rest of *Cyperus* would seem to be important in understanding the evolution of inflorescence characters in these plants, especially as more species are sampled. In recent molecular phylogenies (Larridon et al. 2013; Reid et al. 2014) *Cyperus richardii* (*Kyllinga bulbosa*) is sister to *Kyllinga brevifolia* in a *Kyllinga* clade embedded in a paraphyletic *Cyperus*. Our decision to treat the subject of this paper as *Cyperus richardii*, instead of *Kyllinga bulbosa*, is of course based on this morphological and molecular evidence.

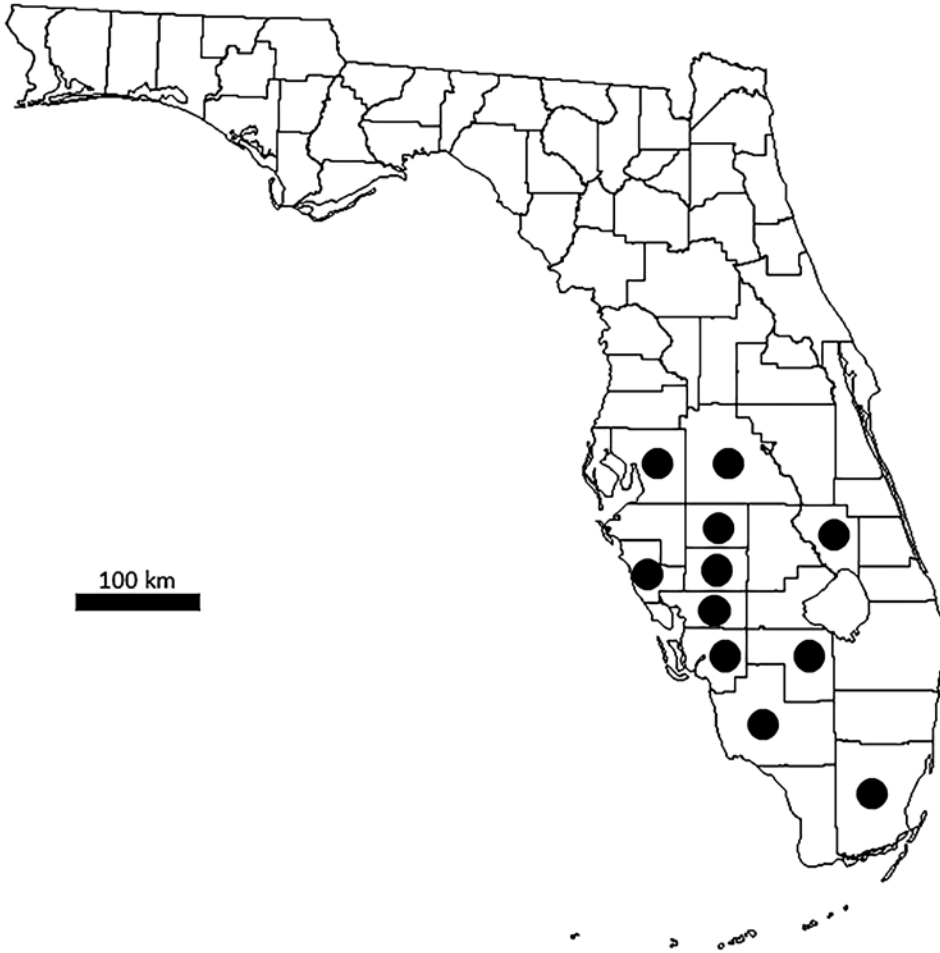


FIG. 6. The distribution by county of *Cyperus richardii* in Florida, U.S.A., based upon vouchers cited herein.

Pollination.—Bees were observed visiting the white heads of *C. richardii* in Polk County (R.L. Mears, personal observation). Although unusual in the primarily anemophilous Cyperaceae, insect pollination has been documented in other sedges (Thomas 1984 a,b; Goetghebeur 1998), particularly those with white bracts or inflorescences (e.g., *Rhynchospora* sect. *Dichromena*).

Dispersal and potential as a weed.—*Cyperus richardii* was cited (as *Kyllinga bulbosa*) as a weed by Bryson and Carter (2008), and our observations indicate it is widespread and weedy in southern Florida (Fig. 6). Its relative frequency along highway right-of-ways and in lawn turf suggest dispersal by highway traffic, road construction and maintenance (e.g., mowing), and transport and installation of turf-grass. Its native range in Asia (Fig. 1) suggests *C. richardii* could become established in southern portions of the southeastern United States and along the Gulf coast. Additional research is needed to determine the potential for production of viable seeds and their role in dispersal of *C. richardii* and the extent tubers may be involved in dispersal.

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TABLE 1. A comparison of *Cyperus richardii*, *C. sesquiflorus*, and *C. brevifolius*.

<i>Cyperus richardii</i>	<i>Cyperus sesquiflorus</i>	<i>Cyperus brevifolius</i>
Plant with tubers borne on stolons; stolons (0.3–) 0.5–1.0 mm diameter	Plant cespitose	Plant with rhizomes, tubers absent; rhizomes > 1 mm diameter
Heads white	Heads white	Heads green
Bases of primary inflorescence bracts whitish green	Bases of primary inflorescence bracts green	Bases of primary inflorescence bracts green
Some primary inflorescence bracts emerging from dense mass of spikelets well above base of inflorescence	All primary inflorescence bracts basal	All primary inflorescence bracts basal
Spikelet with (2–)3–4 floral scales	Spikelet with 2 floral scales	Spikelet with 2 floral scales
Spikelet with (1–)2–3 florets and achenes	Spikelet with 1 floret and achene	Spikelet with 1 floret and achene
Floral scale with inconspicuous (at 10×) narrow medial green zone along central nerve (midrib), medial green zone reaching only one-half to two-thirds the scale length	Floral scale with conspicuous (at 10×) broad medial green zone along central nerve (midrib) extending to adjacent lateral nerves, medial green zone nearly reaching scale tip	Floral scale with conspicuous (at 10×) broad medial green zone along central nerve (midrib) extending to adjacent lateral nerves, medial green zone nearly reaching scale tip
Keel of floral scale smooth	Keel of floral scale smooth	Keel of floral scale toothed
Stamens 3	Stamens 2	Stamen 1
Stigmas ±contorted	Stigmas tightly coiled	Stigmas ±contorted
Achene tan to brown	Achene purplish black	Achene tan to reddish brown

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