



Two new species in *Carex* sect. *Schoenoxiphium* (Cyperaceae) from southern Africa

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Abstract

Carex sect. *Schoenoxiphium* (18 spp.) is a monophyletic group that has its centre of diversity in eastern south Africa. We describe two new species from the Republic of South Africa and Lesotho on the basis of morphological characters. Both new species (*C. badilloi* and *C. parvirufa*) are closely related to *C. ludwigii*, *C. kukkoneniana* and *C. pseudorufa*.

Keywords: *Carex badilloi*, *Carex parvirufa*, new species, sedges, taxonomy

Introduction

Carex Linnaeus (1753:972) (Cyperaceae), with ca. 2000 species and a global distribution (Reznicek 1990, Goetghebeur *et al.* 1998, Judd *et al.* 2007, GCG 2016), is one of the largest angiosperm genera and the most diversified in the temperate regions of the Northern Hemisphere (Escudero *et al.* 2012). Recent molecular phylogenetic studies of the tribe *Cariceae* Pax (1887:531) (= *Carex s.l.*) demonstrated the monophyly of the former genus *Schoenoxiphium* Nees (1832:531) and its placement nested within genus *Carex* (Waterway and Starr 2007, Waterway *et al.* 2009, Gehrke *et al.* 2010), which motivated the transfer of *Schoenoxiphium* to *Carex* (GCG 2015) and its consideration as a section within that genus (*Carex* section *Schoenoxiphium* Baillon (1894:345); Villaverde *et al.* in press.). *Carex* section *Schoenoxiphium* is closely related to two small clades, one containing sections *Junciformes* (Boeckeler) Kükenth. (1909:82) and *Aciculares* (Kükenth.) G. Wheeler (1989:174), and the other grouping *C. distachya* Desfontaines (1799:336) and allies (Gehrke *et al.* 2010, GCG 2015, 2016). Section *Schoenoxiphium* is composed of 18 species (Kukkonen 1983; Gordon-Gray 1995; GCG 2015, Villaverde *et al.* in press.) and is distributed in southern and eastern Africa, including Madagascar, marginally reaching the southeastern Arabian Peninsula, with a clear center of diversity in eastern South Africa. The phylogenetic backbone of the section comprises five major clades (Villaverde *et al.* in press.; see also Gehrke *et al.* 2010): (A) *C. lancea* (Thunb.) Baillon (1894:341), *C. schweickerdtii* (Merxm. & Podlech) Luceño & Martín-Bravo (2015:28), *C. multispiculata* Luceño & Martín-Bravo (2015:28), distributed in South Africa (Cape Province, Natal and Northern provinces) and Madagascar, and *C. chermesonii* Luceño & Martín-Bravo (2015:27), probably endemic to Madagascar; (B) *C. capensis* Thunberg (1794:14), endemic to the Cape Province in South Africa; (C) *C. burkei* (C.B. Clarke) Luceño & Martín-Bravo (2015:26), *C. killickii* Nelmes (1955:89), *C. distincta* (Kukkonen) Luceño & Martín-Bravo (2015:27) and *C. basatorum* (Turrill) Luceño & Martín-Bravo (2015:27), from South Africa (Cape Province, Natal, Free State) and Lesotho; (D) *C. ludwigii* (Hochst.) Luceño & Martín-Bravo (2015:27), *C. pseudorufa* Luceño & Martín-Bravo (2015:28) and *C. kukkoneniana* Luceño & Martín-Bravo (2015:27) from South Africa (Cape Province, Natal and Northern provinces), Swaziland and Lesotho; and (E) *C. sparteae* Wahlenb. (1803:149), *C. schimperiana* Boeckeler (1876:373), *C. uhligii* K.Schum. ex C.B. Clarke (1906:136) and *C. perdensa* (Kukkonen) Luceño & Martín-Bravo (2015:28) from South Africa, Kenya, Uganda, Ethiopia, Madagascar and the Arabian Peninsula.

Revision of herbarium specimens of *Carex* section *Schoenoxiphium* revealed two groups of populations that are morphologically uniform but distinctive from the other accepted species in a clade comprising *C. ludwigii*, *C.*

kukkoneniana and *C. pseudorufa* (Villaverde *et al.* in press.). Each one of these two groups of populations shares a unique set of characters and they form two monophyletic groups in a phylogeny based on four nuclear and plastid DNA regions (Villaverde *et al.* in press.), suggesting they may deserve taxonomic recognition. Therefore, the aim of this study is to characterize morphologically these populations, as part of the effort to clarify the taxonomic complexity of the section *Schoenoxiphium*.

Materials and methods

We examined 78 herbarium vouchers of the species in the *C. ludwigii* group (Villaverde *et al.* in press.) from the following herbaria: E, K, NU, P, PRE, UPOS and Z (acronyms according to Thiers 2016). The most important characters for the taxonomy of the section *Schoenoxiphium* (Levyns 1945, Kukkonen 1983, Gordon-Gray 1995, M. Luceño pers. obs.) were carefully examined (Table 1). Measurements were taken using an Olympus BX53 stereomicroscope with an ocular micrometer, and a ruler for larger measurements. Utricle, nutlet, glume and cladoprophyll measurements were taken from those appearing in the principal axis of the inflorescence. For the two new species, a total of eleven and 46 herbarium vouchers from six and nine populations of the two specimen-groups with distinctive characters, *C. badilloi* and *C. parvirufa* respectively, were measured. Inflorescence terminology is based on Jiménez-Mejías *et al.* (2016).

Results and discussion

Carex section *Schoenoxiphium* is a taxonomically difficult group with problems regarding the morphological boundaries among its species. Although no study to date points out what might be the reasons behind this problem, our field observations, study of herbarium materials and unpublished molecular results suggest that it is probably due to the high phenotypic plasticity present in the group. This is especially true for those traits related to the indumentum and prophyll morphology, the latter being highly dependent on the branching level where the prophyll is placed. Likewise, the size of the organs seems to be influenced by environmental factors. All this, together with the relatively few collections available in herbaria, have led to the development of conflicting treatments (see Kükenthal 1909, Kukkonen 1983, Gordon-Gray 1995).

TABLE 1. Main diagnostic characters between *Carex badilloi*, *C. parvirufa*, *C. ludwigii*, *C. kukkoneniana* and *C. pseudorufa*.

	<i>C. badilloi</i>	<i>C. parvirufa</i>	<i>C. ludwigii</i>	<i>C. kukkoneniana</i>	<i>C. pseudorufa</i>
Distribution	South Africa (KwaZulu-Natal) and Lesotho	South Africa (KwaZulu-Natal) and Lesotho	South Africa (Cape provinces, Free State and KwaZulu-Natal) and Lesotho	South Africa (Northern Provinces), Tanzania, Malawi and Zimbabwe	South Africa (KwaZulu-Natal) and Lesotho
Plant height (cm)	(36)39–74(80)	(4)12–67(90)	(54)69–111	(99)101–183(198)	(67)77–110(116)
Mid-culm width (mm)	2–3.1(3.4)	(0.6)0.8–1.5	1.9–2.5	3–3.7(4)	(2.9)3.1–4.5(4.7)
Leaf width (mm)	3.7–5.1(6.1)	(1)1.5–2.5(2.8)	(2.4)3.2–6(6.9)	(4.1)4.9–8.9(10)	(6.4)7.5–13.5(14.4)
Lowest bract sheath length (cm)	3.5–4.9(5.1)	(0.9)1.7–5.1(7.3)	(2)2.9–5.9(6.6)	(4.5)5.2–9(9.5)	(5.3)6.1–8.2
No. of partial inflorescences	3–4	2–4	4–6	4–9	8–10
Branching orders	Up to 3–4	Up to 3	Up to 3–4	Up to 4	Up to 5
Staminate glume (mm)	(2.9)3–4.4(4.6) × (1)1.2–2.4(2.6)	2.2–3(3.3) × (1)1.1–1.6(1.8)	2.2–3.7 × (1.1)1.3–2.3	(1.9)2.2–3.6(3.9) × 1.4–1.7	(2.9)3.3–4.5(4.7) × 1.4–1.9(2.2)
Staminate glume mucro length (mm)	(0.2)0.6–1.7	0.1–1.3(2.1)	0.2–0.6	0.3–0.6	0.3–0.8
Pistillate glume (mm)	(3.3)3.5–4.2 × (2.1)2.3–2.8	2–2.7(3.1) × (1.1)1.3–2.1	(1.5)1.7–2.7(2.9) × 1.5–2.1	2.7–3.5(4) × 1.5–2.3(2.8)	(2.7)2.9–3.8(4) × 1.7–2.5(2.8)
Pistillate glume mucro length (mm)	0.9–2.4(3.1)	(0.4)0.6–2.1(2.8)	(0.4)0.7–1.7(2)	(0.5)0.7–1.3	0.5–1.1
Utricle (mm)	(4.3)4.7–5.3(5.4) × 1.7–2	(2.2)2.4–3.2(3.5) × (0.8)0.9–1.4(1.6)	(2.4)2.6–3.7(4) × 1.3–1.7	(4.1)4.8–6.5 × 0.9–1.2	5.3–6.5(6.8) × 1.1–1.7
Nutlet (mm)	3–3.3(3.5) × 1.4–1.9(2)	(1.2)1.4–2.2(2.5) × (0.7)0.8–1.2(1.5)	2–2.6 × 1.2–1.6	2.9–3.9(4.1) × (0.6)0.8–1.1	3.6–4.3(4.5) × (0.9)1.1–1.5

We have found that the two studied groups of populations from southern Africa display two congruent and distinct sets of morphological characters (Table 1, Fig. 1), different to those displayed by the other species accepted to date. Moreover, both population groups constitute two well-supported clades in a recent study (Villaverde *et al.* in press.) and in a NGS-based phylogeny (RAD-seq markers; Villaverde *et al.* unpublished). For these reasons, in our opinion, these groups merit formal taxonomic recognition at the species level. Consequently, we herein describe them as two new species.

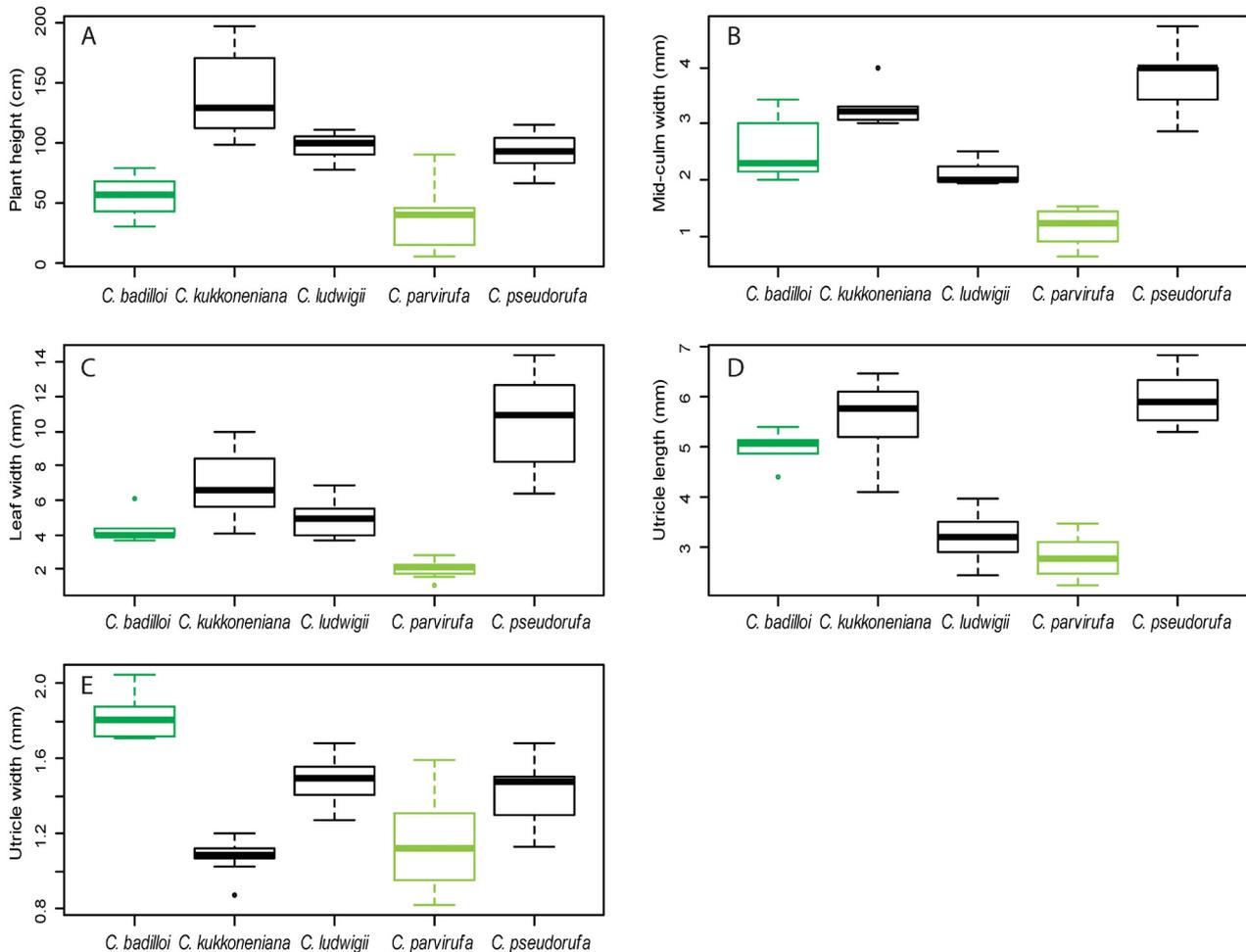


FIGURE 1. Boxplots of the most distinguishing traits among the species in the *C. ludwigii* group (Villaverde *et al.* in press.) of *Carex* sect. *Schoenoxiphium*. A: Plant height (cm). B: Mid-culm width (mm). C: Leaf width (mm). D: Utricle length (mm). E: Utricle width (mm).

Taxonomy

Carex badilloi Luceño & Márquez-Corro, *sp. nov.* (Fig. 2–3).

- *Schoenoxiphium ludwigii* auct. plur., non. Hochst. (1845:764)

Diagnosis:—Similar to *Carex ludwigii* (Hochst.) Luceño & Martín-Bravo (= *Schoenoxiphium rufum* Nees (1810:201)), but presenting longer and straight utricles (usually 4.7–5.3 mm in *C. badilloi* vs. 2.6–3.7 mm in *C. ludwigii*), as well as shortly pedunculate and erect lowest partial inflorescences. It can also be differentiated from *C. kukkoneniana* Luceño & Martín-Bravo by its smaller ovate to ellipsoid utricles (see Table 1 for further details).

Type:—SOUTH AFRICA. KwaZulu-Natal: Drakensberg mountains, Garden Castle Natural Reserve, pathway to Rhino Peak, 1800 m, grassland, 29°44′38.70″S 29°12′21.20″E, 11 November 2011, *S. Martín-Bravo* & *M. Luceño* 96SMB11 (holotype PRE; isotypes NU, UPOS).

Rhizome not caespitose, stout, light-brown. Flowering culms (36)39–74(80) cm long, erect, obtusely trigonous, smooth, leafy in the lower two-thirds of its length, (2.1)2.7–4.1 mm wide at the base and 2–3.1(3.4) mm wide at the middle. Leaves 3.7–5.1(6.1) mm wide, shorter than the inflorescence, moderately rigid, glaucous, slightly V-shaped in

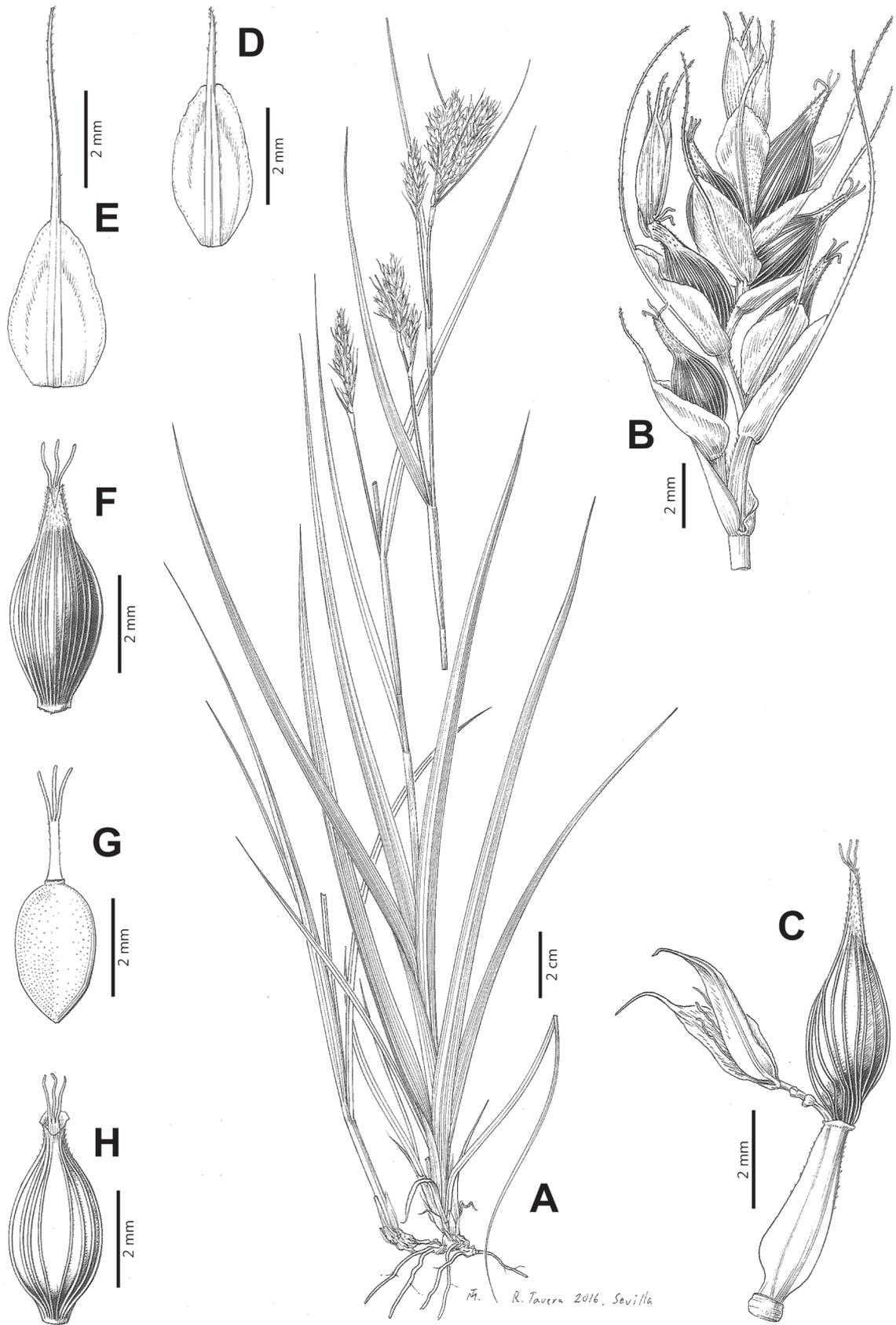


FIGURE 2. Analytical drawing of the holotype material of *Carex badilloi* (South Africa, KwaZulu-Natal, Drakensberg mountains, Garden Castle Natural Reserve, S. Martín-Bravo 96SMB11 & M. Luceño, PRE). A: plant. B: androgynous spike. C: aborted last order utriculiform cladophyll with protruding androgynous spike. D: staminate glume. E: pistillate glume. F: unisexual utricule. G: nutlet. H: fertile utriculiform cladophyll without fertile rachilla depicted.—Drawing by Rodrigo Tavera.



FIGURE 3. Picture of *Carex badilloi* plant and detail of the inflorescence (Garden Castle, South Africa).

cross-section, slightly to moderately scabrous along the edges and sometimes also along the uppermost parts of the the abaxial midrib; adaxial surface densely papillose, with papillae 25–30 µm in height; ligule (2)2.3–3 mm long. Basal sheaths usually not fibrous, lowermost bladeless and uppermost foliose. Lowest bract of the inflorescence leaf-like, much shorter than the inflorescence length with a sheath 3.5–4.9(5.1) cm long. Partial inflorescences 3–4, lowermost 2.5–4.9(7.2) × (0.8)0.9–1.3(1.4) cm and uppermost (2)2.5–3.9(4.2) × 0.9–1.8(2.4) cm, more or less erect, peduncles hispid distally, frequently the uppermost included in the sheath, laterally branching 3–4 times, the main axis ending in a terminal staminate spikelet. Tubular cladophylls always present at the base of the 3rd-to-last order branches and in some of the 2nd-to-last order branches; utriculiform cladophylls 4.4–4.9 × 1.6–1.7 mm, usually present at the base of some of the 2nd-to-last order branches, ovate, green to yellowish brown when mature, hispid in the upper third, with prominent veins across the entire surface, forming an angle of 35–39° with the axis and ending in a mouth 0.7–0.8 mm wide. Glumes of the staminate spikelet (2.9)3–4.4(4.6) × (1)1.2–2.4(2.6) mm, ovate, yellowish brown, with an aculeolate mucro, 0.2–1.7 mm long. Glumes subtending utricles (3.3)3.5–4.2 × (2.1)2.3–2.8 mm, ovate, yellowish brown, with a light green prominent aculeolate mucro 0.9–2.4(3.1) mm long. Utricles (4.3)4.7–5.3(5.4) × 1.7–2 mm, unisexual and bisexual, both more or less similar in appearance, ovate, straight, green to yellowish brown when mature, hispid in the upper third, with prominent veins across the entire surface, forming an angle of 30–59° with the branch axis; unisexual utricles with rachilla protruding from the apex up to 0.5 mm in some utricles, with a bidentate to slightly bifid beak; bisexual utricles wide-mouthed, similar in shape to utriculiform cladophylls. Nutlet 3–3.3(3.5) × 1.4–1.9(2) mm, ovate-triangular, green to yellowish brown when mature, tipped by a short, terete, persistent style base. n= 17, 18 (Luceño *et al.* unpublished).

Etymology:—This species is named after our friend Dr. Juan José González Badillo, a prominent researcher specialized in sport sciences and strength training.

Chorology and ecology:—This species is mainly distributed in mesophilous open grassland on clay soils in the Drakensberg Mountains of KwaZulu-Natal region in South Africa and Lesotho (**Fig. 4**), within an elevation range from 1800 to 2400 m.

Additional specimens examined (Paratypes):—SOUTH AFRICA. KwaZulu-Natal: Bushman's Nek, path to fire tower, 6300 ft, steep grass slope, 2929CC, 16 November 1985, *O.M. Hilliard & B.L. Burt* 18592 (E, photo!); Cathedral peak Forestry Station, 6800 ft, fairly frequent in *Pentachistis* sp. Grassveld, 27 November 1952, *D.I.B. Killick* 1798 (E, photo!); Cobham Forest Reserve, 'lakes' cave area 7100 ft, grass slopes, 2929CB, 13 December 1982, *J. Manning et al.* 16003 (E, photo!); Cobham Forest Station, Ndlovini, Troutbeck, 6000 ft, grassland, above stream, 2929CB, 09 November 1980, *O.M. Hilliard & B.L. Burt* 13377 (E, photo!); Drakensberg mountains, ca. 40 km away from Underberg, Garden Castle Natural Reserve, pathway to Rhino Peak, 2000 m, edges of the path, on grassy and natural slopes, 29°43'55.20"S 29°10'59.20"E, 19 November 2010, *S. Martín-Bravo et al.* 145SMB10 (UPOS-8501); Garden Castle National Park, 1850 m, grassland, 29°44'44.80"S 29°12'25.10"E, 16 December 2008, *M. Luceño et al.* 92ML08 (UPOS-3624); Giant's Castle Game Reserve, huts under Giant's Castle, 7400 ft, 12 December 1969, *F.B. Wright* 921 (NU); Gxalingenwa valley, between Sani Pass and Polela valley, damp S. facing slopes near sandstone, tufted, 2929CB, 11 December 1983, *O.M. Hilliard & B.L. Burt* 17185 (P, photo!); Headwaters of Mlahlangubo River, near Wilson's Cave, 2200 m, drainage line in damp grass, 2929CB, 18 January 1982, *O.M. Hilliard & B.L. Burt* 15150 (NU); Headwaters of Mlahlangubo River, 5–7 miles NNW of Castle View Farm, 6800 ft, in damp grassland over Cave Sandstone, 2929CC, 25 November 1980, *O.M. Hilliard & B.L. Burt* 13631 (NU); Mlambonja Wilderness area, pathway to Cathedral Peak, start of the plateau, 1900 m, grassland, 28°56'00.90"S 29°10'42.90"E, 15 November 2011, *S. Martín-Bravo & M. Luceño* 134SMB11 (UPOS-6599); Mpendle district, path from Loteni N.R. to Redi, 7000 ft, common in patches in grassland, 2929AD, 26 December 1982, *O.M. Hilliard & B.L. Burt* 16120 (NU); Royal Natal National Park, Tiger Falls, 5500 ft, forest patch, damp ground, 2828DB, 03 February 1982, *O.M. Hilliard & B.L. Burt* 150404 (E, photo!); Ukahlamba Drakensberg Park, Garden Castle, path to Rhino Peak, 2373 m, grassland, 16 December 2008, *B. Gehrke & M. Pirie* BG-Af 564 (UPOS-4395); Upper tributaries S of Mkomazi R. (feeders of Ka-Ntubu), 6800–7500 ft, streamside in grass, 2929CB, 03 December 1982, *O.M. Hilliard & B.L. Burt* 15829 (E, photo!); Vicinity of Tarn Cave, above Bushman's Nek, 8000 ft, on steep moist E-facing slope, 2929CC, 21 January 1981, *O.M. Hilliard & B.L. Burt* 17451 (NU).

Notes:—*Carex badilloi* has been abundantly collected in the past, but most authors called it *Schoenoxiphium ludwigii* Hochst. Since the type material of this latter name, collected from Cape region, is a quite typical specimen of the previously called *Schoenoxiphium rufum* Nees, the name *Carex ludwigii* must be applied to this later species (see GCG 2015). The specimens of both species studied by Villaverde *et al.* (in press.) constituted two different monophyletic groups.

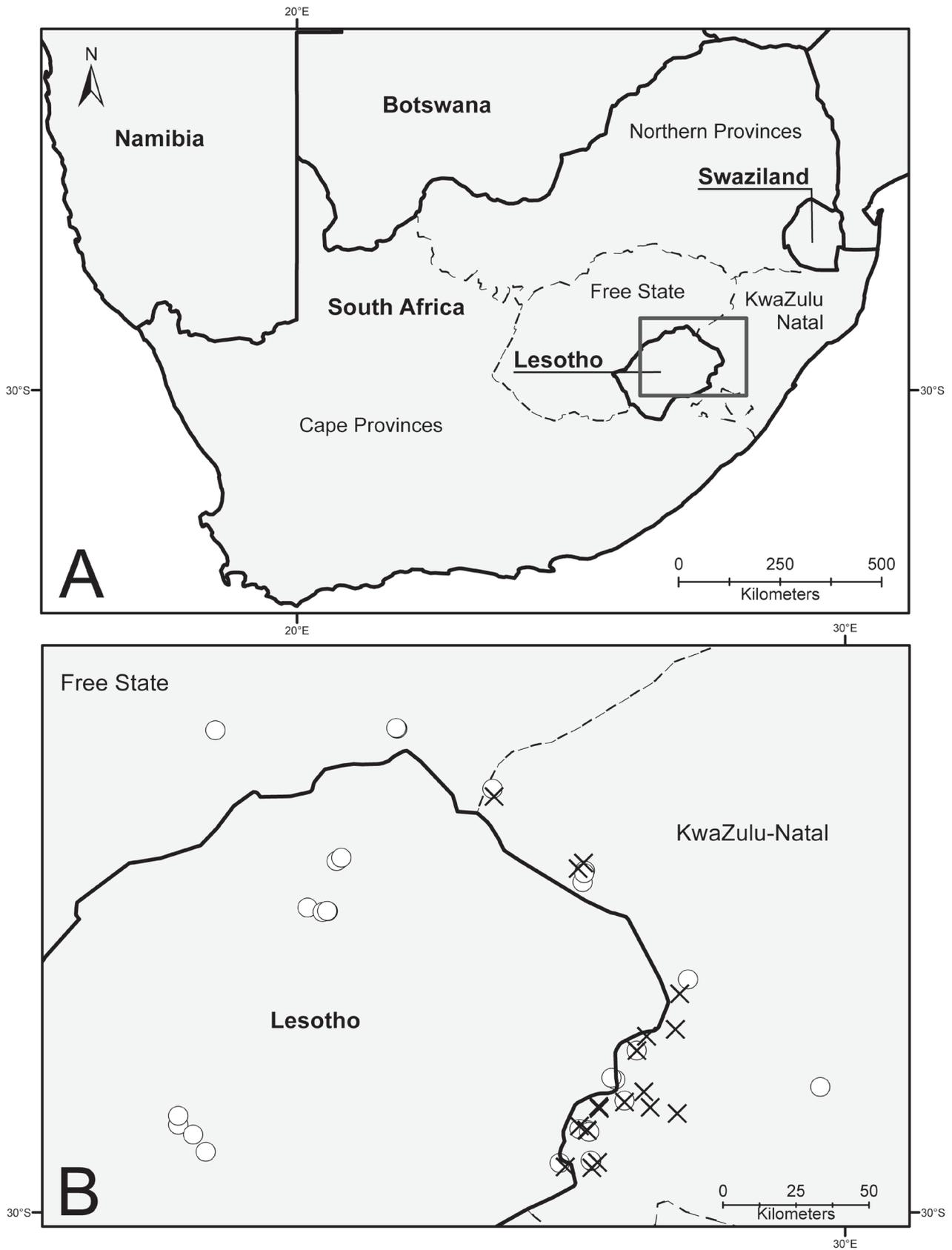


FIGURE 4. A: Southern Africa map. The area enlarged below in B is enclosed in the square. B: Studied populations of *Carex badilloi* (crosses) and *Carex parvirufa* (circles).

***Carex parvirufa* Luceño & Márquez-Corro, sp. nov., Fig. 5–6**

Diagnosis:—Similar to *C. ludwigii* (Hochst.) Luceño & Martín-Bravo (= *Schoenoxiphium rufum* Nees), but much smaller in all its parts and with utricles straight to slightly curved, with many conspicuous prominent veins, while in *C. ludwigii* utricles are very frequently curved and with less prominent veins.

Type:—LESOTHO. Leribe district: Pitseng, left side of the road in the ascent to the Mafika Lisiu pass summit, 3101 m, grassland in the summit, 29°03'58.30"S 28°24'27.10"E, 14 January 2014, *T. Villaverde et al.* 28TVH14 (holotype PRE; isotypes NU, UPOS).

Rhizome more or less caespitose, light-brown. Culm (4)12–67(90) cm long, erect, obtusely trigonous, smooth, leafy from toward one third to nearly half of its length, (0.9)1–1.8 mm wide at the base and (0.6)0.8–1.5 mm in the middle. Leaves (1)1.5–2.5(2.8) mm wide, moderately rigid, ± V-shaped in cross-section, slightly to moderately scabrous on the edges and sometimes on midrib, slightly papillose on adaxial surfaces, with papillae 10–15 µm in height; ligule 0.7–2.9(4) mm long. Basal sheaths foliose, lowermost fibrous and uppermost more or less entire. Lowest bract of the inflorescence foliose, from half of the inflorescence length to equalling it, with a sheath (0.9)1.7–5.1(7.3) cm long. Partial inflorescences 2–4, lowermost (0.9)1–2.7(4) × 0.3–0.8(0.9) cm and uppermost (0.9)1–2.1(2.3) × (0.3)0.4–1.1(1.6) cm, on erect, more or less hirsute to hispid distally peduncles, frequently the uppermost included in the sheath, branching 3 times, ending in a terminal staminate spikelet. Tubular cladoprophylls always present, from 3rd-to-last to 2nd-to-last branching order; utriculiform cladoprophylls usually present, 2.1–2.6 × (0.9)1–1.3 mm, 2nd-to-last order, ovate, green to yellowish brown when mature, hispid in the upper quarter, with conspicuous prominent veins over the entire surface, forming an angle of 38–52° with the axis and ending in a mouth 0.4–0.9 mm wide. Glumes of the staminate spikelet 2.2–3(3.3) × (1)1.1–1.6(1.8) mm, ovate, yellowish brown to brown, with an aculeolate mucro, (0.1)0.2–1.3(2) mm long. Glume subtending utricles 2–2.7(3.1) × (1.1)1.3–2(2.1) mm, ovate, yellowish brown, with a light green prominent aculeolate mucro, (0.4)0.6–2.1(2.8) mm long. Utricles (2.2)2.4–3.2(3.5) × (0.8)0.9–1.4(1.6) mm, the unisexual and bisexual ones more or less similar in size, ovate, straight to slightly curved, green to yellowish brown when mature, usually hispid in the upper third, with conspicuous prominent veins over the entire surface, forming an angle of 31–46° with the branch axis; unisexual utricles with rachilla protruding from the apex up to 0.5 mm in some utricles, with a more or less bifid beak; bisexual utricles wide-mouthed, similar in shape to utriculiform cladoprophylls. Nutlet (1.2)1.4–2.2(2.5) × (0.7)0.8–1.2(1.5) mm, ovate-trigonous, green to yellowish brown when mature, tipped by a short, terete, persistent style base. n=18 (Luceño *et al.* unpublished).

Etymology:—From the Latin *parvus*, -a, -um (small), and *rufus*, -a, -um (red), alluding to the resemblance of this species to *Carex ludwigii* (Hochst.) Luceño & Martín-Bravo, which was formerly known as *Schoenoxiphium rufum* Nees, but smaller in all its parts.

Chorology and ecology:—Mesophilous grasslands on clay soil up to 3150 m from KwaZulu-Natal and Free State regions in South Africa, and northern Lesotho (Fig. 4).

Additional specimens examined (Paratypes):—LESOTHO. Leribe district: Hlotse, 2086 m, streamside near a waterfall, 29°04'18.15"S 28°22'36.07"E, 13 January 2014, *T. Villaverde et al.* 2TVH14 (UPOS-8505); Pitseng, 3142 m, 29°03'55.32"S 28°24'20.60"E, 14 January 2014, *T. Villaverde et al.* 18TVH14 (UPOS-8506); near the road, 2821 m, 29°04'09.30"S 28°23'30.10"E, 14 January 2014, *T. Villaverde et al.* 35TVH14 (UPOS-8524); Tsehlanyane National Park, upper trail to Black Pool, 2141 m, near a waterfall, 28°54'26.45"S 28°26'23.53"E, 15 January 2014, *T. Villaverde et al.* 64TVH14 (UPOS-8514); 2155 m, on the pathway, 28°59'00.22"S 28°27'08.00"E, 15 January 2014, *T. Villaverde et al.* 69TVH14 (UPOS-8515); 1990 m, *Leucosidea sericea* scrub, 28°54'40.38"S 28°26'06.94"E, 15 January 2014, *T. Villaverde et al.* 54TVH14 (UPOS-8510). Maseru district: Semonkong, road from Roma to Semonkong, 2620 m, stream margin, 29°42'01.64"S 27°56'50.70"E, 16 January 2014, *T. Villaverde et al.* 84TVH14 (UPOS-8516); 2620 m, *Leucosidea sericea* scrub, 29°42'01.63"S 27°56'50.70"E, 16 January 2014, *T. Villaverde et al.* 89TVH14 (UPOS-8517); Basaltic stony soil, 29°42'01.63"S 27°56'50.70"E, 16 January 2014, *T. Villaverde et al.* 92TVH14 (UPOS-8518); 2848 m, basaltic stony soil, 29°43'41.40"S 27°56'51.20"E, 16 January 2014, *T. Villaverde et al.* 101TVH14 (UPOS-8520); road from Semonkong to Roma, 2569 m, grassland, 29°45'31.52"S 27°59'37.11"E, 18 January 2014, *T. Villaverde et al.* 120TVH14 (UPOS-8521); 2582 m, dry grassland, 29°45'23.70"S 27°59'27.47"E, 18 January 2014, *T. Villaverde et al.* 124TVH14 (UPOS-8522); 2248 m, slightly moist and nitrified grassland, 29°48'44.51"S 28°01'56.30"E, 18 January 2014, *T. Villaverde et al.* 131TVH14 (UPOS-8523). SOUTH AFRICA. Free State: Drakensberg mountains, 10 km from Phuthaditjhaba, Witsieshoek Mountain resort, 2195 m, grasslands in stony slopes on the roadside, 28°41'13.86"S 28°54'52.14"E, 16 November 2010, *S. Martín-Bravo et al.* 125SMB10 (UPOS-8504); Golden Gate Highlands National Park, 1800–2100 m, grasslands in *Leucosidea sericea* scrub, 28°30'20.10"S 28°03'42.30"E, 13 December 2008, *S. Martín-Bravo et al.* 143SMB08 (UPOS-3601); between Clarens and Phuthaditjhaba, pathway from Glen Reenen Rest Camp to Boskloof Trail, 2070 m, understorey, 28°29'55.58"S 28°37'07.71"E, 20 January 2014, *T. Villaverde et al.*

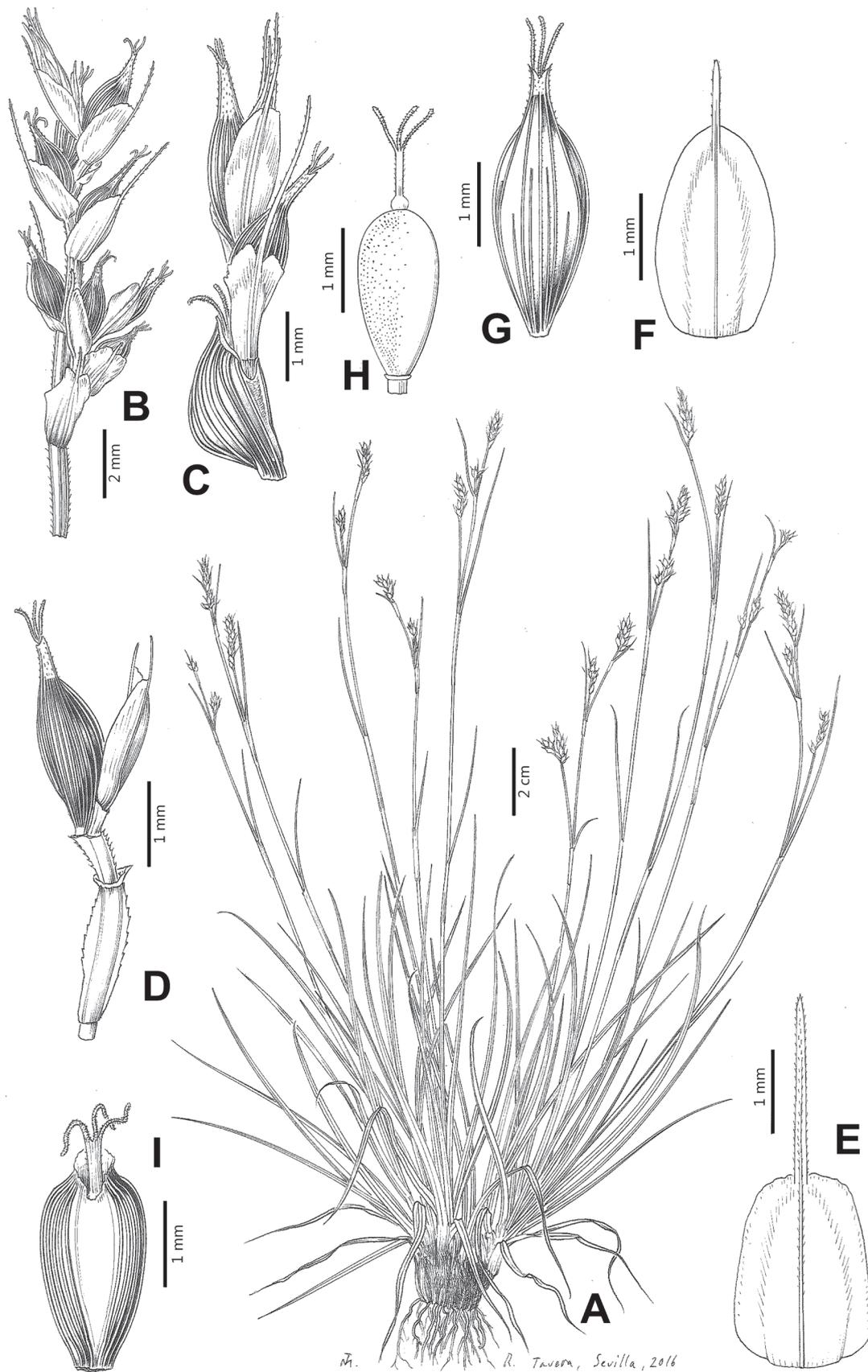


FIGURE 5. Analytical drawing of the holotype material of *Carex parvirufa* (Lesotho, Leribe district, Pitseng, Mafika Lisiu pass summit, T. Villaverde *et al.* 28TVH14, PRE). A: plant. B: androgynous spike. C: last order fertile utriculiform cladophyll and protruding androgynous spike. D: protruding fertile rachilla. E: pistillate glume. F: staminate glume. G: unisexual utricle. H: nutlet. I: utriculiform cladophyll without fertile rachilla depicted.—Drawing by Rodrigo Tavera.



FIGURE 6. Picture of *Carex parvirufa* plant and detail of the inflorescence in both medium mountain altitudes (left; Semonkong, Lesotho, ca. 2600 m) and highlands morphotypes (right; Mafika Lisiu pass, Lesotho, ca. 3000 m).

138TVH14 (UPOS-5255); pathway from Glen Reenen Rest Camp to Echo Ravine Trail, 2057 m, rocky understory, 28°30'02.74''S 28°37'17.77''E, 20 January 2014, *T. Villaverde et al.* 134TVH14 (UPOS-5254). KwaZulu-Natal: Bank of Bushmans River c. 1/2 miles upstream from Giants Castle Rest. Camp, 5700 ft, 25 October 1968, *F.B. Wright* 663 (NU); Cathedral Peak Forest Research Station, 6550 ft, occasional in *Festuca costata*—other spp. grassveld on S-SE facing slope in Catchment 3, 08 November 1951, *D.J.B. Killick* 1545 (NU); Cathedral Peak Area, footpath towards fern forest, 1333 m, in clay soils in open grassland, 28°56'55.00''S 29°11'48.60''E, 20 October 2006, *B. Gehrke et al.* BG-Af 467 (Z-39368); Cathedral Peak Natural Reserve, pathway from Didima Camp Lodge to Cathedral Peak, 1496 m, floodplain, previously burned, 28°56'25.60''S 29°11'54.40''E, 11 November 2012, *E. Maguilla et al.* 69EMS12 (UPOS-8507); Drakensberg mountains, ca. 40 km away from Underberg, Bushman's Nek Natural Reserve, 1850 m, open grasslands on dry slopes, 29°50'24.90''S 29°13'05.00''E, 12 November 2011, *S. Martín-Bravo & M. Luceño* 109SMB11 (UPOS-6584); slope near Caravan Park, 1779 m, grassland, 29°50'19.90''S 29°12'59.60''E, 15 November 2012, *E. Maguilla et al.* 70EMS12bis (UPOS-8502); Cobham Forest Reserve, 'lakes' cave area, 7900 ft, cape of maish on slope, 2929CB, 15 December 1982, *J. Manning et al.* 16057 (NU); Garden Castle Forest Reserve, 6000 ft, in maish by stream near forester's house, 2929CC, 04 December 1980, *O.M. Hilliard & B.L. Burtt* 13792 (NU); Garden Castle National Park, 1850 m, grassland, 29°44'44.80''S 29°12'25.10''E, 16 December 2008, *M. Luceño et al.* 94ML08 (UPOS-3626); 1920 m, grassland, 29°44'29.30''S 29°10'55.60''E, 16 December 2008, *M. Luceño et al.* 101ML08 (UPOS-3591); 1810 m, grassland, 29°45'01.30''S 29°12'43.40''E, 16 December 2008, *M. Luceño et al.* 107ML08 (UPOS-3594); Garden Castle, near concrete bridge above the stream, 1803 m, near a stream, floodplain, 29°45'01.10''S 29°12'43.10''E, 16 November 2012, *E. Maguilla et al.* 77EMS12 (UPOS-8503); Giant's Castle, 6500 ft, 2929AB, November 1914, *R.E. Symons* 120 (PRE-489129); Mpendle district, farm "Tillietudlem", 5800 ft, stream side on mountain slope, 2929DB, 09 December 1980, *O.M. Hilliard & B.L. Burtt* 13855 (NU); Gxalingenwa valley, between Sani Pass and Polela valley, 7200 ft, drainage line on hill slope facing North, 2929CB, 09 December 1983, *O.M. Hilliard & B.L. Burtt* 17115 (NU); Sani Pass, 2880 m, summit wet meadows, 29°34'56.50''S 29°16'50.50''E, 17 December 2008, *S. Martín-Bravo et al.* 163SMB08 (UPOS-3607); 6700 ft, common in moist grass slopes, 2929CB, 13 December 1984, *O.M. Hilliard & B.L. Burtt* 17922 (NU); Upper tributaries S of Mkomazi R. (feeders of Ka-Ntubu), 7300 ft, in drainage line on steep grass slopes, 2929CB, 01 December 1982, *O.M. Hilliard & B.L. Burtt* 15759 (NU); Vicinity of Tarn Cave above Bushman's Nek, below Devil's Knuckles, 8000 ft, tufted on stream bank, 2929CC, 23 November 1983, *O.M. Hilliard & B.L. Burtt* 16909 (NU).

Notes:—This species shows great phenotypic plasticity, probably related to the different range of altitudes where it grows. Populations growing in grasslands up to 2600–2700 m are larger and frequently have longer staminate spikes protruding from the utricles than the populations inhabiting areas above (2900)3000 m. Overall, the qualitative features of this species are very similar to those of *C. ludwigii*, but its chromosome number is slightly higher than in the latter species (n=18 vs. n=17; Luceño *et al.* unpublished), and all samples constituted a monophyletic group in a phylogenetic analysis based on DNA sequences (Villaverde *et al.* in press.).

Key to *C. ludwigii* species group (clade D) of *Carex* sect. *Schoenoxiphium*

1. Utricles (4.1)4.5–6.5(7) mm long, linear to lanceolate, more than 4 times as long as wide 2
- 1'. Utricles (2.2)2.5–5.3(5.4) mm long, elliptic to ovoid, less than 3 times as long as wide 3
2. Permanent style base on nutlet with a conspicuous constriction at its middle; leaves up to 9(10) mm wide; at least some partial inflorescences more or less erect *C. kukkoneniana*
- 2'. Permanent style base on nutlet absent or very short, not constricted at its middle; leaves up to 14.4 mm wide; partial inflorescences usually pendulous *C. pseudorufa*
3. Utricles (4.3)4.7–5.3(5.4) × 1.7–2 mm, straight *C. badilloi*
- 3'. Utricles (2.2)2.5–3.7(4) × (0.8)1–1.5(1.7) mm, frequently curved 4
4. Culms (4)10–65(90) cm long, (0.6)0.8–1.5 mm wide at its middle part; leaves (1)1.5–2.5(2.8) mm wide *C. parvirufa*
- 4'. Culms (54)69–111 cm long, 1.9–2.5 mm wide at its middle part; leaves (2.4)3.2–6(6.9) mm wide *C. ludwigii*

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