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TWO NEW SPECIES OF *SISYRINCHIUM* (IRIDACEAE) FROM SOUTH-CENTRAL UNITED STATES

ERIC L. KEITH
Research Affiliate
University of Texas at Austin
Plant Resources Center

Raven Environmental Services Inc.
P.O. Box 6482
Huntsville, Texas 77342
keith@ravenenvironmental.com

ABSTRACT

Two new species of *Sisyrinchium* are described and illustrated: **Sisyrinchium elizabethiae** E.L. Keith, **sp. nov**., from Texas and Louisiana, and **Sisyrinchium myrioflorum** E.L. Keith, **sp. nov**., from southeastern Texas. Both species are common and often locally abundant within their respective specialized arenic habitats. Included are photographs, distribution maps, and keys that distinguish these novelties from similar species.

Sisyrinchium L. is a genus with 37 species currently recognized in North America north of Mexico (Cholewa & Henderson 2002; Sorrie et. al. 2012). Cholewa & Henderson described it as "a complex polyploid taxon in which the species are not always easily distinguished. …. A definite ploidal series seems to be evident … at least among the blue-flowered species." Hybrids may exist (Ward 1959; Correll & Johnston 1970; Diggs et al. 2006) but definitive evidence of hybridization is lacking and when different species are found growing together or in close proximity, intermediates are rarely, if ever, observed.

Cholewa & Henderson (2002) noted that variability within populations makes accurate identification based on only one individual nearly impossible. At least for the species of the southern USA, flower sizes and colors vary greatly even within populations and on the same plants. They also indicated that flowers and spathes provide the best characteristics for identification and require extreme care during pressing, as characteristics of the flowers are usually lost on dried specimens. Fresh material and field familiarity with populations in their unique ecological niches makes identification easier.

Bicknell (1901) made special note of Texas *Sisyrinchium*: "The Texan species taken as a group present several noteworthy features of botanico-geographical interest. Not only do none of the distinctly Texan species, as far as appears, extend to any distance beyond the borders of the state to the north or east, but, conversely, very few of the more northern or eastern forms cross the Texan border, and not one of them for any great distance." Hornberger (1987) noted that specimens collected from Texas were particularly difficult to identify.

As a preamble to a more comprehensive study of *Sisyrinchium* in Texas and Louisiana (Keith et al. in prep.), two species have presented themselves as worthy of distinction. They are morphologically distinguishable based on multiple characteristics, ecologically and biogeographically distinct, and largely or completely reproductively isolated from one another by phenology, biogeography, and other factors. They appear to constitute separately evolving lineages (de Quieroz 2007) and are justifiably recognized at specific rank.

SISYRINCHIUM ELIZABETHIAE E.L. Keith, **sp. nov.** (Figs. 1 & 2). **TYPE**: **Texas.** Walker Co.: Ca. 30 meters N of Montgomery Co. line on W side of FM 1791, WGS 84: 30.574817, -95.735111, deep sandy soil in pine forest, associates include *Pinus echinata, Pinus taeda, Quercus margaretiae, Quercus falcata, Sassafras albidum, Ilex vomitoria, Callicarpa americana, Prunus gracilis, Pteridium aquilinum, Tradescantia reverchonii, Berlandiera pumila, Hymenopappus artemisiifolius, Glandularia canadensis, Piptochaetium avenaceum,* and *Dichanthelium oligosanthes*, 6 Apr 2021, *E.L. Keith* & *Elizabeth Keith 1396* (holotype: TEX).

This species is similar to *Sisyrinchium albidum* Raf. in its perennial duration and caespitose habit with simple stems, paired inflorescences, and light blue flowers but different in its significantly taller stature, longer leaves, wider stems and leaves, larger spathes, ovaries that dry tan to brown rather than typically dark brown to black, and restriction to deep sandy soils.

Perennial herbs caespitose, light green to olive green when dry, to 4.8 dm, usually glaucous. **Stems** mostly simple or rarely with one or two branched stems, obviously winged (2.5) 3.7–6.0 mm wide when fresh, 2–3.7 mm when dry, mostly glabrous, margins entire, similar in color and texture to stem body. **Leaves** glabrous, 3.1–5.5 mm wide when fresh, 1.5–3.9 mm when dry, leaf bases rarely with persistent fibrous tufts or none. **Inflorescences** paired, closely subtended by bract-like leaf that often obscures inner inflorescence, sessile or rarely outer with branch to 5 cm. **Spathes** green or occasionally tan without a purplish tinge except at base, glabrous, keels entire; outer spathe of outer rhipidium 15.1–48 mm, outer spathe usually longer than inner to 27.1 mm, but occasionally shorter to 5 mm, outer spathe of inner rhipidium 12.9–28.2 mm, 9.1 mm shorter to 4.1 mm longer than inner spathe, both tapering evenly towards apex, margins occasionally distinct but more often connate basally to 3.4 mm; inner with keel straight or somewhat curved, apex acute to obtuse or rarely truncate. **Tepals** light blue, bases yellow; outer tepals 8.9–11.5 mm, apex emarginate, aristate; filaments connate ± entirely, slightly stipitate-glandular basally; ovary color is usually tan, but occasionally to brown, never black when dry. **Capsules** tan to brown, ± globose, 3–6.6 mm; pedicel spreading or ascending. **Seeds** irregular, globose or obconic, 0.8–1.2 mm, granular to rugulose.

Additional collections examined. **Louisiana.** Natchitoches Par.: 2.5 mi W of Natchitoches, 7 Apr 1962, open oak and pine, *Loftin s.n.* (NLU); 2.5 mi W of Natchitoches, wooded area, pine, oak woods, 12 Apr 1962, *Norman s.n.* (NLU); 4 mi W of Natchitoches, sandy soil, 27 Mar 1963, *Rabb 54* (NLU). **Texas.** Anderson Co.: Northern section of Engeling Wildlife Management Area (WMA), openings in post oak-blue jack oak community on deep xeric sands, 4 April 2000, *MacRoberts & MacRoberts 4204* (TEX); Gus Engeling WMA, NW of Palestine, woods N of Lake 2, Pasture 2, 17 Apr 1993, *Dubrule 1097* (TAMU); Gus Engeling WMA, 6 mi NW of Tennessee Colony, Kid Spring Pasture in sandy soil, 2 Apr 1951, *Marsh, Jr. 12* (TEX); Near Lake #2, Gus Engeling WMA, wooded ground, sandy soil, 12 Apr 1975, *Goodman 31* (BRIT); just E of CR 1210, 2.3 km N of FM 228, open disturbed hillside on sandy soil in post oak woodland, 24 Mar 2002, *Keith 103* (TEX); Gus Engeling WMA, deep sand in hardwood forest, 14 Apr 2018, *Keith 1270* (TEX); Gus Engeling WMA, deep sandy soil in sand post oak woodland, 14 Apr 2018, *Keith 1271* (TEX); Gus Engeling WMA, N side of Lake #2; oak-hickory, moist sandy soil, 12 Apr 1975, *Kimball 31* (BRIT); On TX 294, 6 mi from Hwy 294 and 3016 jct 2 Apr 1995, *Leikam 80* (BAYLU); Gus Engeling WMA, 6 mi NW of Tennessee Colony, 16 Apr 1951, *Marsh Jr. 46* (SMU); near Lake #2, Gus Engeling WMA, wooded ground, sandy soil, 12 Apr 1975, *Quesenberry 1038* (BRIT); Lake #2, Gus Engeling WMA, post oak and hickory, sandy soil, 12 Apr 1975, *Rice 97* (BRIT); 3.4 mi NNW of Montalba, sandy hillside, open oak woods, 8 Apr 1951, *Shinners 12964* (SMU). Angelina Co.: Ca. 9 mi N of Lufkin off US Hwy 59, in mixed woods, 11 Apr 1942, *Lundell & Lundell 11100* (LL). Cherokee Co.: 2 mi E of Rusk on red sandy clay of pine-hardwood bluff, 2 Apr 1964, *Kral 19573* (SMU, VDB); off US Hwy 69, between Alto and Lufkin, in pineland, 25 Mar 1944, *Lundell & Lundell 12716* (LL). Falls Co.: Railroad ca. 1/2 mi E of TX Hwy 14, loose sandy soil, 31 Mar 1997, *Holmes & Singhurst 8809* (BAYLU); unmarked Co Rd, 26 Mar 1998, *Lambert 90* (NLU); unmarked Co Rd, 26 Mar 1998, *Zygo 90* (BAYLU). Freestone Co.: 15 mi S of Fairfield; foot of road fill in sand, 9 Apr 1945, *Shinners 7115* (SMU, GH); off

US Hwy 75, SE of Dew, in open sandy woodland, 9 Apr 1945, *Lundell 13420* (LL). Hardin Co.: Ca. 20 m N FM 418 and app 300 m E of Village Creek, deep sandy longleaf pine planted field, 1 Apr 2015, *Keith 1044* (TEX); Temple Inland Easement adjacent to TNC's Roy E. Larson Sandylands Preserve, 1994, *Singhurst 2402* (BAYLU); ca. 4 mi E of US 69/287 & FM 418 jct in Kountze, on FM 418, then S ca. 0.38 air mi to E side of Village Creek, Roy E. Larsen Sanctuary, xeric stream terrace sand ridge, 3 Apr 1989, *Orzell & Bridges 8902* (TEX). Houston Co.: Lovelady, 26 Mar 1930, *Lovelady High School s.n.* (TEX); Davy Crockett Natl Forest, Ratcliff Lake Rec Area along road near headquarters, sandy soil, 20 Mar 1981, *Morden 211* (TAES); Mission Tejas State Historical Park, 31 Mar 1995, *Singhurst 3732* (BAYLU). Leon Co.: 3.6 mi S of jct of Hwy 7 and 35, 29 Mar 1959, *Oliver 6* (ASTC); 4.8 mi S of Buffalo; sandy clay, road shoulder and ROW of bordering oak woods, 4 Apr 1955, *Shinners 19506* (SMU); 13 mi SW of Buffalo, off US Hwy 79, roadside, 10 Apr 1945, *Lundell 13440* (LL, SRSC); off US Hwy 79, SW of Marquez, in sandy woodland, 28 Apr 1941, *Lundell & Lundell 10389* (LL). Madison Co.: Co Rd 219, ca. 1 mi N of OSR jct, road bank at edge of pine woods, deep moist Padina sand, 20 Apr 1997, *Neill 56* (TAMU). Milam Co.: 4 mi NW of Milano, roadside, sandy clay, 16 Mar 1957, *Shinners 25894* (SMU**)**. Montgomery Co.: Sam Houston Natl Forest at parking area for Lone Star Hiking Trail along FR 219a and 50 feet S of intersection with Hwy 149, sandy soil, 12 Apr 1992, *Brown 15933* (SBSC); bank above Hwy 1375 ca. 1 mi E of Hwy 149 N of Montgomery in the SHNF, 31 Mar 1993, *Brown 16849* (SBSC); 4 mi E of Richards along FM 149, SHNF, under forest cover in sandy soil, 5 Apr 1968, *Janne 122* (TAES); 10 m E of FS Rd 239, in pine-hardwood forest on deep sandy soil, 5 Apr 2021; *Keith 1392* (TEX); 10 m E of FS Rd 239, in pine-hardwood forest on deep sandy soil, 8 Apr 2021, *Keith 1399* (TEX). Nacogdoches Co.: Hwy 7, 14 Apr 1964, *Banks 3111* (ASTC); 1 mi W of jct of CR 546 and Co Rd 545 on CR 546, 26 Mar 1988, *Brooks 44* (ASTC); ca. 3 mi down Fern Lake Fire Tower Rd on N side in sandy soil, 15 Apr 1976, *Cox 104* (ASTC); one block E of SFA in moist sandy soil, 14 Apr 1969, *Deiss 48* (ASTC); Ed Rice Farm, sandy soil, 28 Mar 1952, *Robertson 28* (ASTC); Kurth Lease near SFA Experimental Forest, fine sandy loam, shelterwood after cut and burn, 17 Mar 1952, *Hebb s.n.* (ASTC, SMU); ca. 0.25 mi N of FM 1087 and 0.5 mi E of Naconiche Creek, dry sandy upland, 10 Apr 1999, *Keith 491* (TEX); roadside of Co Rd 538, ca. 6 mi S of Nacogdoches, 27 Mar 2003, *Keith 519* (TEX); 8.1 mi N of Nacogdoches, Hwy 21, 18 Mar 1959, *Lewis 5084* (ASTC); SFA Experimental Forest, dry sandy soil, 12 Apr 1958, *Lewis s.n.* (ASTC); 2 mi NE of Martinsville roadside park, Hwy 7, 3 Apr 1961, *Oliver 275* (SMU); Flower Mt. Road 1.1 mi N of crossing with Nat-Trawick Rd, 2 Apr 1961, *Oliver 277* (SMU, TEX); 8 mi S of Nacogdoches; pine-hardwood stand, sandy loam, 12 Apr 1958, *Shinners 26859* (SMU); 11.4 mi N of Nacogdoches, young pine-hardwood stand, sandy loam, 12 Apr 1958, *Shinners 26877* (SMU); 11 mi N of Nacogdoches, sandy pine forest, 23 Mar 1976, *Taylor & Taylor 21064* (BRIT); 25 mi E of Nacogdoches, sandy soil, waste land, 15 Apr 1958, *Thomas s.n.* (ASTC); Winston 8 Ranch, deep sandy soil in pine forest, 12 Mar 2021, *Keith et al. 1356* (TEX); Winston 8 Ranch, deep sandy soil in pine forest, 12 Apr 2021, *Keith et al. 1403* (TEX). Robertson Co.: Mill Creek Bog, 6 Apr 1982, *Starbuck 1611* (BRIT, TAMU). Rusk Co.: ca. 2 mi E of Mt. Enterprise; sandy soil along stream, 18 Mar 1949, *Whitehouse 20824* (SMU). Sabine Co.: 3/4 mi W of Geneva, off Rte 21, among grasses in open pine land, 9 Apr 1964, *Correll & Correll 29086* (LL); ca. 0.3 mi N of FS Rd 108 and 2 mi E of Black Ankle, ca. 5 air mi NW of Geneva, above tributary of Colorow Creek, Matlock Hills, Sabine National Forest, dry sandy upland forests transitional to longleaf pine savannah, 12 Apr 1989 , *Orzell & Bridges 9244* (TEX). San Augustine Co.: NW from new Hwy 147 at Angelina River for 1.3 mi to former Coussen's Farm (now US property), on hillside pasture overlooking Coussen's Bridge over Attoyac River, 16 Apr 1961, *Lacey & Oliver 298* (SMU). Walker Co.: FS Rd 208 in SHNF, deep sand in pine forest, 3 Apr 2018, *Keith 1266* (TEX); Comp 4 of the Sam Houston National Forest, deep sand in pine forest, 8 Apr 2001, *Keith 459* (TEX); FS Rd 208, deep sandy soil in pine forest, 19 Mar 2021, *Keith 1366* (TEX); ca. 10 m N of Montgomery County line on E side of FM 1791, deep sandy soil in pine forest, 30 Mar 2021, *Keith & Keith 1386* (TEX).

Etymology

This new species is named for my beautiful wife of 25 years, who collected the type specimen (Fig. 1).

Habitat and distribution

Sisyrinchium elizabethiae is currently known from the South Central Plains in Texas and Louisiana and East Central Texas Plains (Daigle et al. 2006; Griffith et al. 2007) (Maps 1 and 2). It occurs in upland pine-hardwood and hardwood forests and woodlands over deep sandy soils. It consistently grows on loamy, fine sands and fine sands predominantly in the Arenosa, Boy, Darco, Fetzer, Gunter, Lovelady, McNeely, Naconiche, Padina, Tenaha, and Turkey Soil Series (Soil Survey Staff 2021). The unique habitats that this novelty occupies and their importance as a center of endemism are thoroughly described in MacRoberts et al. (2002a). This species has a similar distribution and often grows with other species endemic to eastern Texas and western Louisiana, including *Palafoxia reverchonii*, *Astragalus soxmaniorum*, *Dalea grisea*, and *Coreopsis intermedia*, all of which occur on xeric sandylands (MacRoberts et. al. 2002a; Turner et al. 2003). MacRoberts et al. (2002b) determined that approximately half of the West Gulf Coastal Plain endemic species occupy these unique, sandy habitats. The recently discovered species *Physalis macrosperma* Pyne, Bridges, & Orzell shares a similar distribution and grows with *S. elizabethiae* at several locations (Pyne et al. 2019; pers. observ.).

Distinction and relationships

Sisyrinchium elizabethiae is characterized by its unusually wide stems and leaves, but older plants often shrink later in the season. In his dissertation study of northeastern USA species, Ward (1959) noted that the width of stems and leaves also shrink significantly when pressed, while other morphological characteristics were not significantly reduced during the drying process. He discovered the shrinkage ratio for stems to be 1.5 times and for leaves 1.3 times. Measurements taken in the present study closely replicate Ward's results.

Sisyrinchium elizabethiae is clearly most closely similar to *S. albidum* in its morphology. The two species are sympatric and occasionally grow in close proximity but are clearly separated by ecological preferences. *Sisyrinchium elizabethiae* appears to be restricted to deep, sandy soils while *S. albidum* occurs most commonly on more mesic, sandy sites or those with rocky or calcareous substrates (Sorrie et al. 2012; pers. observ.).

Sisyrinchium albidum was the first of the blue-eyed grasses with paired inflorescences to be recognized as distinctive (Rafinesque 1832). Bicknell (1899) later described *S. capillare* with its wiry, barely winged stems. More recently, Sorrie et al. (2012) discovered a distinctive Alabama endemic species with paired inflorescences, *S. calciphilum* Sorrie. *Sisyrinchium elizabethiae* is the fourth species with paired inflorescences. In these species, each inflorescence is subtended by two bracts or spathes, which terminate at the unbranched stems, a combination of characteristics unique among the genus (Cholewa & Henderson 2002; Sorrie et al. 2012).

Hornberger (1987) recognized a high degree of variability within *Sisyrinchium albidum* sensu stricto, which she referred to as the *S. albidum* complex, indicating that stem wing width was an important characteristic in distinguishing morphological variants, with western populations having the widest stems on average. The eastern variant from her dissertation has since been recognized as the distinct species *S. capillare* Bicknell (Cholewa & Henderson 2002; Sorrie et al. 2012). It is unknown if specimens of *S. calciphilum* (an Alabama endemic species that possess very narrow stems as well) were examined by Hornberger. Sorrie et.al (2012) recognized the regional differences describing distinctions between populations of *S. albidum* east and west of the Appalachians, but it is unknown whether they examined specimens of *S. elizabethiae*.

A distinctive variant, or potentially undescribed species of *Sisyrinchium albidum*, also occurs in cedar glades and limestone outcrops in northern Mississippi, central Tennessee, and south-central Kentucky (Map 1). It is morphologically different from *S. albidum* sensu stricto by its generally wider stems and leaves, noticeably shorter bracts, leaves averaging only 1/2 to 2/3 the length of the

stems, tan to light brown versus brown to black ovaries when dry, and usually growing in calcareous versus sandy soils.

The following key includes all four USA species with usually simple stems and paired spathes. Stem width refers to live plants. Dried specimen measurements were multiplied by 1.5 for stems and 1.3 times for leaves following Ward's formula (Ward 1959). Measurements in the key were tested using a Scheffe All-Pairwise Comparison ($p>0.0000$). The Chi-square test procedure was used to determine whether the relative frequency distributions of observed colors of ovaries (and other characteristics of the spathe) were homogenous among the species considered. All Chi-square test procedures for relative frequency distributions of observed colors for the structures evaluated were significantly different ($P < 0.05$), suggesting the distributions are not the same for the species being considered.

1. Stems not winged or scarcely so, each wing narrower than stem core; outer spathe pair usually equal in length to inner pair; eastern coastal plain of Georgia, South Carolina, North Carolina, and Virginia ..... **Sisyrinchium capillare**

1. Stems obviously winged, each wing wider than stem core; outer spathe pair longer than inner pair by 2.3 mm or more; west of eastern coastal plain to eastern Texas

2. Stems mostly 1.0–2.0 mm wide; corolla medium blue; endemic to glades in northern Alabama ..... **Sisyrinchium calciphilum**

2. Stems mostly 2.0–6.0 mm wide; corolla light blue to white.

3. Stems (16) 20–40 (42) cm tall, stems 2.0–3.5 (4.1) mm wide, leaves 1.8–3.5 mm wide, outer spathe of outer rhipidium (12) 15–22 (35) mm long ($\bar{x}$ = 20.1 mm), ovaries drying brown to black (tan or light brown on plants from cedar glades in Mississippi, Tennessee, and Kentucky), widespread in eastern USA on a variety of substrates ..... **Sisyrinchium albidum**

3. Stems (20) 30–48 cm tall, stems (2.5) 3.7–6.0 mm wide, leaves (2) 3.1–5.5 mm wide, outer spathe of outer rhipidium (15) 22–40 (48) mm long ($\bar{x}$ = 24.7 mm), ovaries drying tan to brown, endemic to eastern Texas and northwestern Louisiana on deep sandy soil ..... **Sisyrinchium elizabethiae**

SISYRINCHIUM MYRIOFLORUM E.L. Keith, **sp. nov.** (Figs. 3 and 4). **TYPE**: **Texas.** Duval Co.: Ca. 6.5 mi W of Falfurrias on Hwy 285, WGS 84: 27.262561 N; -98.257133 W, deep sandy soil on N side of hwy, 26 Mar 2021, *E.L. Keith 1380A* (holotype: TEX–one plant on 3 sheets; isotypes: BRIT, TAES).

This species is similar to *Sisyrinchium pruinosum* Bicknell in overall aspect (usually numerous branched stems terminated by a single inflorescence), leaf arrangement, floral structure, and blue to violet flowers but different in its significantly wider stems and leaves, more nodes per stem on average, more pedicels per stem on average, shorter leafy bracts on average, and restriction to deep sandy soils (versus typically calcareous substrates).

Perennial herbs caespitose, green to dark olive brown when dry, to 3.4 dm, glaucous. **Stems** branched, with 1–3 nodes (usually 2 and 3) (2.3) 4–7.4 mm wide when fresh, 2–4.9 mm when dry, glabrous or scabrous, margins often minutely denticulate especially basally, darker than lighter stem body; first internode 10–20 cm, shorter than the leaves; upper node with 2–5 branches (peduncles). **Leaves** glabrous or scabrous on margins, 10–39 cm long (3.7) 4.9–8 mm wide when fresh, 3.1–6.2 mm when dry, bases not persistent in fibrous tufts. **Leafy bracts** 43–155 mm long. **Inflorescences** borne singly. **Spathes** green, obviously wider than supporting branch, glabrous, keels denticulate to entire; outer spathe 16–30 mm, equal to 6.3 mm longer than inner spathe or occasionally slightly shorter than inner, usually curving toward apex, margins basally connate 3.2–7.3 mm; inner spathe with keel evenly curved or straight, hyaline margins 0.3–1 mm wide, apex acuminate to acute. **Tepals** blue to violet, bases yellow; outer tepals 9.3–11.9 mm, apex emarginate, aristate; filaments connate ± entirely, slightly stipitate-glandular basally; ovary brown to black and noticeably darker

than foliage when dry. **Capsules** brown, ± globose, 4.3–7.7 mm long; pedicel spreading or ascending. **Seeds** irregular, globose or obconic, 0.8–1.5 mm, granular to rugulose.

Additional collections examined. **Texas.** Aransas Co.: Near cemetery at Rockport, sandy prairie**,** 28 Apr 1947, *Whitehouse 18327* (SMU). Brooks Co.: 8 mi W of Falfurrias, State Hwy 285, loose sand, 16 Mar 1963, *Arreola, Davila, & Vergara 121* (TAES); S of Encino, off Hwy 281, sandy plains, 6 Apr 1944, *Lundell & Lundell 12769* (LL); 3 mi S of Falfurrias, low pasture on sandy plain, 21 Apr 1949, *Lundell 14910* (LL); 10 mi N of Conception, US Hwy 281, loose sandy soil, 25 Mar 1963, *Cabrera 94* (TAES); 4.75 mi NW of Falfurrias, infrequent in sandy field, 31 Mar 1949, *Cory 55273* (SMU); 4.75 mi NW of Falfurrias; infrequent in sandy field, 31 Mar 1949, *Cory 55274* (SMU); 7 mi E of Falfurrias on Hwy 285, broad grassy road right-of-way, 18 Apr 1958, *Gould & Hycka 8121* (SMU, TEX); 13 mi E of Hebbronville, State Hwy 285, pale tan loose sand, 7 Apr 1962, *Ramos, Sandoval, & McCart 7953* (TEX); "Brooks County," 28 Mar 1932, *Jones 29063* (TAES); 8 mi W of Falfurrias, State Hwy 285, loose sand, 16 Mar 1963, *Arreola, Davila, & Vergara 121* (TEX); State Hwy 285, 13 mi E of Hebbronville, sand, 23 Mar 1963, *Solis 135* (SMU, TAES, TEX); 10 mi N of Concepcion, Hwy 281, loose sandy soil, 25 Mar 1963, *Cabrera 94* (TEX); 13 mi E of Hebbronville, State Hwy 285, 7 Apr 1962, *Ramos, Sandoval & McCart 7974* (TAES); ca. 0.3 air mi WNW of Vargas Creek culvert on R.M. 755, 1.5 air mi SE of La Viznaga Windmill, at N26°49'35.3", W98°20'44.4", deferred pasture, Encinitos Ranch, rare in fairly intact grassland on deep loose sand on very gently undulating landscape of South Texas Sand Sheet, 20 Mar 2007, *Carr et al. 25538* (TEX); ca. 8.5 mi W of Falfurrias, Hwy 285, deep sandy soil on N side of hwy, 26 Mar 2021, *Keith 1382* (TEX); S of Encino, off Hwy 281, sandy plains, 6 Apr 1944, *Lundell & Lundell 12769* (LL); 7 mi E of Falfurrias on Hwy 285, broad grassy road right of way, 18 Apr 1958, *Gould & Hycka 8121* (TEX). Dimmit Co.: 11 mi W of Carrizo Springs on the road to Eagle Pass, 31 Mar 1959, *Johnston 3845* (TEX). Duval Co.: 7 mi SE of Bruni, State Hwy 359, scattered in sandy loam, 2 Apr 1963, *Candelario & Flores 180* (TAES); 4 mi E of Bruni, State Hwy 359, sand, 18 Mar 1963, *Garcia 44* (SMU, TEX); 7 mi SE of Bruni, State Hwy 359, scattered in sandy loam, 2 Apr 1963, *Flores & Flores 180* (SMU); 15 mi E of Hebbronville, State Hwy 285, pale tan loose sand, 7 Apr 1962, *Ramos, Sandoval, &McCart 7974* (TEX); 6 mi SW of Realitos, State Hwy 359, in pale tan loose sand, 7 Apr 1962, *Ramos, Sandoval, & McCart 7994* (TEX); ca. 8 mi W of Falfurrias on Hwy 285, deep sandy soil on N side of hwy, 17 Mar 2011, *Keith & Keith 995* (TEX); 9.9 road mi E of Hebbronville on Hwy 285, deep sandy soil on N side of hwy, 17 Mar 2011, *Keith & Keith 997* (TEX); 6.0 road mi NW of Hwy 16 and Hebbronville, Hwy 359, deep sandy soil on N side of hwy, 18 Mar 2011, *Keith & Keith 999* (TEX); 8 mi NW of Falfurrias, sandy prairie, 7 Mar 1954, *Johnston 5485* (TEX); 3 mi NE of Realitos on Hwy 359, loose sand, 3 Mar 1963, *Arzola 117* (TEX); 18.8 mi SW of Benavides, Highway 359, loose sand, 9 Mar 1962, *Alvarez, Guajardo, Salazar, & McCart 7676* (SRSC, LL); ca. 7.5 mi W of Falfurrias on Hwy 285, deep sandy soil on N side of hwy, 26 Mar 2021, *Keith 1381* (TEX). Hidalgo Co.: S of Encino, sandy plain, 19 Mar 1942, *Lundell 10828* (LL); San Manuel ranch, sandy soil, edge of water hole, 9 Apr 1933, *Clover 808* (TEX); well drained and highly disturbed along highway median, sandy soil, 26 Mar 1988, *Gonzales s.n.* (BRIT); 23 mi N of Edinburgh, sandy upland, 29 Feb 1944, *Painter & Barkley 14425* (TEX); ca. 34 mi N of Edinburg, sandy soil at a roadside park, 26 Mar 1988, *Luna 048* (BRIT); north Hidalgo Co., along highway, occasional on sandy soil and open ground, 18 Apr 1941, *Runyon 5264* (TEX); 34 mi N of Edinburg at Brooks/Hidalgo Co. line, 26 Mar 1988, *Smith 043* (BRIT); Hunke Ranch, ca. 1.5-1.6 air mi SSW of jct. of Hidalgo, Kenedy and Willacy counties (as marked on topo), La Sal Vieja Quadrangle, 50 ft, occasional among gopher mounds in grazed pasture with no standing grass cover, mesquite savanna on well-drained loose sandy soils of South Texas Sand Sheet, 15 Mar 2004, *Carr & Pons 22758* (TEX). Jim Hogg Co.: 8 mi E of Hebbronville, Hwy 359, loose gravel, scarce, 18 Mar 1963, *Gamez 40* (SMU, TAES, TEX); 12 mi SW of Hebbronville, FR 496, sandy red soil, 4 Apr 1965, *Schneider & Schneider 39* (TEX); ca. 4 mi SW of Hebbronville, Route 496, open sandy flat 5 Apr 1959, *Correll 20802* (SMU, LL); 10 1/3 mi E of Hebbronville, frequent on sandy roadside, 31 Mar 1949, *Cory 55291* (SMU); 10 mi E of Hebbronville, infrequent on sandy roadside, 31 Mar 1949, *Cory 55298* (SMU); 3.5 mi S of Agua Nueva, Rte. 1017, sandy, open soil, 20 Mar 1966, *Correll 32374* (LL); fields about 1/2 mi S of Hebbronville, Rte 16, hard red sands of rocky fields, 20 Mar 1969, *Correll 36796* (LL); State Hwy 285, 5 mi E of Hebbronville, pale tan loose sand, 7 Apr 1962, *Ramos, Sandoval, & McCart 7931* (TEX); 4 mi E of

Hebbronville, reddish-brown sand, 14 Apr 1960, *McCart 7501* (VDB); State Hwy 285, 5 mi E of Hebbronville, light tan loose sand, 21 Mar 1962, *Gutierrez & McCart 7818* (LL, SRSC). Kenedy Co.: 4 mi S of Armstrong, sandy open soil, 21 Apr 1959, *Correll & Rollins 21005* (SMU, LL); 1 mi S of Sarita, sandy, open soil, 21 Apr 1959, *Correll & Rollins 21011* (SMU, LL); US Hwy 77, S of Sarita, sand, 9 Mar 1963, *Gongora et al. 8820* (SMU); 0.6 mi W of Laguna Madre beach ridge, southern part of Norias Division of King Ranch, loose sand prairie 12 Mar 1954, *Johnston 54263* (TEX); just SE of La Calandria, Norias Division of King Ranch, top of high sand hill, open prairie, 12 Mar 1954, *Johnston 54268* (TEX); Armstrong, frequent bordering the hwy, 8 May 1949, *Runyon 4339* (TEX); 42 mi S of Riviera, 15 mi N of Raymondville, 21 Mar 1967, *Taylor & Taylor 3577* (SMU). Kleberg Co.: ca. 18 mi E of Falfurrias on Hwy 285, 8 Mar 1998, *Branch 121* (BAYLU); 12 mi SW of Riviera, frequent on sandy roadside, 31 Mar 1949, *Cory 55256* (SMU); 2 mi W of Loyola Beach, 9 Mar 1963, *Gongora, Garza, & McCart 8802* (TEX); Riviera, 19 Apr 1941, *Fisher 41038* (SMU, TEX); Riviera, 30 ft, 19 Apr 1941, *Fisher 17288* (SMU); Kingsville, 1940, *Sinclair s.n.* (TEX); FM 628 and Hwy 77, side of road in sandy/loamy soil, 11 Apr 1994, *Skeeter 043* (BAYLU); Vatteman, FM 628 at Hwy 77, side of the road, sandy soil, 11 Mar 1994, *Voight 038* (BAYLU). Nueces Co.: Ca. 4 mi S of Flour Bluff, between Laguna Madre and the Oso, sandy loam, 11 Apr 1955, *Jones 1112* (SMU). Refugio Co.: Beyond Refugio, near Greta, sand, 22 Mar 1942, *Lundell & Lundell 10858* (LL, SRSC). Willacy Co.: Katherine, [Katherine was a settlement on the site of present-day Armstrong, which is in Kenedy Co.; but, Katherine was earlier in Willacy Co.], 20 Mar 1907, *York s.n.* (TEX); 4 mi W of Redfish Bay on S edge of Norias erg, loose sand prairie, 9 Mar 1954, *Johnston 54161* (TEX); 4 mi W of Redfish Bay, S edge of Norias erg, loose sand prairie, 9 Mar 1954, *Johnston 54188* (SMU, TAES, TEX); Yturria Station in Willacy on Hwy 96, in open fields, sand, 10 Apr 1937, *Runyon 1631* (TEX-2 sheets).

Etymology

The epithet refers to the characteristically many-flowered plants that make this species arguably the showiest in the genus.

Habitat and distribution

Sisyrinchium myrioflorum is currently known only from the Coastal Sand Plain of the Western Gulf Coastal Plain in Texas and adjacent areas in similar habitats (Griffith et al. 2007) (Map 3). This region is referred to as the South Texas Sand Sheet, also known as the Coastal Sand Plains and the Llano Mesteño. It is a vast region covering more than two million acres at the southern tip of the state, just north of the Lower Rio Grande Valley (Peacock & Smith 2019). The landscape's distinctive feature is the dunes created from sheets of sand blown inland from the shoreline of an ancient sea (Peacock & Smith 2019). The flora of the South Texas Sand Sheet includes about 54 taxa that are endemic to Texas (Carr 2021). Among those, this new species brings the total to fifteen endemic to the Sand Sheet proper and/or similar habitats in close proximity (Carr 2021). Endemic taxa observed in association with *S. myrioflorum* include *Monarda fruticulosa*, *Abronia ameliae*, *Brazoria arenaria*, *Sphaeralcea lindheimeri*, *Eriogonum riograndis*, and *Phacelia patuliflora* var. *austrotexana* (Turner et al. 2003). Other associated species include *Allium elmendorfii*, *Aphanostephus skirrhobasis* var. *kidderi*, *Argemone sanguinea*, *Cirsium texanum*, *Cryptantha texana*, *Eragrostis secundiflora*, *Galactia canescens*, *Paspalum setaceum*, *Phlox glabriflora*, *Physaria lindheimeri*, *Pyrrhopappus pauciflorus*, *Tetragonatheca repanda*, and *Urochloa maxima*. *Sisyrinchium myrioflorum* is restricted to xeric, sandy soil primarily in the Falfurrias, Nueces, and Sarita Soil Series, or very similar soil types (Soil Survey Staff 2021).

Distinction and relationships

Sisyrinchium myrioflorum has been recognized by other taxonomists in the past and was listed in Guy Nesom's range map notes (unpublished) as "*Sisyrinchium myriaflorum.*" Upon inspection of the type specimen, Dr. George Yatskievych at TEX noted that the correct orthography should actually be "myrioflorum" (email of 20 April 2021). It was also mapped by Turner et al. (2003) as *S. helleri*, within the distribution of the South Texas Sand Sheet and adjacent counties.

Sisyrinchium helleri was described in Bicknell (1901) from Nueces County and the type specimen is clearly not *S. myrioflorum* but a unique species currently included in synonymy with *S. pruinosum* sensu stricto in most recent literature (Cholewa & Henderson 2002; Kartesz 2021) (Fig. 5; Map 3).

Sisyrinchium myrioflorum is distinguished by numerous flowers on each plant, resulting from the highest average number of branched nodes ($\overline{x}$ = 2.3 per stem) and peduncles ($\overline{x}$ = 3.1) of any known species, and its unusually wide stems ($\overline{x}$ = 4.5 mm) and leaves ($\overline{x}$ = 5.8 mm). It also possesses more stems per plant than any other observed by the author, although this trait is often not captured by herbarium specimens — the holotype itself was so large that it had to be mounted on three separate sheets. One large plant observed near the holotype possessed 55 stems, but it was not collected because of sentimentality for its impressive size.

This new species is closely sympatric with *Sisyrinchium helleri* but is clearly separated by morphological differences (as described in the key) and by distinctive ecological preferences. *Sisyrinchium myrioflorum* appears to be restricted to xeric sands, while *S. helleri* occurs in coastal prairies, old fields, and adjacent roadsides and disturbed areas on black clay soil (pers. observ.) (Fig 5). The new species apparently is endemic to the South Texas Sand Sheet and adjacent similar habitats (Map 3).

The Dimmit County specimen appears to be the correct location, as all of Johnston's collections from the same trip were consistent with its location (Lundell Plant Diversity Portal 2021; *Johnston 3845*, TEX). Similar, deep, sandy habitats have been observed by the author in Dimmit and adjacent Frio Counties. While this species is restricted to its specialized habitats, it is usually abundant where it occurs and tolerates infrequent mowing along roadsides. *Sisyrinchium myrioflorum* possesses the widest leaves and stems on average of all the known species in the U.S. and is very similar to the types of *S. colubriferum* and the generally unrecognized *S. varians*, which are currently lumped within *S. ensigerum* and *S. pruinosum*, respectively (Cholewa & Henderson 2002). *Sisyrinchium varians* occurs approximately 130 kilometers to the northeast of the nearest known collection of *S. myrioflorum* in prairies, old fields, and associated roadsides on clayey soil, usually within close proximity to rocky or gravelly outcrops (Fig.6) (Map 3). *Sisyrinchium colubriferum* is probably synonymous with *S. varians*, and it is only known from the type specimens collected on April 9, 1899, by B.F. Bush on prairies at Columbia, Texas, what is now West Columbia (Bush 66, MO, NY) (Bicknell 1901). The nearest collection of *S. varians* to the type location of *S. colubriferum* is approximately 140 kilometers to the west in Fayette Co., Texas (Keith & Keith 990, TEX). Based on Bush's other collections made on the same trip, he did not travel west of Brazoria County, only collecting in the area of Houston and West Columbia from April 2nd to April 25th. By April 30th, he returned to Courtney, Missouri (TORCH Portal 2021). Several attempts by the author to relocate plants with morphology of *S. colubriferum* from Brazoria County have been unsuccessful and no other herbarium specimens from the area match the wide leaves of the type of *S. colubriferum* or *S. varians*.

Two other previously described species are also included in the key below to clarify similar species that may be found in the southern half of Texas, including *Sisyrinchium texanum* Bicknell and *S. dimorphum* R. Oliver (Bicknell 1901; Oliver 1968) (Map 3). *Sisyrinchium texanum* is distinguished by mostly branched stems with turgid tan to brown spathes and occurring on sandy to loamy soils in prairie remnants, fields, adjacent roadsides, and grassy bayous in Austin, Brazoria, Fort Bend, Galveston, Harris, Montgomery, and Waller counties in southeastern Texas (Bicknell 1901). *Sisyrinchium dimorphum* is distinguished by branched and unbranched stems on the same plant, relatively small capsules, and annual or short-lived perennial habit with short, fibrous roots. It occurs along and in rocky and gravelly floodplains from central to southwestern Texas into northern Mexico (Oliver 1968). All these taxa and variants, including those species in the following key, will be covered in detail in an upcoming manuscript (Keith et al., in prep.).

The following key includes the perennial, typically branched species in Texas. Stem widths and leaf widths refer to live plants. Dried specimen measurements were multiplied by 1.5 for stems and 1.3 for leaves following the formula in Ward (1959). Measurements in the key were tested using a Scheffe All-Pairwise Comparison ($p>0.0000$).

1. Main stems and leaves averaging < 3 mm wide, leaves 1– 3 (4.1) mm wide.

2. All stems branching, often numerous (to 43), 1.1–3.5 mm wide ($\bar{x}$ = 2.1), stem body flattened with discernable wings; blooming from early March to early May; occurring in eastern third of Texas north of coastal counties and growing in remnant prairies, open woodlands, saline prairies, Weches Geological outcrops, and adjacent roadsides ..... **Sisyrinchium langloisii**

2. Most stems branching, but often with one to several simple stems on same plant and less numerous (to 19), 1.7–4.1 mm wide ($\bar{x}$ = 2.8), stem body mostly broader than the margins, thus whole stem appears somewhat rounded with sides tapering to scarcely discernable wings; occurring along coast or in western half of Texas.

3. Spathe valves on branched stems equal to 9.3 mm longer than inner ($\bar{x}$ = 2.8); capsules orbicular, 3.7–5.7 mm long ($\bar{x}$ = 5.0); annual or weakly perennial with fibrous shallow roots; blooming from late March through July; occurring in gravelly or rocky floodplains in central to southwestern Texas ..... **Sisyrinchium dimorphum**

3. Spathe valves on branched stems with inner to 3.6 mm longer than outer to outer 4.5 mm longer than inner ($\bar{x}$ = 0.3); capsules oblong, 5.5–8.9 mm long ($\bar{x}$ = 6.9); perennial with fleshy roots; blooming year-round; occurring along entire length of Texas coast to rarely 120 km inland ..... **Sisyrinchium biforme**

1. Main stems and leaves averaging > 3 mm wide, leaves (1.7) 2.5–8.4 mm wide.

4. Plants light green when fresh and drying yellowish, light green, green or olive; relatively fewer stems from base, rarely to 32 stems, but averaging 5.5 stems or less; blooming from early April through October.

5. Stem body mostly broader than the margins, thus whole stem appears somewhat rounded with sides tapering to scarcely discernable wings; plants drying yellowish or light olive-green; stem and wings drying about the same color; ovaries and capsules dark brown or black and contrasting with the much lighter dried foliage; stems averaging 3.3 from base (fewest of any branched species in Texas); blooming early April through May; occurring in moist to wet sandy or silty soils in open areas in southeastern Texas and in bogs and marshes in the Pineywoods and Post Oak Savanna Ecoregions ..... **Sisyrinchium atlanticum**

5. Stem body as wide or narrower than the margins (body looks more like a midvein), stems appear flattened with easily discernible wings, plants drying olive or green; stem body often drying slightly lighter than wings, forming a pale "stripe" down the center; ovaries and capsules not strongly contrasting with dried foliage.

6. Live plants green, not glaucous, drying olive; wide stems (2.9–7.4 mm, $\bar{x}$ = 5.0) and leaves (3.9–7.8, $\bar{x}$ = 5.4); stems appearing flat with prominent wings; blooming from late March through May; flowers blue or often white on clayey substrates; in rich calcareous forests, bottomland hardwood forests, and shady roadsides in eastern third of Texas ..... **Sisyrinchium angustifolium**

6. Live plants glaucous, drying green; stems (2.3–5.6 mm wide, $\bar{x}$ = 3.6) and leaves (2–6.4 mm wide, $\bar{x}$ = 3.8) narrower; stems more terete with narrower wings; flowers blue to violet; on mostly rocky substrates in the western half of Texas.

7. Outer spathe (14.4–29.7 mm, $\bar{x}$ = 21.1), to 3.7 mm longer than inner ($\bar{x}$ = 0.4); capsules usually drying dark brown to black; hyaline margin of inner spathe tapering to acute or acuminate apex, never projecting as lobes; blooming from late April through October; occurring in mountains, only in the Trans-Pecos in Texas ..... **Sisyrinchium demissum**

7. Outer spathe (18.7–42.8 mm, $\bar{x}$ = 25.4), to 13.5 mm longer than inner ($\bar{x}$ = 2.5); capsules usually drying tan to brown; hyaline margin of inner spathe broadly acute, obtuse, or truncate apically, and often projecting as lobes; blooming from late March through July; usually over limestone substrates in a wide variety of habitats, in the western half of Texas, primarily only along water courses in the Trans-Pecos ..... **Sisyrinchium ensigerum**

4. Plants dark green when fresh, drying olive to dark brown; mature plants with numerous stems from base (to 55), averaging 7.3 or more; blooming from late February through April, rarely into May.

8. Surface of leaves, stems and peduncles distinctly granular (like grains of white sand); leaves and spathes scabrous on surface and margins of fresh plants (this character often lost in drying); outer spathe 18.6–34.1 mm ($\bar{x}$ = 25.8) (longest on average of any species in Texas); 0.4–12.4 mm longer than inner spathe ($\bar{x}$ = 4.7); occurring in northcentral Texas on calcareous soils in remnant prairies, fields, open post oak woodlands, and adjacent roadsides and lawns ..... **Sisyrinchium pruinosum** sensu stricto

8. Surface of leaves, stems and peduncles glabrous, margins sometimes scabrous or denticulate (character often lost on dried plants); outer spathe shorter on average and spathes equal or outer spathe averaging much less than 4.7 mm longer than inner; occurring east and south of northcentral Texas.

9. Most stems branched, but often with one to a few unbranched stems from base; spathes turgid usually tan or brown and strongly tinged with purple to 6.2 mm wide ($\bar{x}$ = 4.9); occurring on sandy to loamy soils in prairie remnants, fields, adjacent roadsides, and along grassy bayous in southeastern Texas ..... **Sisyrinchium texanum**

9. All stems branched with numerous stems on mature plants; spathes green, not turgid and narrower, with purple coloration mostly confined to base of spathe.

10. Plants typically sprawling; majority of spathes with the inner spathe longer than the outer (character unique to this species), some spathes equal or with outer slightly longer than inner; endemic to prairies and adjacent disturbed habitats primarily in Coastal Bend of Texas, rarely south and west, on calcareous substrates; forming showy displays of blue in remnant prairies because of its sprawling habit ..... **Sisyrinchium helleri**

10. Plants typically ascending to erect (*S. varians* sprawling); spathes equal or with the outer slightly longer than inner (rarely with inner longer than outer).

11. Stems 1.8–5.2 mm wide ($\bar{x}$ = 3.2); leaves 2–4.9 mm ($\bar{x}$ = 3.9); in a wide variety of open habitats typically on or in close proximity to calcareous substrates (abundant along roadsides); occurring in eastern half of Texas, south and east of northcentral Texas ..... **Sisyrinchium pruinosum** (glabrous form)

11. Stems 2.3–7.4 mm wide ($\bar{x}$ = 4.2); leaves 3.6–8.4 mm wide ($\bar{x}$ = 5.4); occurring in southeastern and southern Texas.

12. Plants usually sprawling; stems 2.6–5.6 mm wide ($\bar{x}$ = 3.9); stems 2 to 18 ($\bar{x}$ = 8); leaves 3.6–8.4 mm wide ($\bar{x}$ = 5); peduncles 2 to 3 ($\bar{x}$ = 2.5); endemic from southcentral Texas, rarely eastward to Brazoria County historically; on calcareous substrates in prairies, open woodlands, and adjacent roadsides and typically on or in close proximity to rocky or gravelly outcroppings ..... **Sisyrinchium varians**

12. Plants ascending to erect; stems 2.3–7.4 mm wide ($\bar{x}$ = 4.5); stems 2 to 55 ($\bar{x}$ = 10.8) (most of any species observed); leaves 3.7–8 mm wide ($\bar{x}$ = 5.8); peduncles 2 to 5 ($\bar{x}$ = 3.1); endemic to deep sandy substrates in southern Texas ..... **Sisyrinchium myrioflorum**

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The taxonomic difficulty of the genus has driven previous researchers to suffer an untimely quietus or to pivot to research in other taxa. Appropriately, I would like to thank the late Dr. Daniel Ward in the universal ether for an enlightening and helpful conversation in the early 2000's that began with him stating that he "was out of the *Sisyrinchium* business."

I would finally like to thank my wife, Elizabeth Keith, for her love and support, critical review of the paper, and suffering being toted around less travelled areas of Texas in search of botanical novelties.

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Figure 1. *Sisyrinchium elizabethiae* with its namesake in Walker Co., Texas. The type specimen was made from this plant.

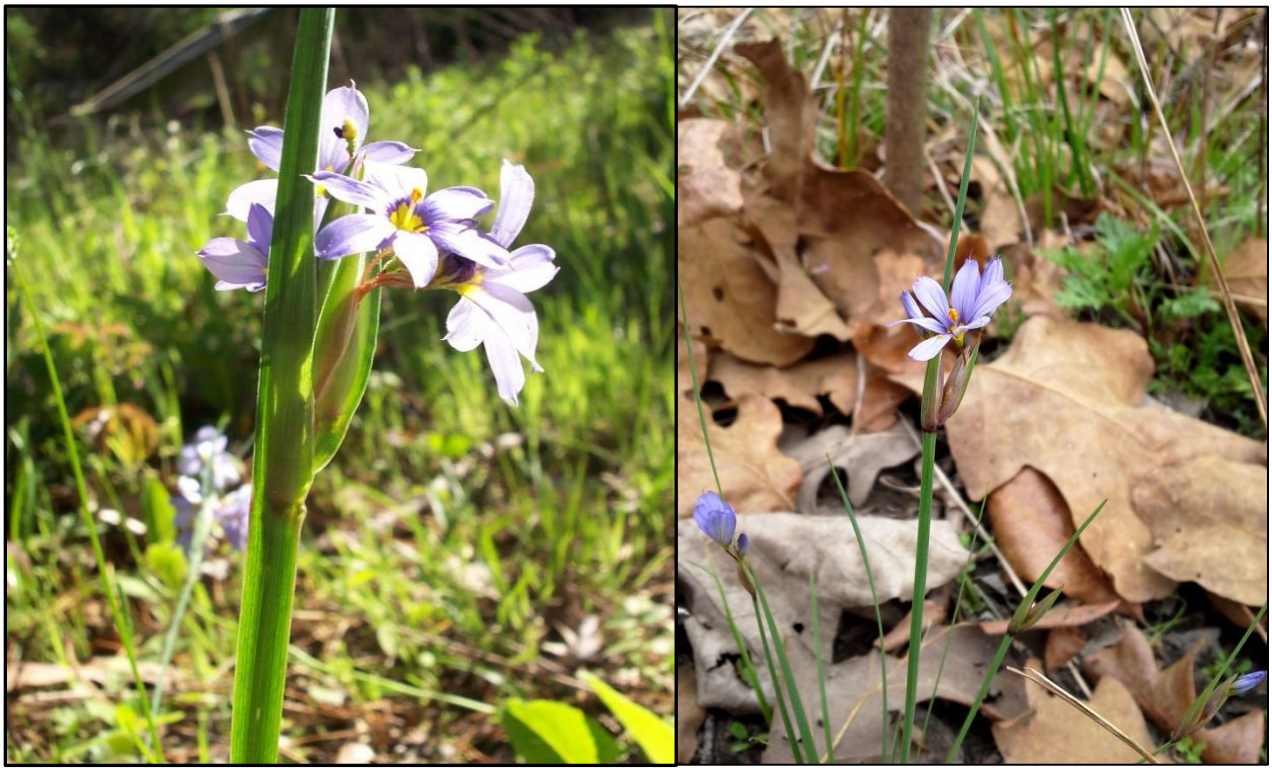


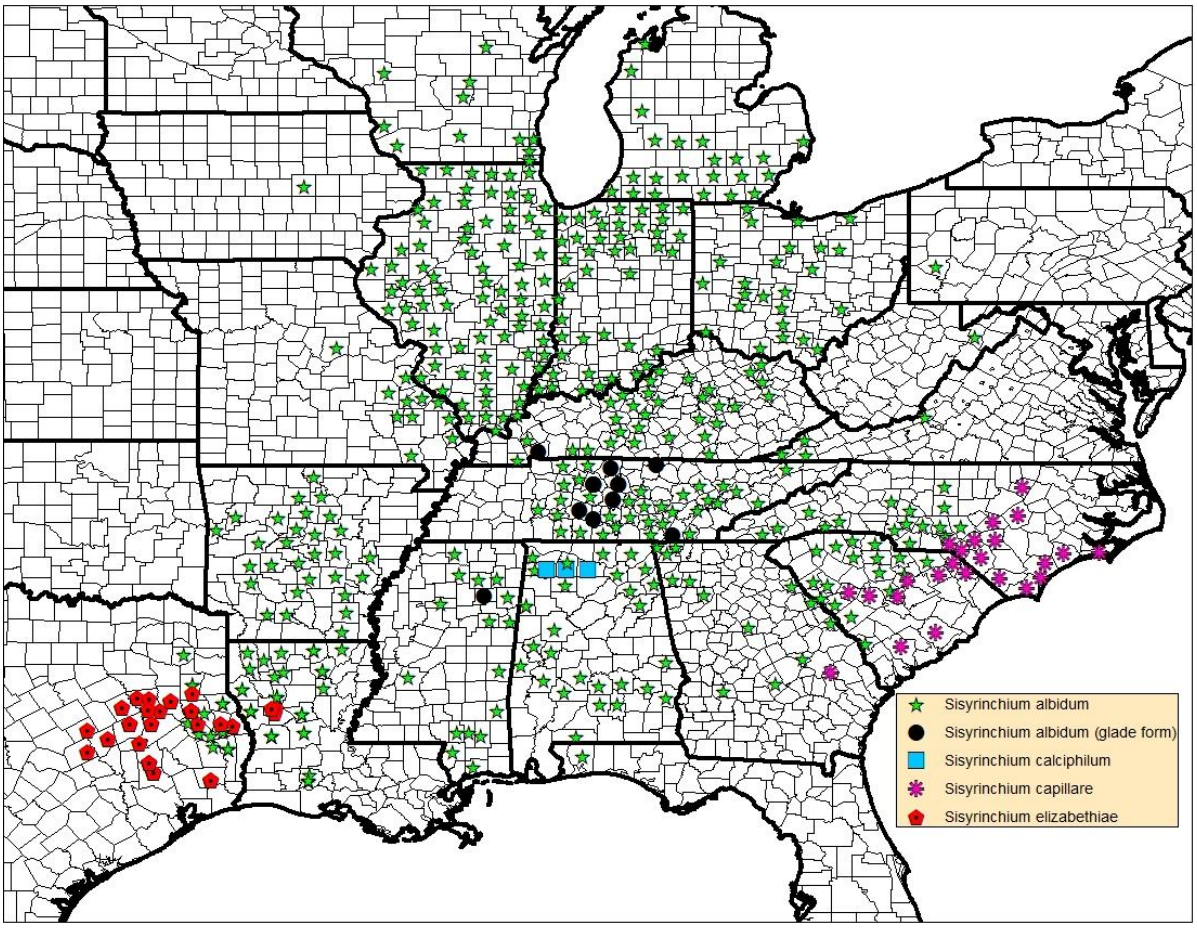
Figure 2. Comparison of inflorescences for *Sisyrinchium elizabethiae* (left) from Walker Co., Texas, and *S. albidum* (right) from Jasper Co., Texas.

Figure 3. *Sisyrinchium myrioflorum* from Duval Co., Texas. The type specimen was made from this plant.

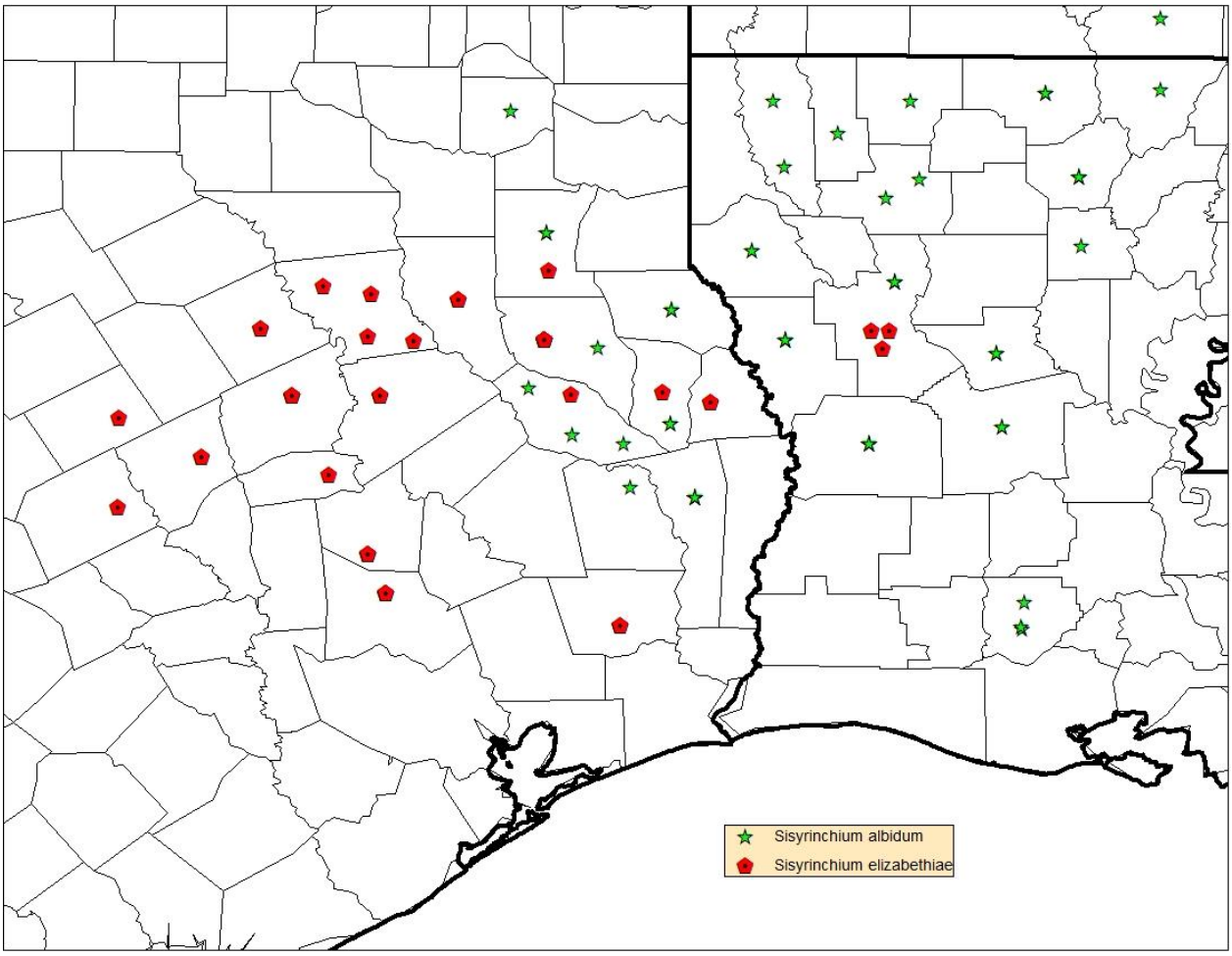
Figure 4. Roadside habitat with hundreds of plants of *Sisyrinchium myrioflorum* along Hwy 285 in Duval Co., Texas.

Figure 5. *Sisyrinchium helleri* from Colorado Co. (*Keith 1378*). Note sprawling habit and inner spathe longer than the outer (inset).

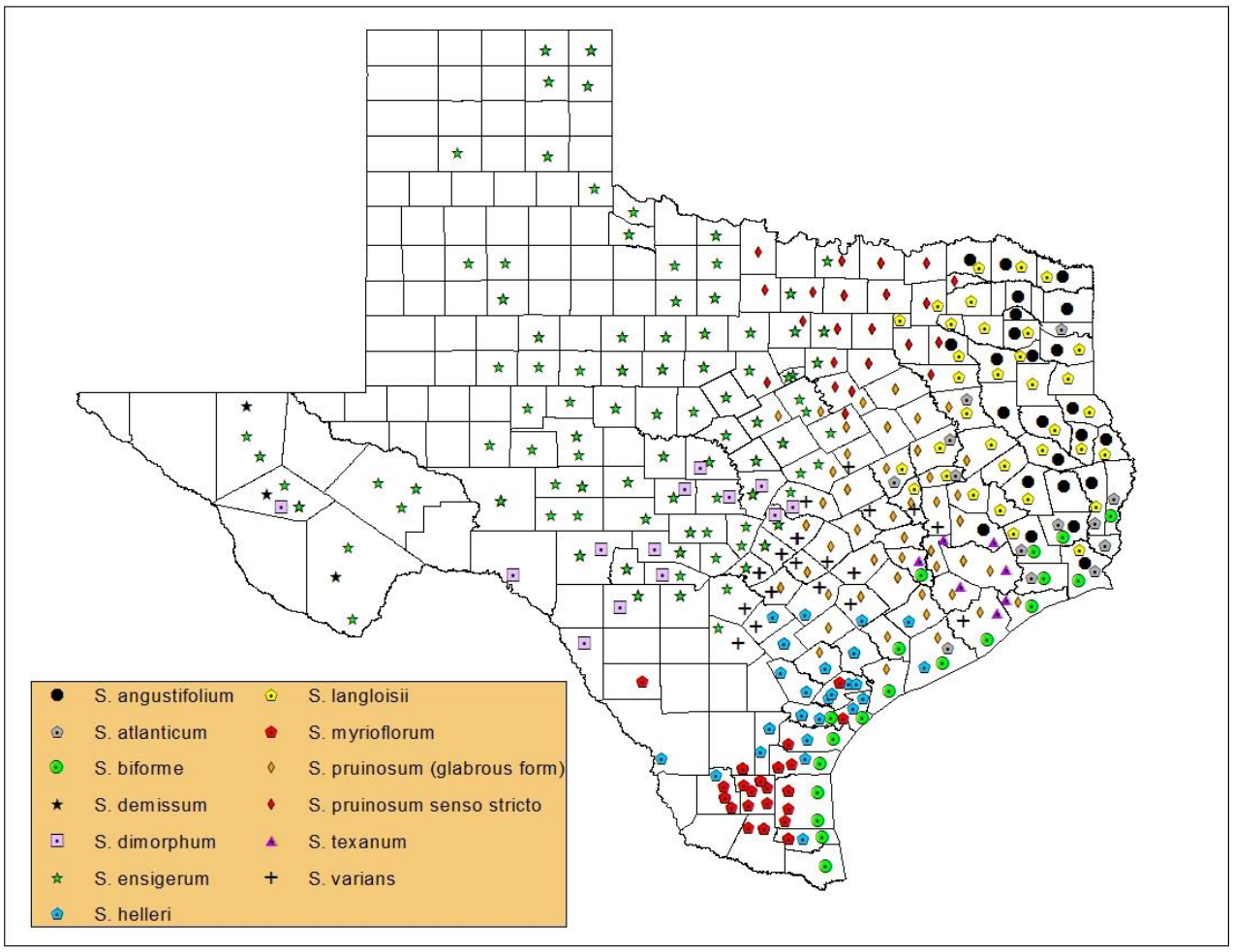
Figure 6. *Sisyrinchium varians* from Gonzales Co. (*Keith & Keith 991*). Note sprawling habit and wide leaves.



Map 1. County distribution of all species with paired spathes in the United States including *Sisyrinchium elizabethiae*, based on collections from ASTC, LSU, MERCA, SBSC, SHST, SMU-BRIT-VDB-NLU, SRSC, TAES, TAMU, and TEX-LL, digital type specimens (Torch Portal 2021), and map in Sorrie et al. (2012).



Map 2. County distribution of *Sisyrinchium elizabethiae* and *S. albidum* in Texas and Louisiana based on collections from ASTC, LSU, MERCA, SBSC, SHST, SMU-BRIT-VDB-NLU, SRSC, TAES, TAMU, TEX-LL, and digital type specimens (Torch Portal 2021).



Map 3. County distribution of perennial usually branched species of *Sisyrinchium* in Texas, including *Sisyrinchium myrioflorum*, based on collections from ASTC, LSU, MERCA, SBSC, SHST, SMU-BRIT-VDB-NLU, SRSC, TAES, TAMU, TEX-LL and digital type specimens (Torch Portal 2021).