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SOLIDAGO TURNERI, A NEW SPECIES OF GOLDENROD (ASTERACEAE: ASTEREAE) FROM THE BIG BEND AREA OF TEXAS

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ABSTRACT

A new species in *Solidago* subsect. *Triplinerviae* is described from a collection made in Presidio Co., Texas by Matt Turner and B.L. Turner — **Solidago turneri** Semple, **sp. nov.** Lengths and widths of 2389 mid stem leaves from 19 taxa in subsect. *Triplinerviae* were compared. In multivariate analyses of *S. altissima*, *S. juliae*, *S. lepida*, *S. pringlei*, and the new species, the new species was confirmed to have distinctive very narrow, oblanceolate stem leaves.

Solidago subsect. *Triplinerviae* (Torr. & Gray) Nesom includes 20 species of goldenrods with most species endemic to Canada, the USA, and Mexico. Although multiple species of the genus have been reported to occur in Presidio and Brewster counties in the Big Bend area of Texas, all collections examined can be assigned to just five taxa with one exception: **Solidago altissima var. pluricephala** M.C. Johnston (*Carr 34360* BRIT); **Solidago juliae** Nesom (*Butterwick & Strong 950* TEX, *Carr 20019* TEX, *Chiang et al. 9696* LL, *Correll & Johnston 24372* NY, *Correll 34121* LL, *Cory 31099* FSU, *Fisher 19* F, *Fisher 14759* BRIT, *Hinckley 1246* NY(2), *Hinckley 1969* TEX, *Hinckley 2240* NY annotated as *S. nemoralis* Ait. in 1979), *Lott et al. 5158* TEX, *Morey 169* SRSC); **Solidago lepida** var. **salebrosa** (Piper) Semple (*Robinson 5* TEX annotated as *S. gigantea* Ait in 1966 and 2001) of subsect. *Triplinerivae*; **Solidago velutina** DC. (*Correll & Correll 30543* BRIT and LL, *Hinckley 1969* BRIT and NY, *Hinckley 2621* NY) of subsect. *Radulae* Semple & J.B. Beck (Semple & Beck 2021); and **Solidago wrightii** A. Gray (*Hinckley 362* BRIT) of sect. *Thyrsiflorae* (A. Gray) A. Gray. The odd collection *M. Turner & B.L. Turner 23-181*, consisting of two herbarium sheets housed at TEX, was not readily assignable to any of these species but had long and very narrowly oblanceolate mid stem leaves. These latter specimens were borrowed from TEX-LL for detailed examination along with 12 collections from the two counties that were all samples of *S. juliae*. The *Turner 23-181* collection was cited as the voucher for a diploid count reported under the name *S. gigantea* Ait. (Powell & Turner 2005).

The identity of *Turner 23-181* (TEX 2; Figs. 1-3) was uncertain because the stems did not appear to be densely hairy like stems of *Solidago juliae* and *S. velutina*, the leaves were too narrow for *S. altissima* and nearly all collections of *S. lepida*, and the inflorescences were secund-conical and not like those of *S. wrightii*. Also, no complete shoot was present on either of the sheets of *Turner 23-181*; one herbarium sheet includes what appears to be portions of the stem and a robust inflorescence and the upper portion of a much smaller shoot with a small inflorescence (Fig. 1), while the second sheet includes a much younger large inflorescence with lower branches bearing immature heads and a portion of the mid stem of a shoot. It cannot be determined whether the pieces of stem come from two or three different shoots, nor can the total height of these shoots be determined. It seems likely that several shoots were harvested as samples of different height shoots and stages of floral development. I have observed robust shoots of plants of *S. lepida* in multiple locations throughout its range and it is common for a clone/population to include both robust and small shoots. Stems and leaves are glabrous or at most glabrate, but minute stipitate glands occur on peduncles, peduncular bracts, and margins of some involucral phyllaries. These latter traits are common in *S. lepida*

Figure 1. Holotype of *Solidago turneri*: *M. Turner & B.L. Turner 23-181* (TEX).

Figure 2. Isotype of *Solidago turneri*: *M. Turner & B.L. Turner 23-181* (TEX).

Figure 3. Details of the types of *Solidago turneri, M. Turner & B.L. Turner 23-181* TEX. **A-C.** Mid and upper stems of large shoot and upper stem of small shoot. **D.** Mid stem leaf, adaxial surface. **E**. Mid portion of mid stem leaf, abaxial surface. **F.** Upper stem leaf of small shoot, abaxial surface. **G.** Details of peduncle and bracts. **H.** Heads. **I.** Cypselae of disc and ray florets. Scale bars = 1 mm in A-C, E, G-H; 1 cm in D and F.

(Semple et al. 2016*)*, but glands are more easily observed in tetraploid and hexaploidy individuals. Lastly, the habitat given is "growing in water about Tinajas [sic] and in flowing streams." Tinajas are depressions in bedrock scoured out by gravel and sand. *Solidago lepida* is often found in wet soils and along stream banks. Thus, *Turner 23-181* (TEX) is more similar to *S. lepida* than other species of *Solidago* present in Presidio and Brewster counties, but it is also distinct from that species.

Multivariate Analyses

Multivariate comparisons were made using data on some 650 specimens representing all 20 known species of subsect. *Triplinerviae*. Multivariate analyses of 38 specimens of *Solidago altissima* var. *pluricephala*, 11 specimens of *S. juliae*, 70 specimens of *S. lepida*, 12 specimens of *S. pringlei*, and the two sheets of *S. turneri* were undertaken following the methods described in Semple et al. (2015, 2016). Two analyses were run. First, raw and mean values of mid stem leaf length to width ratios were determined and compared. Second, a STEWISE discrimiant analysis (SYSTAT 10. SPSS Inc. 2000) of *S. altissima* var. *pluricephala*, *S. juliae, S. lepida* (include both var. *lepida* and var. *salebrosa*), and *S. pringlei* was run with one specimen of *S. turneri* only included a posteriori. All traits scored are listed in Table 1.

Table 1. Traits scored for the multivariate analyses of 137 specimens of *Solidago* subsect. *Triplinerviae*.

Abbreviation	**Description of trait scored**
MLFLN	Mid leaf length measured from the leaf base to tip (mm)
MLFWD	Mid leaf width measured at the widest point (mm)
MLFWTOE	Mid leaf measured from the widest point to the end (mm)
MLFSER	Mid leaf dentation-number of serrations of mid leaf
ULFLN	Upper leaf length measured form the leaf base to tip (mm)
ULFWD	Upper leaf width measured at the widest point (mm)
ULFWTOE	Upper leaf measured from the widest point to the end (mm)
ULFSER	Upper leaf dentation-number of serrations of upper leaf
CAPL	Length of inflorescence (cm)
CAPW	Width of inflorescence (cm)
CAPLBRLN	Length of longest lower inflorescence branches (cm)
INVOLHT	Involucre height at anthesis (mm)
OPHYLL	Outer phyllary length (mm)
IPHYLL	Inner phyllary length (mm)
RAYNUM	Number of ray florets per head
RSTRAPLN	Ray strap length top of the corolla tube to the tip of the strap (mm)
RSTRAPWD	Ray strap width measured at the widest point (mm)
RACHLN	Ray floret ovary/fruit body length at anthesis (mm)
RPAPLN	Ray floret pappus length at anthesis (mm)
DCORLN	Disc floret corolla length from the base to tip of the corolla lobes (mm)
DLOBLN	Disc floret corolla lobe length lobe (mm)
DACHLN	Disc floret ovary/fruit body length at anthesis (mm)
DPAPLN	Disc floret pappus length at anthesis (mm)

Mean values of length to width ratios for 2389 mid stem leaves of 19 species and varieties in subsect. *Triplinerviae* and subsect. *Serotinae* (sensu Semple & Beck 2021) ranged from 5.5 times as long as wide (*Solidago elongata* native to the Pacific Northwest) to 13.2 times as long as wide (*S. pringlei* native to southern Coahuila and west-central Nuevo Leon) with a mean value of 7.63 times as long as wide for all 19 taxa. The mean ratio for leaves of *S. turneri* was 17.9 times as long as wide. Lengths and widths of individual leaves and means for individual specimens of the five taxa included in the STEPWISE analysis are shown in Fig 4.

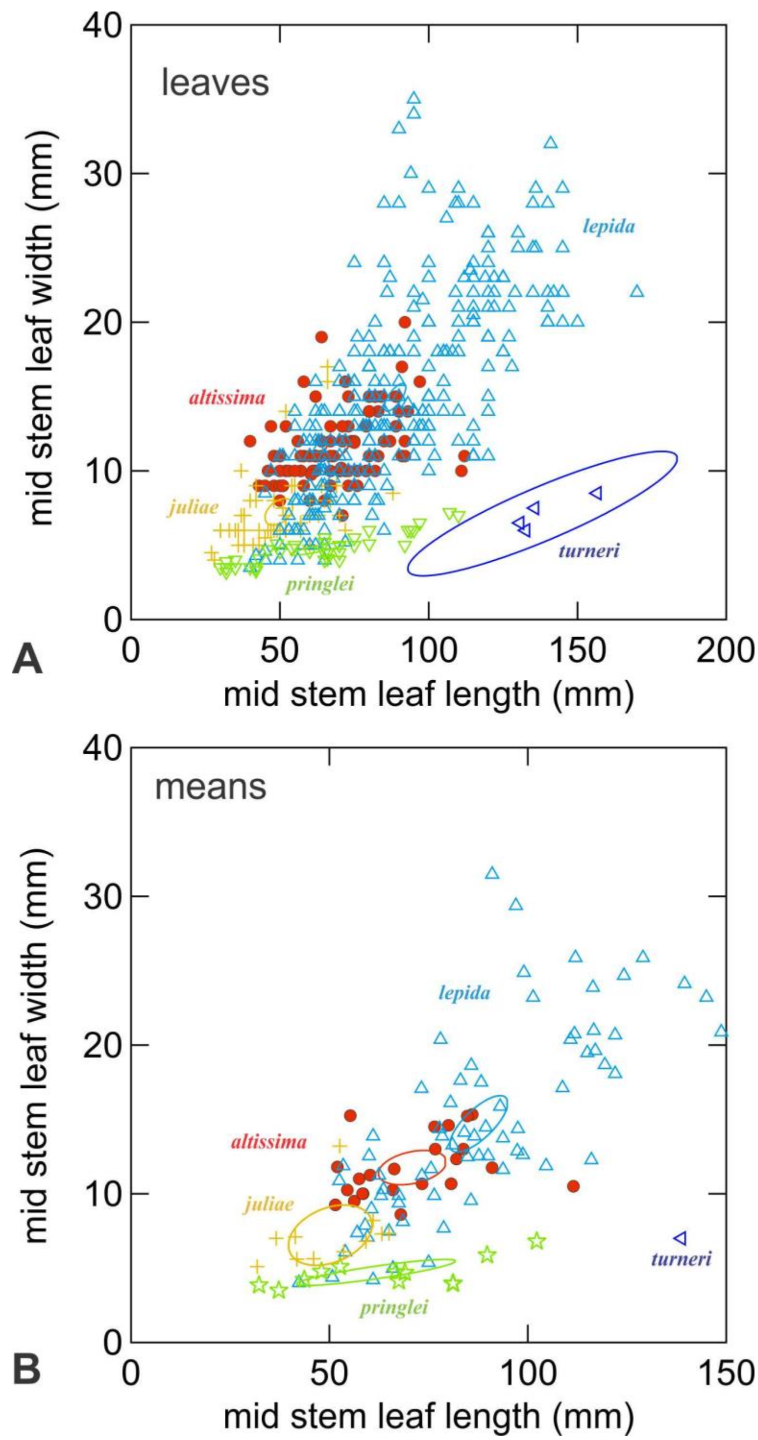

Figure 4. Two dimensional plots of mid stem leaf length versus width for individual leaves (A) and mean values for specimens (B) of *Solidago altissima* var. *pluricephala*, *S. juliae*, *S. lepida*, *S. pringlei*, and *S. turneri*. 95% confidence ellipses are show for each taxa.

The Pearson correlation matrix yielded r > |0.7| for most leaf traits and only mid stem leaf length, mid stem leaf number of serrations, and upper stem leaf width were included in the STEPWISE analysis. Ray and disc floret ovary/fruit body lengths at anthesis correlated highly and only the latter trait was included in the analysis. Involucre height, number of ray florets, ray floret lamina length, ray floret pappus length at anthesis, number of disc florets, disc floret corolla and lobe lengths were not highly correlated and were included in the STEPWISE analysis.

In a STEPWISE discriminant analysis of 110 specimens of four species level a priori groups (*Solidago altissima* var. *pluricephala*, *S. juliae*, *S. lepida*, and *S. pringlei*) the following 6 traits were selected and are listed in order of decreasing F-to-remove values: number ray florets (21.07), upper stem leaf width (14.70), number disc florets (13.22), disc floret corolla lobe length (11.71), ray floret pappus length at anthesis (10.83), and disc corolla length (9.93). Wilks's lambda, Pillai's trace, and Lawley-Hotelling trace tests of the null hypothesis that all groups were the samples of one group had probabilities of p = 0.000 that the null hypothesis was true. The F-matrix for the discriminant analysis is presented in Table 2. F-values based on Mahalanobis distances of the between group centroids indicated the largest separations were between *S. altissima* var. *pluricephala* and *S. pringlei* (22.959) and *S. altissima* var. *pluricephala* and *S. lepida* (20.479); the smallest separation was between *S. juliae* and *S. pringlei* (1.931).

Table 2. Between groups F-matrix for the four a priori groups in a STEPWISE analysis (df = 6 101).

Group	***altissima***	***juliae***	***lepida***
juliae	16.772		
lepida	20.479	15.262	
pringlei	22.959	1.931	15.184

Wilks' lambda = 0.1587 df = 6 3 106; Approx. F= 14.5729 df = 18 286 prob = 0.0000

In the Classificatory Discriminant Analysis of 110 specimens of the four species level a priori groups (*Solidago altissima* var. *pluricephala*, *S. juliae*, *S. lepida*, *S. pringlei*, and one specimen of *S. turneri* only included a posteriori), percents of correct a posterori assignment to the same a priori group ranged from 82-95%. The Classification matrix and Jackknife classification matrix are presented in Table 3. The single specimen of *S. turneri* was placed a posteriori into *S. lepida* with 37% probability (31% to *S. juliae*, 24% to *S. pringlei*, 8% to *S. altissima* var. *pluricephala*). Results for other taxa are presented in order of decreasing percents of correct placement. Twenty-one of 22 specimens of the *S. altissima* var. *pluricephala* a priori group (95%) were assigned a posteriori to the *S. altissima* var. *pluricephala* group; 16 specimens with 94-100% probability, 4 specimens with 84-89% probability, and 1 specimen with 66% probability. One specimen of the *S. altissima* var. *pluricephala* a priori group was assigned a posteriori to *S. lepida* with 50% probability (35% to *S. altissima* var. *pluricephala*, 10% to *S. juliae*, and 5% to *S. pringlei*; *Nesom et al. 7848* TEX from Natchitoches Par., Louisiana, $2n=18_{II}$). Fifty-nine of 66 specimens of the *S. lepida* (including both var. *lepida* and var. *salebrosa*) a priori group (89%) plus one specimen only included a posteriori were assigned a posteriori to the *S. lepida* group; 32 specimens with 90-100% probability; 8 specimens with 80-89% probability; 6 specimens with 71-79% probability; 5 specimens with 58% probability (16% to *S. pringlei*, 13% to *S. juliae*, and 12% to *S. altissima* var. *pluricephala*; *Semple & Brouillet 7078* WAT from Yakima Co., Washington; 2*n*=54), 55% probability (36% to *S. pringlei*, 10% to *S. juliae*; *Semple & Xiang 10329* WAT from Broadwater Co., Montana; 2*n*=54), 55% probability (20% to *S. pringlei* and 13% to *S. juliae*; *Eastham s.n.* UBC from British Columbia), 54% probability (33% to *S. juliae* and 11% to *S. altissima* var. pluricephala; *Semple & Brouillet 4306* WAT from W of Hinton, Alberta; 2*n*=54), 53% probability (30% to *S. altissima* var. *pluricephala* and

13% to *S. juliae*; *Semple & Brouillet 7066* WAT from Valley Co., Idaho; 2*n*=54), and 1 specimen with 42% probability (12% to *S. juliae* and 11% to *S pringlei*; *Lomer 6467* UBC from British Columbia). Eight specimens of the *S. lepida* a priori group with assigned to other species: 3 specimens to *S. altissima* var. *pluricephala* with 99% probability (*Semple & Brouillet 4326* WAT from Jasper N.P., Alberta; 2*n*=54), 69% probability (30% to *S. lepida*; *Semple & B. Semple 11451* WAT from New Brunswick; 2*n*=54), and 56% probability (23% to *S. lepida*, 17% to *S. juliae*; *Semple et al. 11167* WAT from Nahanni N.P.R., Northwest Territories; 2*n*=18); 4 specimens to *S. juliae* with 71% probability (*Semple et al. 11167* WAT from Nahanni N.P.R., Northwest Territories; 2^{nd} shoot on sheet, 2*n*=18), 63% probability (23% to *S. pringlei* and 12% to *S. lepida*; *Semple & Brouillet 7089* WAT from Klicktat Co., Washington; 2*n*= 54), 54% probability (42% to *S. pringlei* and 5% to *S. lepida*; *Semple et al. 11157* WAT from Nahanni N.P.R., North West Territories; 2*n*=18), and 37% probability (37% to *S. lepida* and 22% to *S. altissima* var. *pluricephala*; *Semple & Brouillet 7219* WAT from Teton Co., Wyoming; 2*n*= 18); and 1 specimen to *S. pringlei* with 44% probability (32% to *S. juliae* and 24% to *S. lepida*: *Semple & Brouillet 4381* WAT from Boundary Co., Idaho; 2*n*=18). Nine of the 11 specimens of the *S. pringlei* a priori group (82%) were assigned a posteriori to the *S. pringlei* group: 2 specimens with 97-98% probability, 3 specimens with 81-88% probability, 2 specimens with 77% and 70% probabilities, 1 specimen with 62% probability, and 1 specimen with 53% probability (46% to *S. juliae; Villareal 8366* TEX from Sierra la Gavia, southern Coahuila). Two specimens of the *S. pringlei* a priori group were assigned a posteriori to other species: 1 specimen to *S. lepida* with 59% probability (37% to *S. juliae*; *Mueller 2086* GH; this is the isotype of *S. muelleri* Standl. a synonym of *S. pringlei*) and 1 specimen to *S. juliae* with 54% probability (46% to *S. pringlei*; *Pringle 2886* GH from near Monterey, Nuevo León; this is the holotype of *S. pringlei*). Nine of the 11 specimens of the *S. juliae* a priori group (82%) were assigned a posteriori to the *S. juliae* group: 2 specimens with 95% and 92% probabilities, 2 specimens with 86% and 80% probabilities, 1 specimen with 74% probability, 2 specimens with 68% and 60% probabilities, 1 specimen with 57% probability (42% to *S. pringlei*; *Cory 50517* BRIT from W of Kerrville, Kerr Co., Texas) and 1 specimen with 46% probability (42% to *S. pringlei* and 9% to *S. lepida*; *Nesom 7520* BRIT from Kerr Co., Texas). Two specimens of the *S. juliae* a priori group was assigned a posteriori to *S. pringlei* with 62% probability (36% to *S. juliae*; *Nesom 7213* BRIT from Real Co., Texas; $2n=9_{II}$) and 58% probability (40% to *S. pringlei*; *Keeney 907* BRIT from Uvalde Co., Texas).

Two dimensional plots of CAN1 versus CAN3 and CAN1 versus CAN2 canonical scores for 111 specimens of *Solidago altissima* var. *pluricephala*, *S. juliae*, *S. lepida* , *S. pringlei*, and *S. turneri*) are presented in Fig. 5. Eigenvalues on the first three axes were 1.762, 01.144, and 0.064

Table 3. Linear and jackknife classification matrices from the Classificatory Discriminant Analysis of four a priori groups; a posteriori placements to groups in rows.

Group	***altissima***	***juliae***	***lepida***	***pringlei***	**% correct**
altissima	21	0	1	0	95
juliae	0	3	0	2	82
lepida	3	3	59	1	89
pringlei	0	1	1	9	82
Totals	24	13	61	12	89

Jackknifed classification matrix

Group	***altissima***	***juliae***	***lepida***	***pringlei***	**% correct**
altissima	21	0	1	0	95
juliae	0	8	0	3	73
lepida	5	3	55	3	83
pringlei	0	2	1	8	73
Totals	26	13	57	14	84

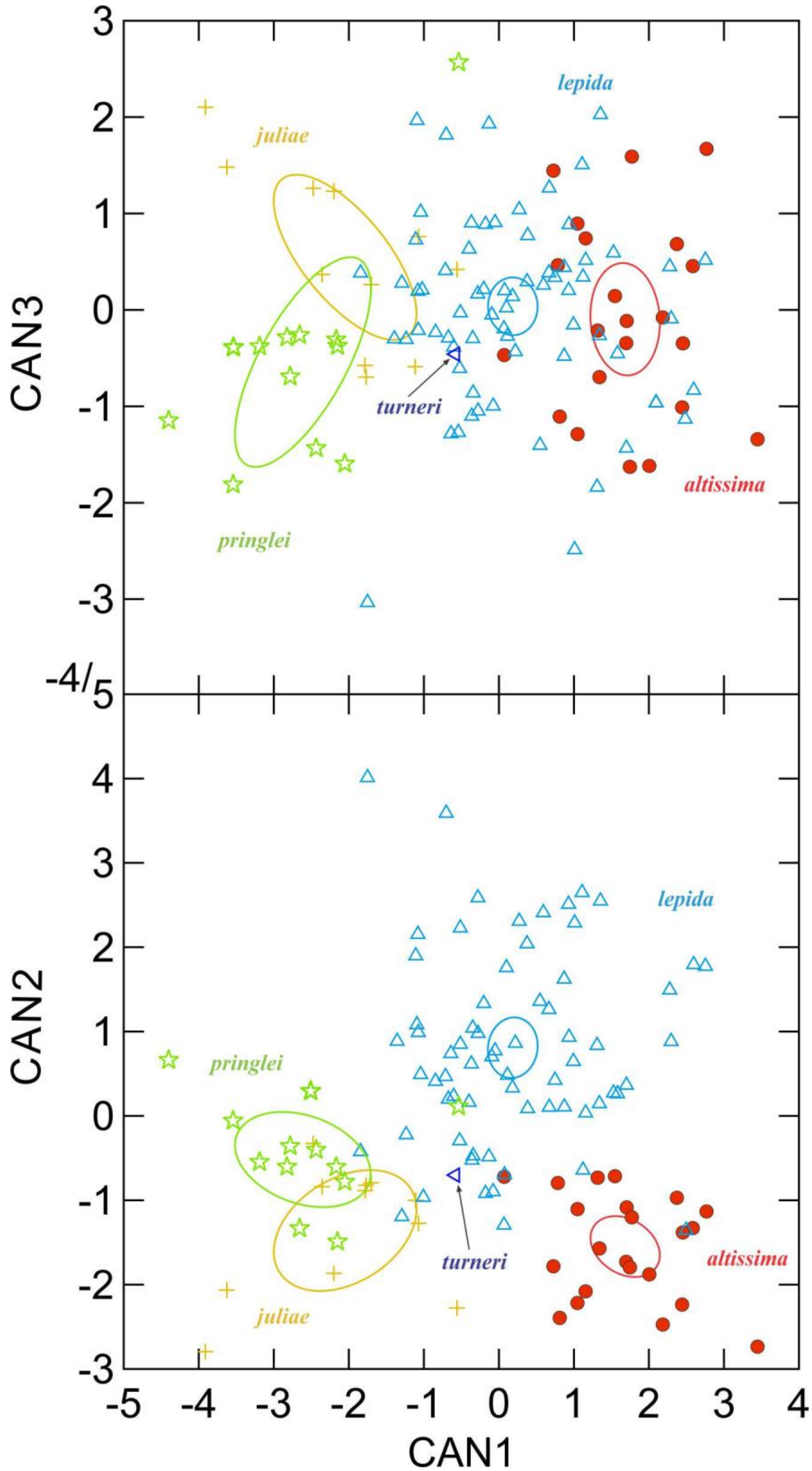

Figure 1. Plot of canonical scores (CAN1 vs CAN3 and CAN1 vs CAN2) for 111 specimens of *Solidago* subsect. *Triplinerviae*: *S. altissima* var. *pluricephala* (red dots), *S. juliae* (tan +s), *S. lepida* (light blue triangles), *S. pringlei* (open green stars), and *S. turneri* (dark blue left oriented triangles).

The results of the multivariate studies indicate that *Turner 23-181* does not fit well into any of the species of *Solidago* known to occur in Presidio Co., Texas. The narrow and very long mid stem leaves of *Turner 23-181* are significant outliers from all other leaf samples in both the plots of individual leaves and the plots of means for samples (Fig. 4). The widths of leaves of *S. juliae*, *S. pringlei*, and the narrowest of *S. lepida* are similar in width to those of *Turner 23-181*. The longest leaves of *S. lepida* are 2 to 4 times as wide as those of *Turner 23-181*. The small sample size of *Turner 23-181* like plants included in the STEPWISE discriminant analysis precluded treating *S. turneri* as a separate a priori group. *Turner 23-181* was not definitively placed a posteriori into any of the 4 a priori group species included in the analysis; 37% probability to *S. lepida*, 31% to *S. juliae*, 24% to *S. pringlei*, and 8% to *S. altissima* var. *pluricephala*. Some of the diploid samples of *S. lepida* from Idaho, Montana, British Columbia, and the Northwest Territories can be similar in general appearance to some collections of *S. pringlei*, but the low density or absence of lower stem hairs separates such plants and the narrow phyllaries distinguish these collections as *S. lepida* rather than as wildly disjunct samples of *S. pringlei*. *Turner 23-181* also has glabrous to glabrate stems and narrow phyllaries. *Solidago juliae* appears to be the most common member of subsect. *Triplinervae* in the Big Bend area of Texas, with infrequent occurrences of *S. altissima* var. *pluricephala* and *S. lepida*. To this short list of rare subsect. *Triplinerviae* taxa in the southern Trans Pecos a new species with *Turner & Turner 23-181* as the type is proposed.

SOLIDAGO TURNERI Semple, **sp. nov.** **TYPE**: **USA**. **Texas**. Presidio Co.: Ca. 2.2 mi NNE of Ruidosa in "Blumberg Canyon," growing in water about tinajas and in flowing stream, 30° 00' 45" N, 104° 44' W, 5 Jul 2003, *Matt Turner & B.L. Turner 23-181* (holotype: TEX; isotype: TEX). Figures 1-3.

Solidago turneri is similar to diploid *S. lepida* var. *salebrosa* but differs from it in having very narrow and very long midstem leaves.

Plant height and rhizome state unknown. **Stems** erect, mid stems glabrous or glabrate becoming very sparsely short villous-strigose distally and sparsely minutely stipitate-glandular. **Leaves**: lower stem leaves unknown; midstem leaves sessile, blades very narrowly oblanceolate, 130–160 mm long × 6–8.5 mm wide, tapering to sessile base, apices acute, glabrous on abaxial and adaxial surfaces, margins with 10 or more serrations, 0.5–1.5 mm long, sparsely short ciliate; upper stem leaves sessile, blades narrowly oblanceolate to linear-oblanceolate, 35–60 mm long × 2–3 mm wide, much reduced distally, vestiture like midstem leaves, margins entire, sparsely finely ciliate. **Heads** 30–300+, in narrow to broad apically secund conical arrays 8–26 cm tall × 2–16 cm wide, lower branches 2–20 cm long, usually diverging ascending-arching, heads secund on longest branches of large arrays, bracts, linear-lanceolate. **Peduncles** 2–10 mm, glabrate, sparsely minutely stipitate-glandular; bracteoles few, linear-lanceolate. **Involucres** likely cylindrical when fresh, but spreading distally when pressed, 2.5–3 mm tall. **Phyllaries** in 3–4 series, narrowly lanceolate, unequal (outer ca 1/3 length of inner), margins entire to slightly fimbriate distally, apices acute, sometimes with minute stipitate glands; central vein thicker proximally. **Ray florets** 7–9; laminae yellow 1.3–1.8 × 0.35–0.45 mm; ovary 0.5–0.6 mm at anthesis, sparsely moderately strigillose, pappus bristles ca. 2 mm at anthesis, longest not clavate, narrow, tapering. **Disc florets** yellow, 6–8; corollas 2.5–3 mm, lobes 0.4–0.6 mm; ovary (narrowly obconic) 0.5–0.6 mm at anthesis, sparsely to moderately strigillose; pappus bristles 25-30, 2.6–4 mm long, longest not clavate, tapering. **Mature cypselae**: fruit body 1.5–2 mm, pappus bristles ca. 2–3 mm long. **Chromosome number**: $2n$=18 (Powell & Turner 2005, as *S. gigantea*).

The species is currently known only from the type collection material, which is incomplete. The species is named for the collectors Matt and Billie Turner.

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