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A NEW SPECIES OF *EVOLVULUS* (CONVOLVULACEAE) FROM THE HIGH PLAINS OF THE TEXAS/NEW MEXICO BORDER

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ABSTRACT

Evolvulus arenarius Harms, **sp. nov**., is described here. It is endemic to the High Plains sands of the Texas/New Mexico border region from Winkler Co., Texas, and Eddy Co., New Mexico, in the south to Hartley Co., Texas, and Curry Co., New Mexico, in the north. In some of these areas the new species is sympatric with the related *E. nuttallianus*. Some 15 collections of *E. arenarius* exist in Texas and New Mexico herbaria, where it has been identified as either *E. sericeus* or *E. nuttallianus*.

EVOLVULUS ARENARIUS Harms, **sp. nov. TYPE: USA. Texas.** Winkler Co.: Waddell Ranch, ca. 11 mi ENE of Kermit, N of Texas Hwy 302, in deep sand among *Quercus havardii*, 2800 ft, 7 Jun 1950, *B.H. Warnock & J.O. Parks 8773* (holotype: TEX 00295128!; isotype: SRSC!). (Fig. 1)

Similar to *Evolvulus nuttallianus* Schult. in its pentastichous phyllotaxis, pinnate venation, vestiture consisting of thick hairs on both leaf surfaces, and lavender flowers at anthesis; different in its slender, open habit (Figs. 2, 3), leaves narrowly linear, with sparse vestiture, leaves with slightly denser pubescence on the upper surface, consisting of hairs more strongly asymmetrically forked (short branch <0.25 mm), flowers turning yellow with age, and ovate sepals. Similar to *E. sericeus* Sw. in its slender habit (Fig. 3), ovate sepals and flowers yellowing with age; differing in leaf orientation, phyllotaxis, venation, vestiture, and flower color at anthesis.

In the description below character states that differ significantly between *Evolvulus arenarius* and *E. nuttallianus* are highlighted in italic bold.

Perennial herbs. **Stems** ascending, 8–30 (43) cm long, 0.7–1.1 in diameter at the base, at mid stem 0.4–0.8 mm, branched at the base with limited branching above, also with ***long subterranean stems***. Phyllotaxis pentastichous 5/2 (Fig. 4). ***Foliage not dense, mid stem internodes 2–10 mm*** (67% > 4 mm in a sample of 30) (Figs. 5–7). **Leaves** oriented toward the branch tip from their base, margin entire, ***mid stem blades linear to narrowly elliptical***, 8–15.5 mm long, 0.8–1.4 mm wide, ***length/width ratio 1:8.1–1:12.2***, leaf apex acute, base cuneate, petiole < 1 mm if present and poorly differentiated, venation pinnate (visible only with clearing) with a strong midvein (Figs. 8–9). **Vestiture** of stems and leaves similar, consisting of ***sparse appressed hairs*** (Fig. 12), strongly tawny to silver-gray (even on the same leaf), aligned parallel with the midrib, ***denser on upper surface*** (Fig. 13), thick (not sericeus) and ***strongly asymmetrically forked*** (Figs. 14–16), stalkless, with two concentric basal cells (Fig. 18), slightly spreading and tapering from the connecting base to acute tips, ***the weak fork (0.08) 0.1–0.25 (0.3) mm long***, the strong fork (0.4) 0.6–1.5 mm long with max. hair width 19.6 µm; max. hair width at the base of the weak fork ca. 70% of that of the adjacent strong fork (Figs. 17–18). **Flowers** solitary at the nodes, primarily in central portions. **Peduncles** absent. **Pedicels** 1–4 mm at anthesis, lengthening and recurved in fruit. ***Outermost two sepals ovate*** with an acute tip, 3.1–4.1 mm long, ***±1 mm wide 1 mm from the base*** (Figs. 19-20), ***scant hairs on the distal inner surface***. **Corolla** rotate, 9.2–14 mm in diameter (in dried specimens), the lower tube ± 2.5 mm long; interplicae paler than plicae and pubescent on the outside distal half; corolla color in shades of

lavender at anthesis, paler in the throat, ***yellowing with age***, interplicae fading first (Figs. 21–22). **Filaments** to 3.2 mm long; anthers 0.7–0.9 mm long. Styles exceeding the anthers, with 2 branches 2–3 mm long. **Capsule** subglobose, tan, dehiscing by valves, circumscissile. **Seeds** dark brown, smooth, globose, ca. 0.8 mm in diameter.

Blooming from late May to early September (earliest collection 23 May, latest 2 Sep). In deep sand, grasslands, scrub (especially *Quercus havardii*). Endemic to the High Plains sands (Shinnery Sands & Rolling Sand Plains and immediately adjacent areas) of the Texas/New Mexico border from Winkler Co., Texas, and Eddy Co., New Mexico, in the south to Hartley Co., Texas, and Curry Co., New Mexico, in the north (Fig. 23).

Additional collections examined. **New Mexico**. Curry Co.: 18 mi NW of Melrose, 14 Jul 1951, *Clark s.n.* (NMU). Eddy Co.: Los Medanos Site near Carlsbad, 32.34805 -103.78270, 15 Jun 1978, *Marley s.n* (NMU); 0.5 mi N of James Ranch, 32.31909 -103.81690, 29 Jun 1978, *Marley, Knight, Martin, and Powell s.n* (NMU). Roosevelt Co.: Melrose Air Force Range, 2 mi due N of mesa top installation, 1.5 mi E of Krider Rd, Springer loamy fine sand, slope: 3 degrees, aspect: 15 degrees azimuth, elev. 1314 m, 14 Jun 1994, *Bleakly & DeBruin 546* (NMU); N of Causey, 31 Jul 1938, *Castetter 10693* (NMU); ENMU Natural History Preserve, elev. 4000 ft, 4 Aug 1971, *Secor 73* (TEX); Milnesand Prairie Preserve, W side of hwy pasture near natural gas well, grass dominated area, swale present dominated by *Eleocharis* sp., *Bouteloua hirsuta*, *B. curtipendula*, *Eragrostis curvula*, *Paronychia jamesii*, *Linum berlanderieri* associated, N33 40.654 W103 21.921, 26 Aug 2006, *Strahan 473* (NMCR); Parkinson Ranch, Milnesand, *Quercus havardii/Schizachyrium scoparium - Boutelous hirsuta* shrubland, UTM 663524 E 3722719 N NAD83 Zone 13, elev. 4100 ft, 7 Aug 2007, *Chauvin 07GC001-F34* (NMU). **Texas**. Andrews Co.: Survey site #1, dry sandy soil, 23 May 1962, *Adv. Bio. Class s.n.* (SRSC). Gaines Co.: 4 mi of Seminole, 10 Jul 1941, *Tharp s.n.* (TEX). Hartley Co.: 2 mi SW of Dalhart, red sand sage, 19 Jun 1936, *McMurry s.n.* (TEX). Winkler Co.: 10 mi E of Kermit on Hwy 302, infrequent in sandy soil, 4 Aug 1952, *McCullough 320* (SRSC); Waddell Ranch, E of Kermit, sparse among shinney deep sand, 7 Jun 1950, *Warnock & Parks 8773* (SRSC, TEX).

Although not seen, there is reason to believe that *K.W. & L. Allred 9437* (NMCR; Chaves Co., New Mexico), originally identified as *Evolvulus sericeus*, may also represent *E. arenarius*.

In late June I was able to visit Winkler and Andrews counties to search for *Evolvulus arenarius*. We did not have access to ranches or other sites in the area, so my daughter Kirsti and I started from the roadside along the Waddell Ranch some 10 miles east of Kermit, the site of Warnock's type collection and of *McCullough 320* (SRSC). We walked the roadside on two highways through the shinnery sands east of Kermit for the whole morning, but without luck. The area had been in extreme drought for over a year and only recently had some rains (Figs. 25–28).

Relevant *E. nuttallianus* specimens examined. **Colorado**. Baca Co.: Springfield, Two Buttes Cr. 14 mi N, 4300 ft., ***dry sandy soil*** in sun on hill top, prairie grassland, 9 Jun 1948, *Taylor 38* (TEX). Yuma Co.: J. Conrad property, N of Wray, 5.5 mi N of Hwy 34, 1 mi E of County rd BB, T2N R44W S7, 3800 ft, ***sand hills***, 8 Jun 1988, *Neely 5062* (TEX); ***sand hills*** due E of Arikaree River, 1.25 mi NE of Willow Creek Ranch, T1S R42W S27, 3450 ft., N-facing slope, ***sand hills***, 9 Jun 1988, *Neely 5081* (TEX); **New Mexico**. Eddy Co.: The Divide, 15-May-87, *Cockman 87-70* (NMC). Harding Co.: Black Hills at pass through hills on State Rd. 65 ca. 0.8 mi E of State Rd. 102, 35.83856ºN 103.66159ºW, elev. 4490 ft, ***sandy clay hill*** slope with basalt cobble, 24-Aug-08, *Sivinski 6969* (NMU). Lea Co.: Los Medanos, T22S, R32E sec 9 (SE 1/4) A-3 S edge of divide quarry area, elev. ca. 3800 ft, 15-Jun-78, *Marley, Knight, Martin, & Powell 1458* (NMU); Quay Co.: Tucumcari, roadside, elev. 4200 ft, 20-Jun-31, *Castetter 7362* (NMU). Roosevelt Co.: Melrose Air Force Range, 2

mi due N of mesa top installation, 1.5 mi E of Krider Rd, ***Springer loamy fine sand***, slope: 3 degrees, aspect: 15 degrees azimuth, elev. 1314 m, 3 May 1993, *Bleakly* & *DeBruin 12* (NMU); ENMU Natural History Preserve, Portales (Bouteloua-Buchloe Grassland), elev. 4000 ft, 8 May 1970, *Secor 12* (TEX); ENMU Natural History Preserve, Portales (short-grass prairie), ***sandy soil***, elev. 4000 ft, 19 May 1973, *Secor 14* (TEX). **Texas**. Andrews Co.: city of Andrews, common on vacant lots, 20 May 1962, *Adv. Bio. Class s.n.* (SRSC). Bailey Co.: near Muleshoe, 14 Jun 1929, *B.C. Tharp s.n.* (TEX). Cochran Co.: ca. 2 mi N of Bledsoe along hwy 595, ***red sandy soils***, 16 May 2000, *B.L. Turner & M. Turner 20-238* (TEX); ca. 2 mi N of Bledsoe along hwy 595, ***red sandy soils***, 16 May 2000, *B.L. Turner & M. Turner 20-238* (TEX). Crockett Co.: Hwy 163 3 1/2 mi N of Ozona in the NE part of the county, elev. 2300 ft, 21 Apr 1964, *Read 599* (SRSC). Culberson Co.: McKittrick Canyon, Guadalupe Mountains, elev. 6500 ft, 22 May 73, *Warnock 21506* (SRSC); Manzanita Spring, Guadalupe Natl. Park, 519065 E 3530637 N NAD83 Zone 13, elev. 5571 ft, aspect 115, slope 5%, rock type limestone, *Juniperus pinchotii*/*Muhlenbergia setifolia* shrubland, 26 Aug 2006, *Chauvin 06YC198-FS* (NMU); eastern foothills of Guadalupe Mts., 3 mi E of Nickel Creek, 15 Jul 1945, *Muller 8255* (LL). Dallam Co.: Rte. 1879, 6-10 mi S of Rte. 296, dry roadside ***on dune sand***, 8 Jul 1963, *Correll & Ogden 28390* (TEX). Donley Co.: Conchas Dam, Davis Mountains, elev. 4000 ft, 2 Jun 1957, *Correll 16576* (LL). Hudspeth Co.: head of Victoria Canyon, Sierra Diablo, at T.A. Beards lodge, elev. 3500 ft, on limestone soil, infrequent, 18 Aug 1953, *Warnock 11426* (SRSC); **Utah**. Kane Co.: ***very sandy soil around the edge of big sand dune*** 1.5 mi E of the Paria River and 12 mi W of Glen Canyon City, 45 mi E of Kanab, Twp. 43 W, R 1 W, S 2, elev. ca. 4500 ft, plants deep-rooted, and also with slender, creeping roots, flowers lavender, 23 May 1965, *Cronquist 10174* (TEX).

Relevant *E. sericeus* specimens examined. **New Mexico**. Catron Co.: Apache National Forest, Saddle Mountain region, next to bridge that crosses Pueblo Creek near the campground, N33d35.51' W108d57.74', 7 Aug 2001, *Johnson 604* (NMCR). Eddy Co.: Queen, elev. 5900 ft., 1 Aug 1909, *Wooton s.n.* (NMC); Dark Canyon along FSR 69, 2.8 air mi E of Klondyke Gap, 32º 07.359' N 104º 43.283' W, 5850 ft., 10 Jul 2010, *Worthington 36166* (SRSC). San Miguel Co.: Las Vegas, 13 Mar 1905, *Cockerell s.n.* (NMC); Conchas Dam E of north campground, elev. 4000 ft., 12 Nov 1965, *Broeske MO-6* (NMU); Conchas Dam, Davis Mountains, elev. 4000 ft., 12 Nov 1965, *Broeske MO-65* (NMU). **Texas**. Jeff Davis Co.: jct of Goat and Merrill Canyons about 5 mi SW of Mt. Livermore, elev. ca. 5500 ft, on dry exposed gentle slopes, 30 Jul 1935, *Hinckley 234* (LL).

The contrasts below distinguish *Evolvulus arenarius* from *E. nuttallianus* and *E. sericeus* in trans-Pecos Texas and New Mexico. All three can have hairs on both leaf surfaces, but forms of *E. sericeus* may have the upper surface glabrous.

1. Leaves spreading, upper leaves often falcate and conduplicate (may be pressed flat when mounted); phyllotaxis distichous; venation palmatipinnate (one or more pairs of secondary veins from the base parallel to the leaf margin to the midpoint of the leaf or higher; pinnate secondaries only above the midpoint); hairs fine (sericeous) ..... **Evolvulus sericeus**
1. Leaves erect and typically bent upward at attachment, upper leaves typically flat or broadly u-shaped; phyllotaxis pentastichous 5/2; venation pinnate; hairs stout.

    2. Foliage sparse with internodes commonly > 4 mm; mid leaves linear, length/width ratio > 8:1; hair strongly asymmetrical with weak forks < 0.25 mm long; hairs denser on upper surface; outermost sepals ovate; corolla yellowing with age ..... **Evolvulus arenarius**
    2. Foliage dense with internodes rarely > 4 mm; mid leaves elliptical, length/width ratio < 8:1; hair weakly asymmetrical with weak forks > 0.25 mm long; hairs denser on lower surface; outermost sepals lanceolate; corolla not turning yellow with age ..... **Evolvulus nuttallianus**

The new species has been confused with both *Evolvulus sericeus*, especially due to the narrow leaves and open habit, and *E. nuttallianus*, which shares with *E. arenarius* several critical character states not found in *E. sericeus*, as outlined in the diagnosis above. While the new species has some character states of each of these two species, the possibility that it represents a hybrid seems remote on morphological, ecological, and distributional grounds. Hair type in *E. arenarius* (Fig. 15) is different from either of the other two species and in no way intermediate. The new species is restricted to deep sands, not a habitat "intermediate" between that of the other two species, and through most of its range it is sympatric with only *E. nuttallianus*.

The possibility that *Evolvulus arenarius* is an environmentally triggered form (or variety) of *E. nuttallianus* was seriously considered. It has clearly adapted to its deep sand ecology, with longer internodes and long subterranean stems. And it shares the venation and phyllotaxis of *E. nuttallianus*, which suggests a close relationship.

On the other hand, it is sympatric with *Evolvulus nuttallianus* in the same deep sand environments and locales; e.g., *Bleakly & DeBruin 546 & 12* (NMU) represent both taxa at the same location in Roosevelt Co., New Mexico, with the ecological information "soil: Springer loamy fine sand, slope: 3 degrees" (Fig. 2); similarly *Secor 73 & 12* (TEX), at the ENMU Natural History Preserve in Roosevelt Co. (Fig. 3), and Robert Strahan's collection at Milnesand Prarie (*473*) is matched with his photograph of *E. nuttallianus* from that site (Strahan 2008). Sand and dune collections of *E. nuttallianus* were examined for all sites for which collections were available; e.g., "Sand hills due E of Arikaree River", Yuma Co., Colorado, *Neely 5081* (TEX) and "Very sandy soil around the edge of big sand dune," Kane Co., Utah, *Cronquist 10174* (TEX). All of these specimens have typical *E. nuttallianus* features, contrasting with *E. arenarius*.

Where they are sympatric and both have been collected by the same person, they have been identified as different taxa, reflecting a sense that they are not the same, with *E. arenarius* being labeled *E. sericeus*, the only other option in available *Evolvulus* keys. In general, the type specimens and 5 others were originally determined as *E. nuttallianus*, while 7 other specimens were identified as *E. sericeus*. The labels on several indicate some hesitance in assigning a species epithet (Fig. 24).

Features not shared with *Evolvulus nuttallianus* that cannot easily be attributed to environmental forces are (1) ovate outer sepals, (2) corolla turning yellowish with age, (3) overall sparse pubescence, with denser hairs on the upper leaf surface, and (4) the strong reduction in trichome length of the weak fork.

Sepal differences have played a significant role in distinguishing *Evolvulus sericeus* and *E. nuttallianus*, from Nuttall's 1818 description of *E. pilosus* Nutt. (an illegitimate name for *E. nuttallianus* Schult.) to the present. Van Ooststroom's 1934 monograph (pp. 101–103) distinguishes *E. pilosus* (i.e., *E. nuttallianus*) as having lanceolate or narrow-lanceolate sepals; *E. sericeus* with narrow-oblong-lanceolate to oblong-lanceolate sepals. The five sepals of *Evolvulus* are quite different in overall form (equal to subequal only if length is considered). Only the outermost two sepals show the critical form for distinguishing taxa. Determining sepal morphology with pressed, mounted specimens can be challenging but an outer sepal can generally be found.

Leaf venation

Leaf venation in *Evolulus* presents useful taxonomic characters, but its study and use is complicated by two factors. First, *Evolvulus* leaves are characterized by low (1r) "leaf rank", as defined by the Leaf Architecture Working Group (1999). This means that the level of organization of the leaf venation is relatively low, with vein course and other characteristics often more or less irregular, and the petiole (as is the case in *Evolvulus*) often not strongly differentiated from the

lamina. Differences in venation between species, when they exist, are thus more on the level of tendencies than absolute differences, and details can vary from leaf to leaf.

Secondly, leaf venation in the *Evolvulus* species under study here is often not easily determined, especially when obscured by pubescence. It was studied in two ways: (1) leaf clearing and (2) shining a bright light through a rehydrated or fresh leaf, using a slide scanner. Samples of *E. arenarius*, *E. nuttallianus*, and ***E. sericeus*** leaves were cleared using a 1% aqueous solution of basic fuchsin to which 10 gm of solid NaOH had been added. The leaves were then processed for mounting on slides with Permount. Detailed venation patterns were then photographed using a dissecting microscope with SPOT 4.6 software. Both *E. nuttallianus* (Fig. 10) and *E. arenarius* (Fig. 8) showed pinnate venation. With *E. sericeus* venation was palmatipinnate (Figs. 9, 11) — one or more pairs of secondary veins from the base parallel to the leaf margin to the midpoint of the leaf or higher; pinnate secondaries only above the midpoint. These studies will be detailed in a separate publication.

Rehydrated leaves were also imaged as 'transparencies' using an Epson Perfection flatbed slide scanner. Leaves of *Evolvulus sericeus* have relatively good light transmittance, revealing secondary veins, even for the narrowest (ca. 1.5 mm wide) leaves (Fig. 11G-H). Both *E. nuttallianus* (Fig. 10C-D) and *E. arenarius* have very weak light transmittance, with secondary veins not clearly visible.

Hair morphology

A study of *Evolvulus* hair morphology seemed appropriate in view of the distinctive vestiture of *E. arenarius* collections. With a dissecting microscope at higher magnification, entire individual trichomes are readily discerned (unlike the 'spagettiform' vestiture of *E. nuttallianus*), and the fork asymmetry is apparent, although the slightly erect angle of the very short weak fork often made it difficult to see. To examine the hairs in more detail one leaf was taken from TEX/LL and SRSC specimens from Roosevelt Co., New Mexico, Winkler Co., Texas, Andrews Co., Tesax, Gaines Co., Texas, and Yuma Co., Colorado. Two approaches were applied: (1) extracted trichomes were viewed with light microscopes and (2) small leaf samples were scanned by SEM.

For light microscope examination a sampling of hairs was scraped off both surfaces with a sharp razor into a drop of water containing a small amount of Aerosol OT Solution as wetting agent onto a glass slide and then covered with a cover glass. These were immediately photographed with a dissecting microscope. This procedure was applied to leaves of (1) *Evolvulus arenarius* from Winkler Co., Texas, Gaines Co., Texas, and Roosevelt Co., New Mexico; (2) *E. nuttallianus* from Roosevelt Co., New Mexico, Donley Co., Texas, and Culberson Co., Texas; and (3) with *E. sericeus* leaves from various collections in the Davis Mountains, the closest area in Texas for which they were available. With *E. sericeus* I examined hairs from specimens with a glabrous upper surface and from those with hairs on both surfaces. Only with *E. sericeus* were the hairs found to be different on the two surfaces.

SEM images were made for a limited selection for *Evolvulus arenarius* (Winkler Co., Texas, TYPE), *E. nuttallianus*, Culberson Co., Texas, and *E. sericeus*, Jeff Davis Co., Texas. Small leaf sections (±1 mm) mounted on aluminum stubs were sputter coated with platinum. Scans were made at 800x for hair arrangement and density and at 2000x & 6000x with 45º tilt to show trichome base features *in situ* (not possible with scraped hairs).

Evolvulus nuttallianus in the sand areas has strong fork lengths and asymmetrical trichome widths similar to *E. arenarius*, but with longer weak forks commonly having max. lengths to 0.5 mm long. For *E. sericeus* the hairs were typically narrower and both forks longer — but width at the base does not permit distinguishing a weak and strong fork even when the widths differ (Fig. 15).

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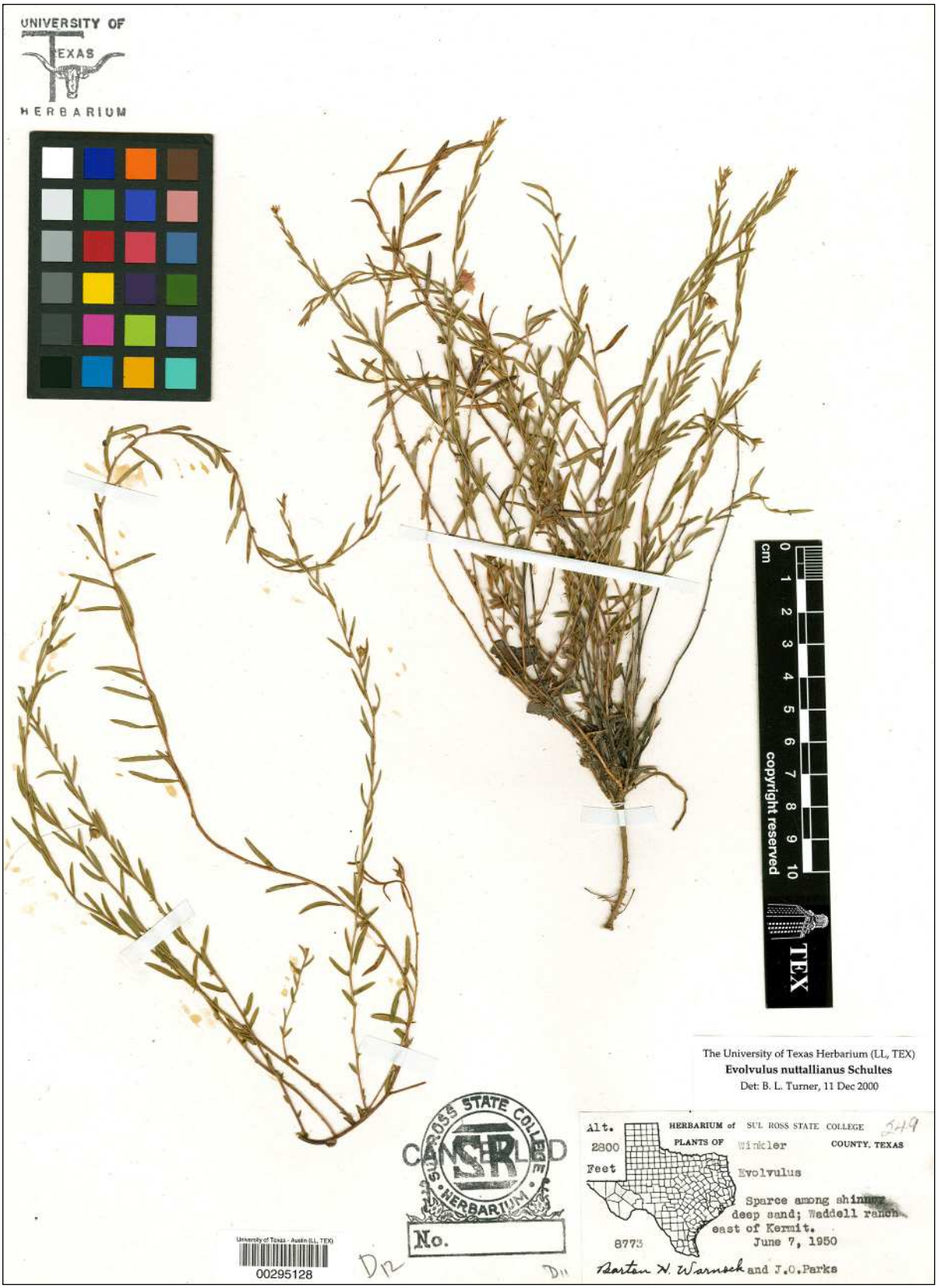

Figure 1. *Evolvulus arenarius*, holotype.

Figure 2. *Evolvulus arenarius, Bleakly & DeBruin 546* (NMU) (left) and *E. nuttallianus. Bleakly & DeBruin 12* (NMU), both in "Springer loamy fine sand" at Melrose Air Force Range in Roosevelt Co., New Mexico.

Figure 3. Left: *Evolvulus arenarius, Secor 73* (TEX), Mid: *E. nuttallianus. Secor 12* (TEX), both from ENMU Natural History Preserve in Roosevelt Co., New Mexico; Right: *E. sericeus, Worthington 36166* (SRSC), Eddy Co., New Mexico. Eddy is the only county with *E. arenarius* as well as *E. sericeus* collections, the latter from the Guadalupe Mts. in the SW corner.

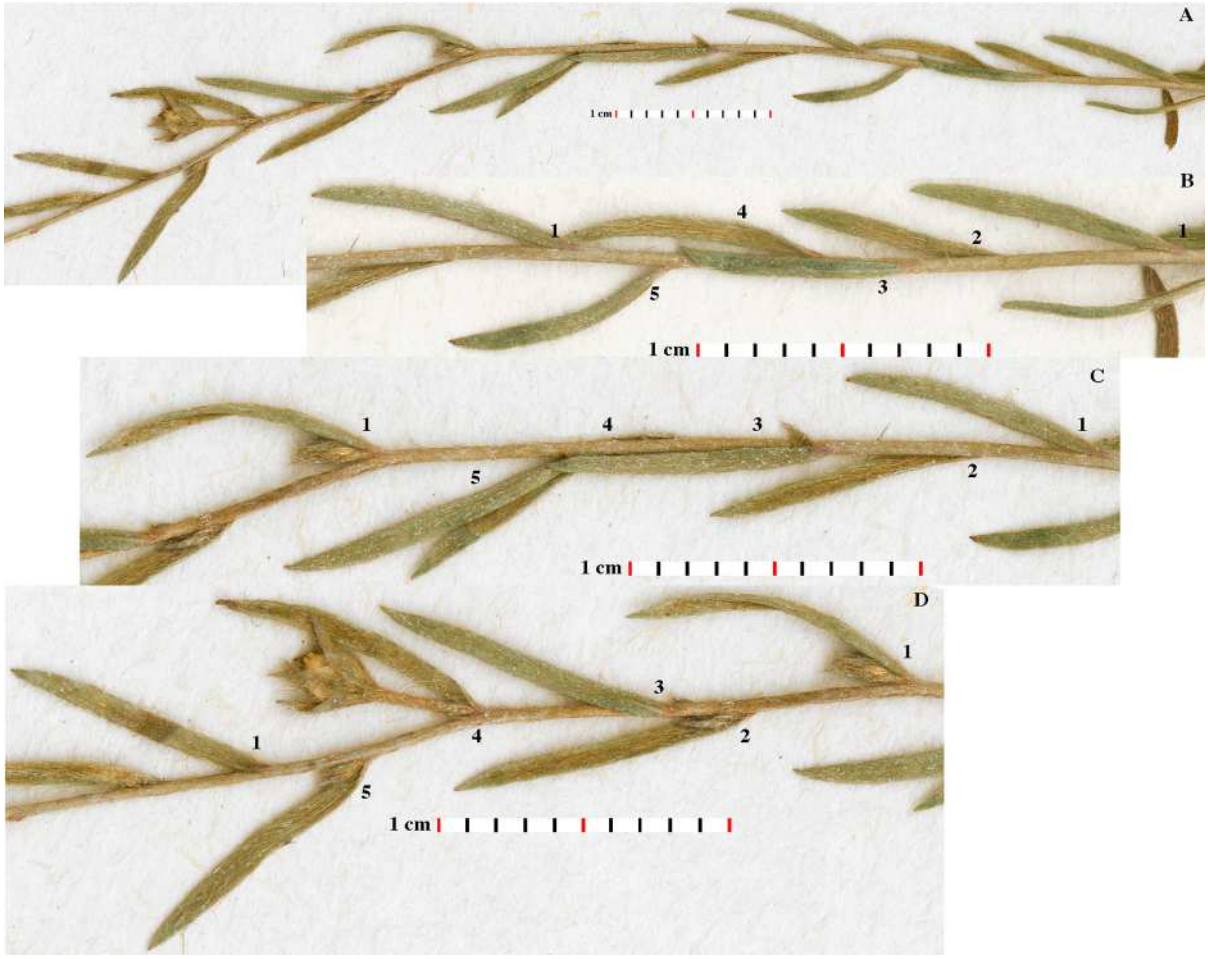

Figure 4. *Evolvulus arenarius*. Pentastichous 5/2 leaf arrangement, with leaf orientation toward the stem apex. View A [top] consists of the segments D, C, B, read bottom up. *Warnock & Parks 8773* (TEX).

Figure 5. *Evolvulus arenarius*. 5 cm section of mid leaves of *Warnock & Parks 8773* (TEX)

Figure 6. *Evolvulus arenarius*. 5 cm section of mid leaves of *Bleakly & DeBruin 546* (NMU, Roosevelt Co., New Mexico) ["Soil: Springer loamy fine sand"]

Figure 7. *Evolvulus nuttallianus.* 5 cm section of mid leaves of *Bleakly & DeBruin 12* (NMU, Roosevelt Co., New Mexico) ["Soil: Springer loamy fine sand"]

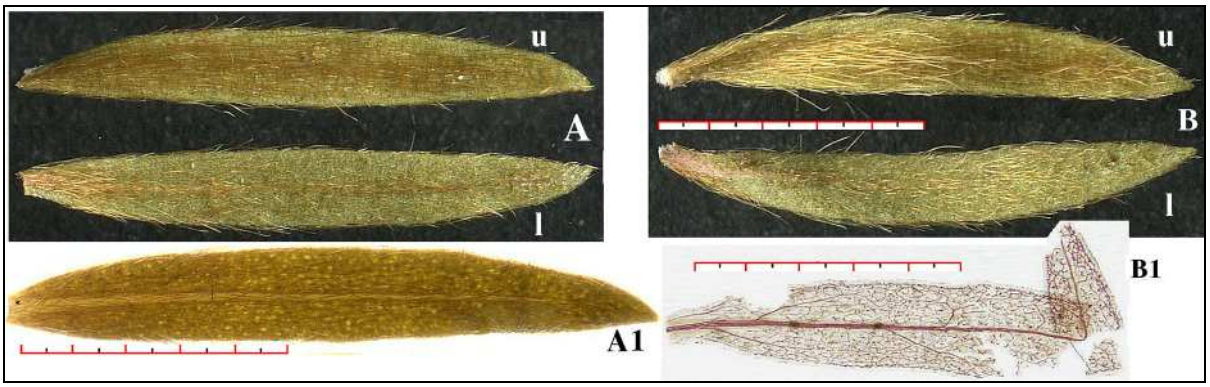

Figure 8. *Evolvulus arenarius.* A: leaf 1; u: upper surface; l: lower surface; A1: leaf 1 rehydrated for transparency scanning of venation; B: leaf 2; B1: leaf 2 venation after clearing & staining. *Warnock & Parks 8773* (TEX).

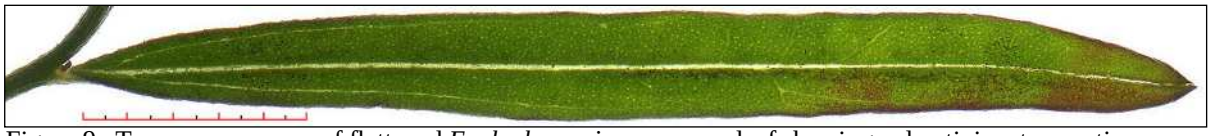

Figure 9. Transparency scan of flattened *Evolvulus sericeus* narrow leaf showing palmatipinnate venation.

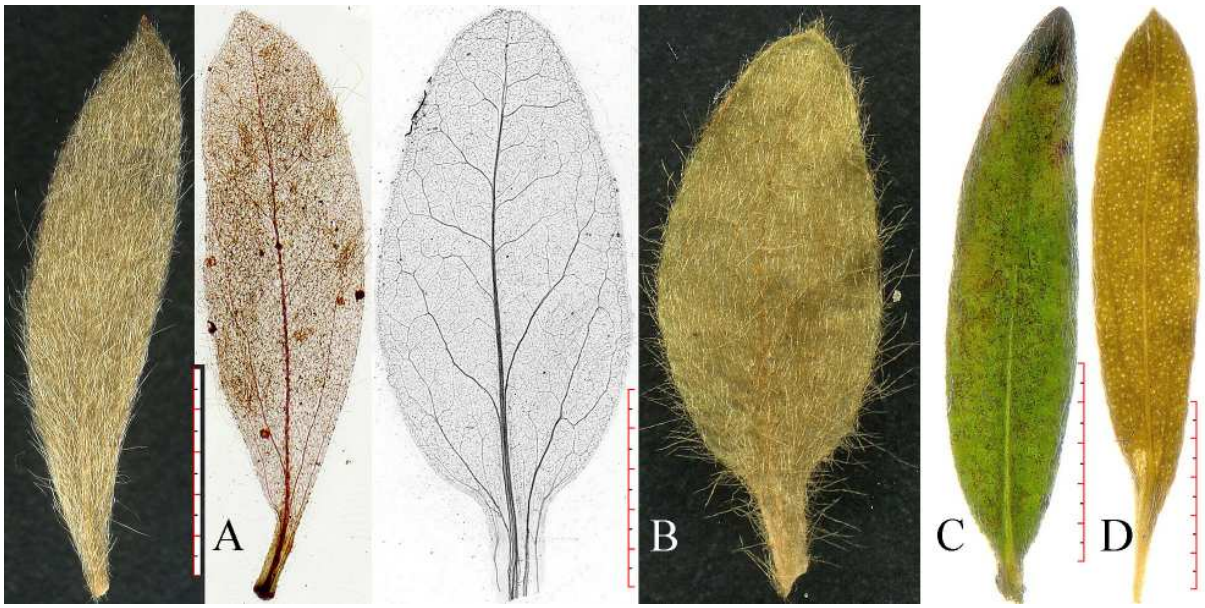

Figure 10. *Evolvulus nuttallianus.* A-B: Leaf clearings showing pinnate venation; A: Culberson Co., Texas, *Muller 8255* (LL); B: Kane Co., Utah, *Cronquist 10174* (TEX); C-D: Transparency scans; C: fresh leaf, Hays Co., Texas; D: rehydrated leaf, Dallas Co., Texas, *Lundell & Lundell 10618* (LL).

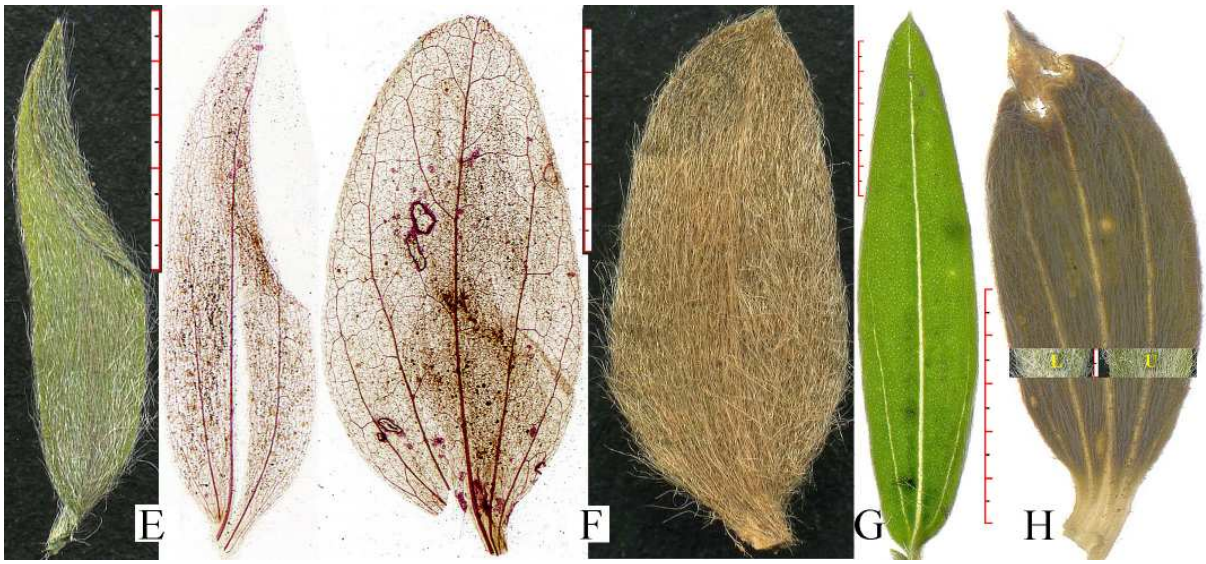

Figure 11. *Evolvulus sericeus.* E-F: Leaf clearings showing palmatipinnate venation; E: Jeff Davis, Co., Texas, *Harms et al. 109* (TEX); F: Brewster Co., Texas, *Warnock 21472* (TEX); G-H: Transparency scans; G: fresh leaf, Hays Co., Texas; H: rehydrated, with insert showing dense hairs of 1 mm section of lower surface (L) & upper surface (U), Presidio Co., Texas, *Carr 31161* (TEX).

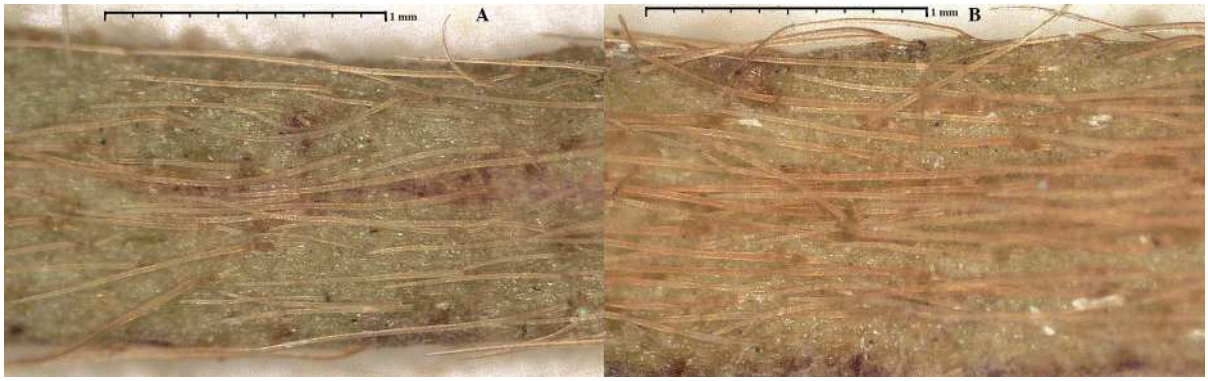

Figure12. *Evolvulus arenarius* pubescence detail. A: lower surface; B: upper surface. *Warnock & Parks 8773* (TEX).

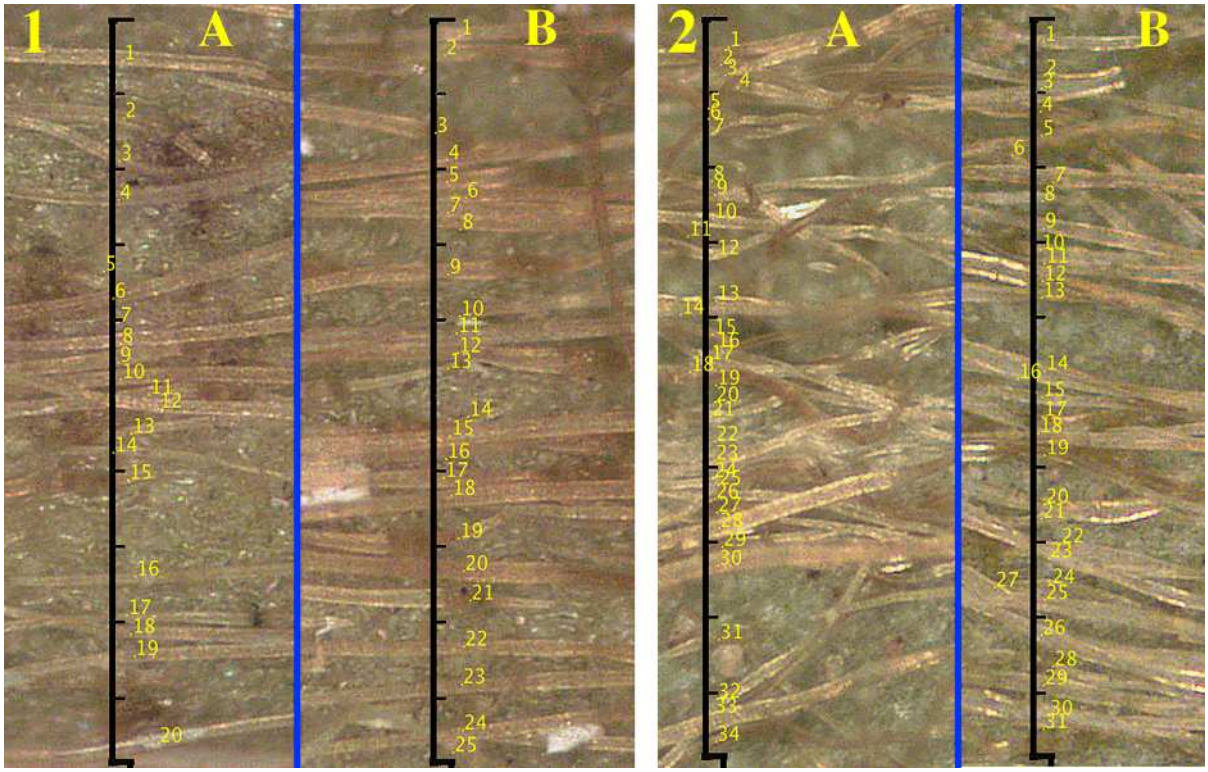

Figure 13. Hair counts for 1 mm. 1. *Evolvulus arenarius* (Type; Winkler Co.), 2. *E. nuttallianus* (Roosevelt Co.); A. Lower surface, B. Upper surface.

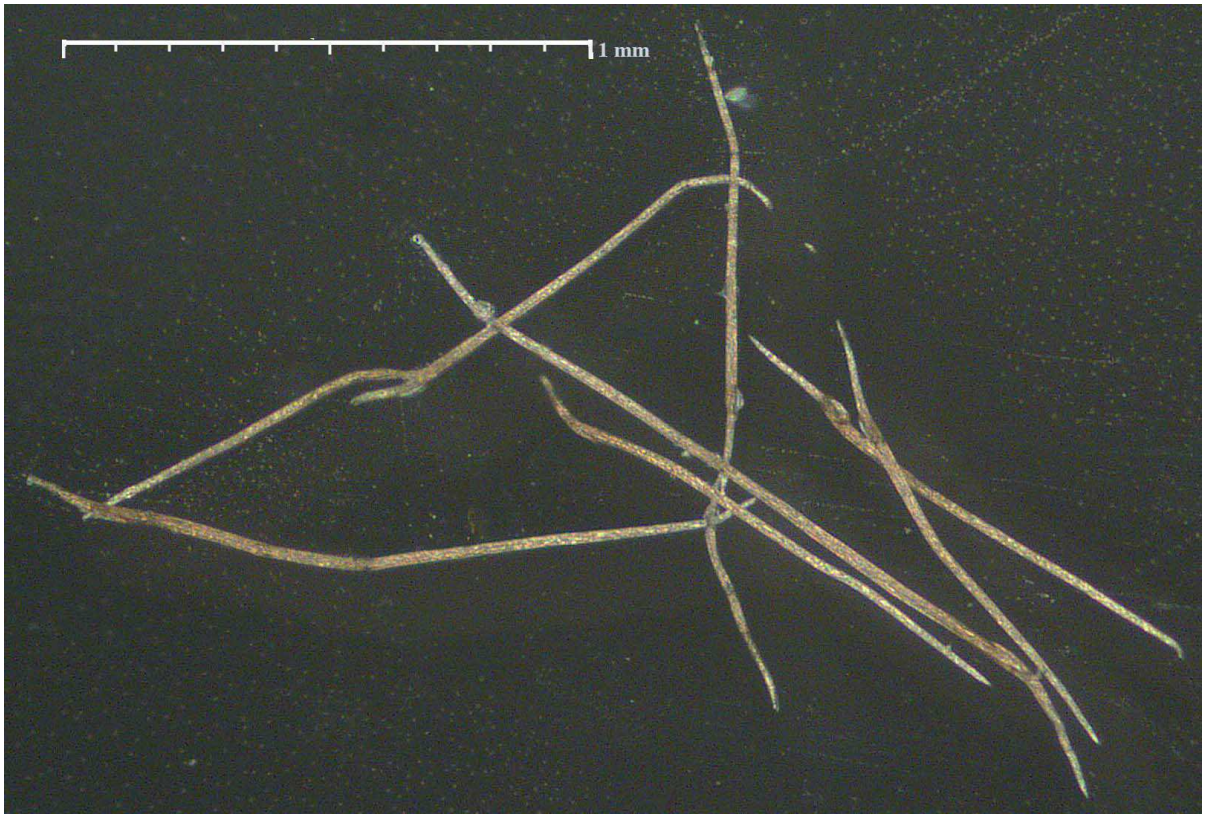

Figure 14. *Evolvulus arenarius* asymmetrical bifurcate hairs. *Warnock & Parks 8773* (TEX).

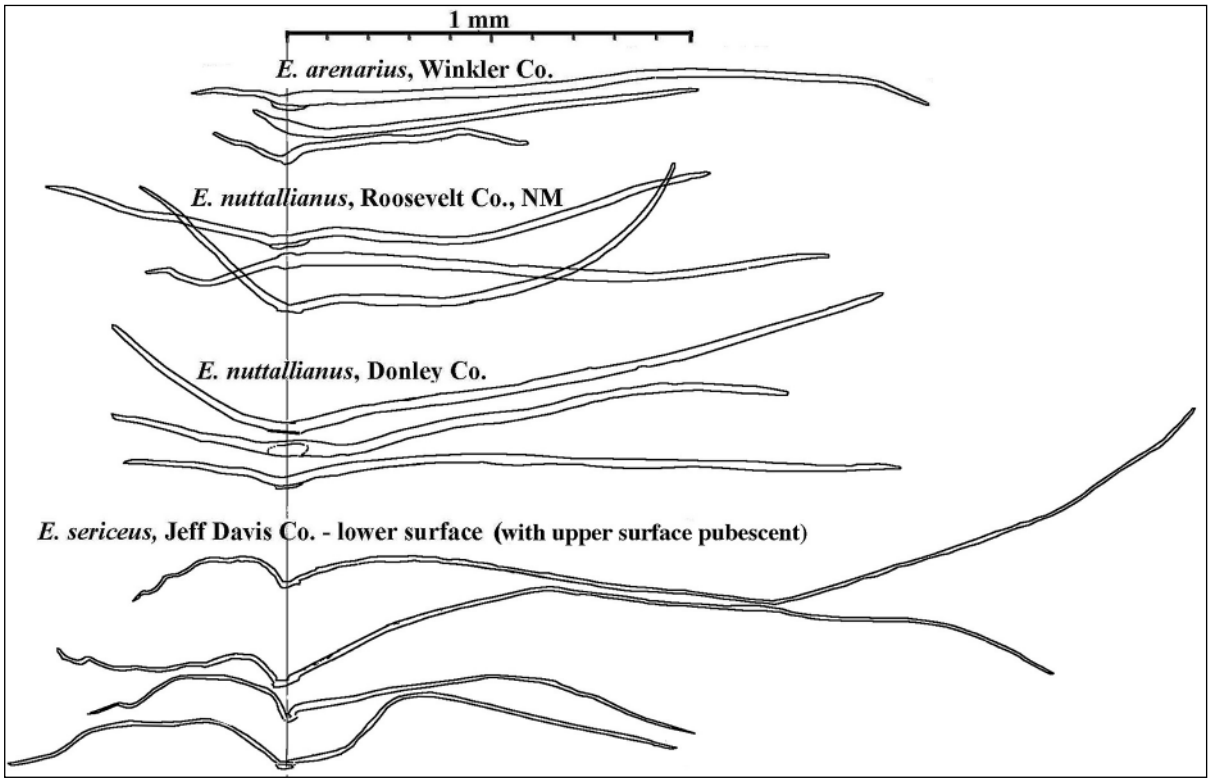

Figure 15. Typical leaf hairs from 3 taxa. With *Evolvulus sericeus* a difference between hairs of the upper and lower surface was noted. Vertical line indicates the base (point of attachment), with the weak fork to its left.

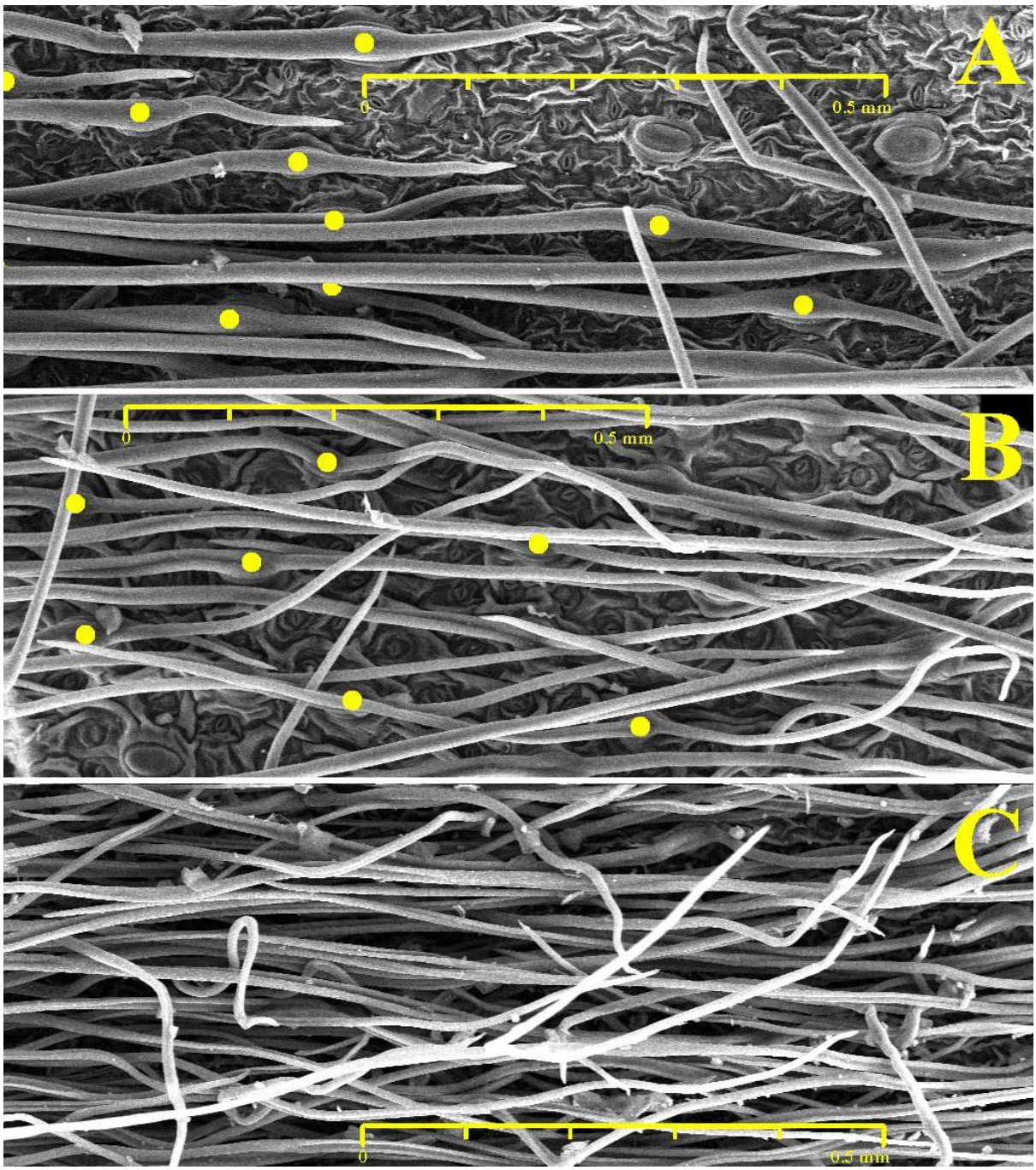

Figure 16. SEM images of leaf surfaces for A: *Evolvulus arenarius*, Winkler Co., Texas (holotype); B: *E. nuttallianus*, Culberson Co., Texas; *C*: *E. sericeus*, Jeff Davis Co., Texas. Scanned at 800 x. Yellow dots at trichome base for hairs having the full length of weak forks visible. None were apparent in the dense hairs of *E. sericeus*.

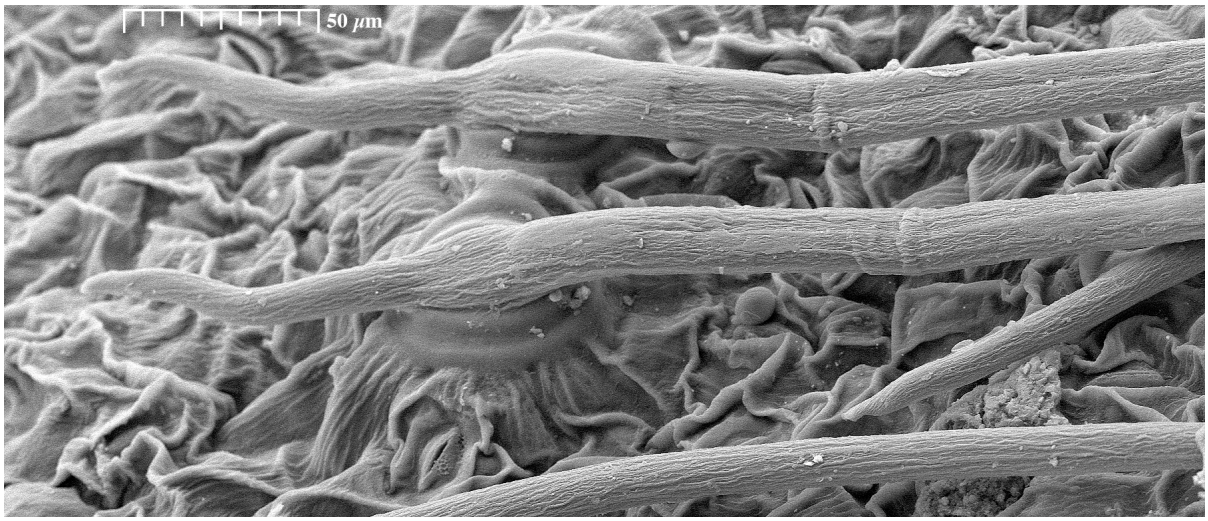

Figure 17. Trichomes of *Evolvulus arenarius*, Winkler Co., Texas (holotype), SEM images scanned at 6000 x, 45º tilt.

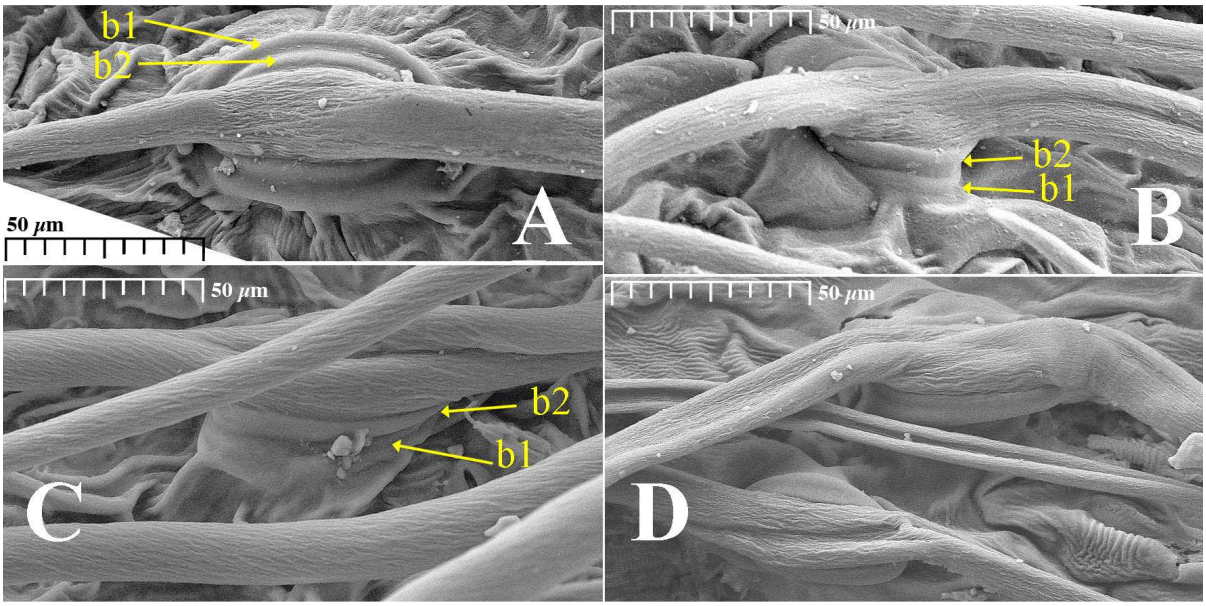

Figure 18. SEM images of concentric trichome basal cells (b1, b2) for A: *Evolvulus arenarius*, Winkler Co., Texas (holotype); B-C: *E. nuttallianus*; B: Culberson Co., Texas; C: Yuma Co., Colorado; D: single cell trichome base of *E. sericeus*, Jeff Davis Co., Texas. Scanned at 6000 x, 45º tilt.

Figure 19. Sepal comparison. Roosevelt Co., New Mexico. Left: *Evolvulus arenarius, Secor 73* (TEX); right: *E. nuttallianus, Secor 12* (TEX).

Figure 20. Sepal comparison. Left: *Evolvulus arenarius,* Winkler Co., Texas, *McCullough 320* (SRSC); right: *E. nuttallianus,* Andrews Co., Texas, *Adv. Bio. Class s.n.* (SRSC).

Figure 21. *Evolvulus arenarius* corolla, Eddy Co., New Mexico, *Marley s.n.* (NMU); yellowing, Roosevelt Co., New Mexico, *Strahan 473* (NMCR).

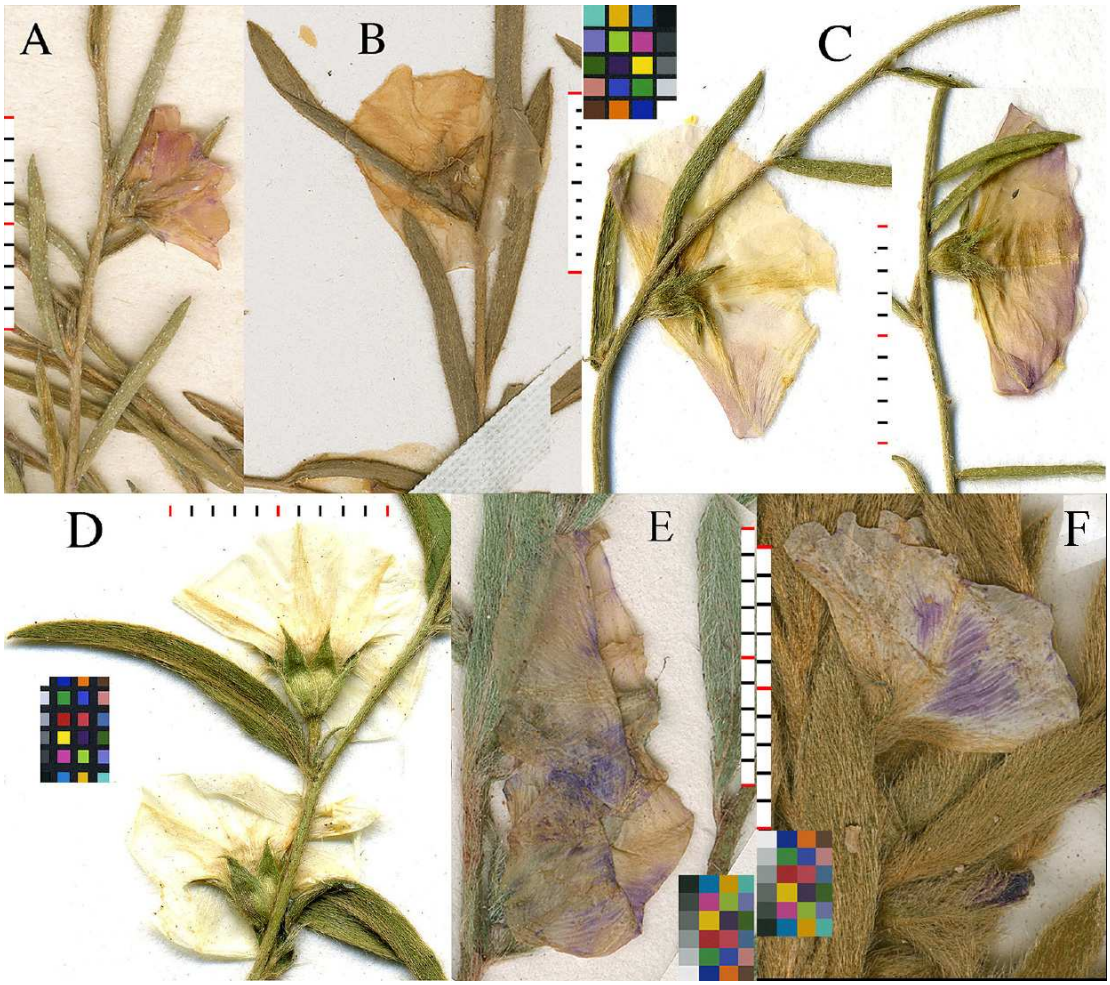

Figure 22. Corolla color changing with age. A–C, *Evolvulus arenarius*, yellowing; D, *E. sericeus*, yellowing; E–F: *E. nuttallianus*, losing color; A: Winkler Co., Texas, *Warnock & Parks 8773* (TEX); B: Gaines Co., Texas, *Tharp s.n.* (TEX); C: Roosevelt Co., New Mexico, *Strahan 473* (NMCR); D: Catron Co., New Mexico, *Johnson 604* (NMCR); E: Harding Co., New Mexico, *Sivinski 6969* (NMU); F: Crockett Co., Texas, *Read 599* (SRSC).

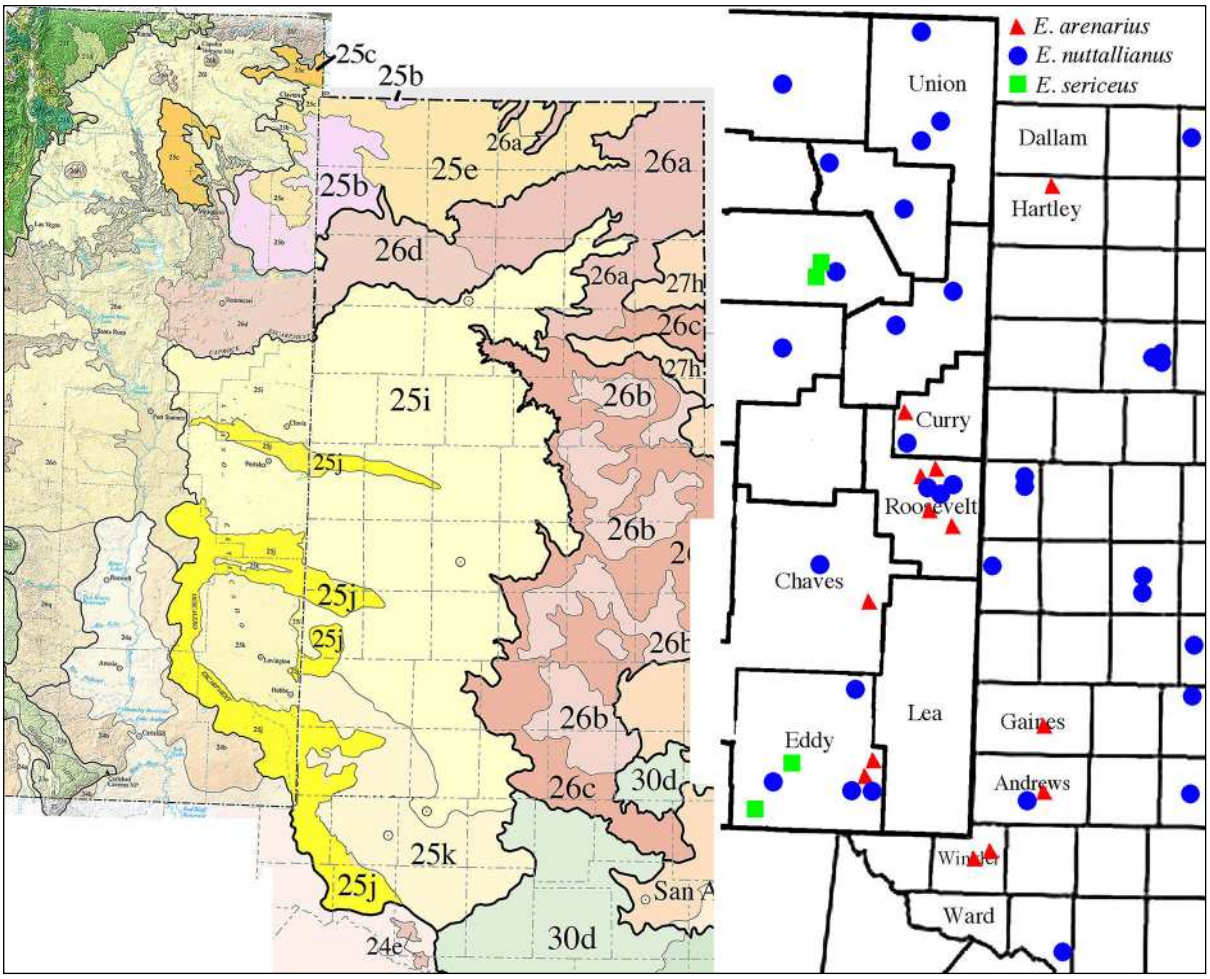

Figure 23. High Plains along the New Mexico–Texas border; areas indexed '25b–k'. *Evolvulus arenarius* occurs in areas 25j (Shinnery Sands) & 25b (Rolling Sand Plains) and immediately adjacent areas. Ecoregions are adapted from Griffith et al (2006 & 2007) and Strahan (2008).

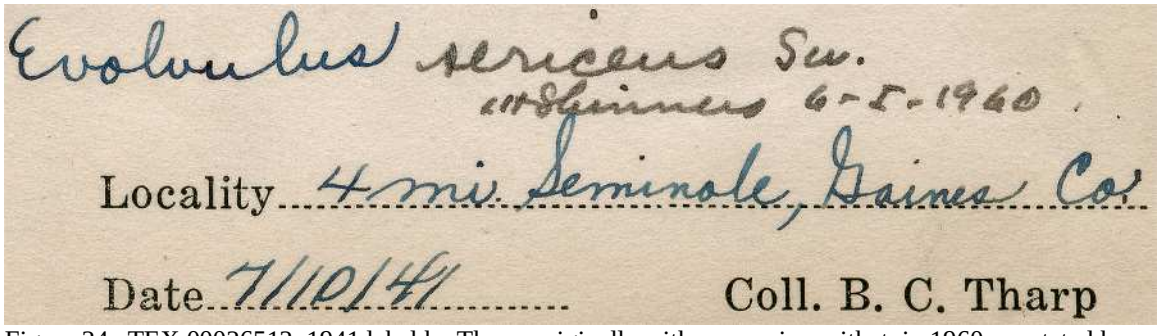

Figure 24. TEX 00026512, 1941 label by Tharp, originally with no species epithet; in 1960 annotated by Shinners as *Evolvulus sericeus*; subsequently placed with *E. nuttallianus* collections.

Figure 25. Shinnery oaks on the Waddell Ranch, 10 miles E of Kermit along State 302, Winkler Co., Texas, 23 June 2013. The type of *Evolvulus arenarius* was collected from this ranch.

Figure 26. Roadside 9 miles E of Kermit along State 115, Winkler Co., Texas, 23 June 2013.

Figure 27. Dunes along roadside 9 miles E of Kermit along State 115, Winkler Co., Texas, 23 June 2013.

Figure 28. Roadside 9 miles E of Kermit along State 115, Winkler Co., Texas, 23 June 2013.